JOINT EUROPEAN X-RAY MONITOR

JEM - X

X-RAY MONITOR FOR THE INTEGRAL MISSION

Experiment Interface Document Part B

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List of acronyms

ADC	Analog to Digital Converter
ANA#:	ANA0, ANA2, ANA3, ANA4 are four of the 9 electronic boards contained in the JEM-X electronics box (the DFEE-box)
ANOD:	The Anode electronics board. (in the DFEE box)
AOCS	Attitude Orbit Control System
Co-I	Co-Investigator
CPU:	The microprocessor board. (In the DFEE box)
CPU	Central Processing Unit
DAE:	Detector Analog Electronics - that part of the JEM-X electronics which is located inside the enclosed detector volume.
DCRS	Data Change Record Sheet
DDHK:	Data digitalization and Housekeeping Board (in the JEM-X DFEE box)
DFEE:	Digital Front End Electronics - a misleading name. In the JEM-X context it is the box containing all the JEM-X electronics outside the enclosed detector volume.
DM	Development Model
DPE	Data Processing Electronics
DPE	Data Processing Electronics
DRD	Document Requirement Description
DSRI	Danish Space Research Institute
EGSE	Electrical Ground Support Equipment
EICD	Electrical Interface Control Document
EID	Experiment Interface Document
EM	Engineering Model
EMC	Electro Magnetic Compatibility
ESA	European Space Agency
FCFOV	Fully Coded Field Of View
FIFO	First In First Out
FIFOV	Fully Illuminated Field Of View
FM	Flight Model
FOV	Field of View
FPGA	Field Programmable Gate Array
FS	Flight Spare
FWHM	Full Width Half Maximum
GND	Ground
GSE	Ground Support Equipment
HEPC	High Energy Proportional Counter (on-board SRG)
HK	House Keeping
HS	High Speed
HURA	Hexagonal Uniformly Redundant Array
HV	The high voltage converter board. (in the DFEE box.)
HV	High Voltage
I/F	Interface
IBIS	Imager on Board Integral Satellite
ICD	Interface Control Document
ILS	Instrument Line-of-Sight
ISVR	Instrument Science Verification Review
JEM-X	Joint European X-Ray Monitor
LEPC	Low Energy Proportional Counter (on-board SRG)
LS	Low Speed
LV	Low Voltage
MGSE	Mechanical Ground Support Equipment
MS	Micro Strip
MSGC	Micro Strip Gas Chamber
MSPC	Micro Strip Proportional Counter
OBDH	On-Board Data Handling
OCC	Operations Control Center

PA	Product Assurance
PCB	Printed Circuit Board
PCFOV	Partially Coded Field Of View
PDU	Power distribution Unit
PI	Principal Investigator
PLM	Payload Model
PWR:	The power converter board (in the DFEE box)
QM	Qualification Model
RDF	Rationalized Data Format
ROM	Read Only Memory
RTU	Remote Terminal Unit
S/C	Spacecraft
SMM	Structural Mathematical Model
SPI	Spectrometer
SRG	Spectrum Roentgen Gamma
STM	Structural Thermal Model
STR-LOS	Star Tracker Line Of Sight
TBC	To be confirmed
TBD	To be defined
TBV	To be verified
TBW	To be written
TC	Tele Commands
TM	Telemetry
TMM	Thermal Mathematical Model
ZRFOV	Zero Response Field Of View

DOCUMENT CHANGE RECORD (OLD)

EID-B issue 4.0 to 5.1

Page	Chapter	Table/ Figure	Description of Change
			Mechanical
17	1.2	Table 1	Updated according to detector redesign (see MICD)
22	1.3.2	Figure 3	Updated according to detector redesign (see MICD)
35	2.1.1		Field-of-wiev definition updated
35-37	2.1.3		$\delta(\alpha)$ stated as goal only
35-37	2.1.3		$\delta(\omega)$ stated as goal only
38			Mounting handles deleted (previous section 2.1.5.2)
44	2.5.1	Table 2	Mass Budget updated
48	3.2.3	Figure 14	Unit Support Brackets now integrated with DFEE box
49-50	3.2.7	Table 5	MICD Drawing Change Record re-initialized
137	Appendix A	130010B	Updated MICD
135	Appendix A		Reference to MICD drawing number changed (typo)
			Electrical
57	3.4.1	Figure 17	Power interface drawing updated
59	3.4.7	Table 11	Power budget updated
61		Figure 18	Grounding scheme updated. Ground bus bar removed.
62	3.6.2		Internal timing concept updated
63	3.6.4		New thermistor lines added, discrete command added
148	Appendix B	J07 & J08	All heater wiring deleted
147	Appendix B	J06	Pin functions for 1Hz and 8 Hz BCP interchanged
145	Appendix B	J04	Pins 36, 37, 38, 39 used for temp. sensors
150	Appendix B	J03	Connector renamed to “Test”
153	Appendix B	Annex 4	Interface circuit 5 redesigned
153	Appendix B	Annex 4	Interface circuit 6 added (HV off from RTU)
154	Appendix B	Annex 4	Interface circuit 7 added (FIFO flag)

Thermal			
51-56	3.3	Annex 4	Thermal interface chapter rewritten
Telemetry			
17	1	Table 1	Timing accuracy updated
45	2.5.3	Table 3	Telemetry packet rate updated
104	3.7.7.2		Time format in packet header
67-126	3.7		Software and Interface chapter updated
120-122	3.7.7.14		On Event Telemetry updated
Telecommand			
85-100	3.7.5		Detailed descriptions of TC-packet formats added
98-100	3.7.5.3		JEM-X operational states description updated
101-102	3.7.6		TC parameter description updated
Operations			
33	1.4		Separate state lists for DPE og DFEE
33+98	1.4 + 3.7.5.3	Figure 10	JEM-X state diagram
38	2.2.3		JEM-X mode table updated
125	3.7.9		CPU memory budget added
125-126	3.7.10		Autonomous Functions defined

DOCUMENT CHANGE RECORD (OLD)

EID-B issue 5.1 to 5.2

Page	Chapter	Table/ Figure	Description of Change
Electrical			
65	3.6.4.1		Number of thermistor lines changed. Correction of typographical error in Issue 5. rev. 1.
61	3.5.2	Figure 18	Drawing updated regarding cable shielding
66	3.6.6.1		Text added to describe FIFO flag interface
Telecommand			
65	3.6.5		Editorial changes in text
67-126	3.7		Chapter 3.7 updated with editorial changes in text,major modifications are listed below
	3.7.4.6.7		Deleted. DFEE status request command removed
	3.7.4.6.8		Added. Pulseheight Translation Tables cmd.
	3.7.4.6.9		Added. Set Grey Filter cmd.
	3.7.5.2.1		Parameter and command numbers added
	3.7.5.2.2		Parameter and command numbers added New command descriptions added
	3.7.5.2.3		Parameter and command numbers added
	3.7.5.2.4		Parameter and command numbers added
	3.7.5.2.5		Parameter and command numbers added
	3.7.5.2.6		Parameter and command numbers added
	3.7.7		Revised definition of delta-time for first event in each packet for Full Imaging, Spectral-Timing and Timing formats.
	3.7.10.2.4		Updated description of switching logic between primary and secondary formats
	3.7.10.2.8		Added. Autonomous flushing of DFEE and DPE buffers at the start of each new observation.

DOCUMENT CHANGE RECORD (OLD)

EID-B Issue 5.2 to 5.4

Including changes made in User Manual issues 4.0 and 4.2

Changes for User Manual 4.0, 2000-12-04. Now included in the EID-B 5.3				
Page	Section	Table/ Figure	ECR	Remarks
				Changes implemented in chapter 3 of the User Manual. This chapter is common between the User Manual and the EID-B
	3.7.5.2.1.3			New default values for the anode configuration
	3.7.5.2.1.4			New default value for the discriminator
	3.7.5.2.1.5			New default value for the Cathode-HV
	3.7.5.2.1.6			New default values for the delta-HV **Note: Instrument model dependencies!**
	3.7.5.2.1.18			On-board reactions defined for mRTU Out-of-range conditions
	p. 94			Three sections describing TC(9,1), TC(9,4) and TC(9,5) commands deleted
	3.7.5.2.9			New section about Shutdown/Recovery logic
	3.7.5.2.10			New section about Eclipse/Rad. Belt actions
	3.7.7.13			HK reporting of HV command setting updated
	3.7.7.14			On-event message format updated

DOCUMENT CHANGE RECORD (OLD)

EID-B Issue 5.2 to 5.4

Including changes made in User Manual issues 4.0 and 4.2

Changes for User Manual 4.2, 2001-05-18. Now included in EID-B 5.3				
Page	Section	Table/ Figure	ECR Group	Remarks
	1.4 and 3.7.5.3			State diagram updated (Goto Safe possible from all other states)
	3.3.1			Thermal test case specifications updated
	3.3.5.3			Thermal model updated
	3.7.5.2.1.6			Reduced value for the maximum V_C voltage
	3.7.5.2.1.16			Command modified to control the DFEE CPU state and the precise level of automatic recovery of the JEM-X state after passage of the radiation belts and after eclipses.
	3.7.5.2.1.20 (and 6.1.13)			Usage of the “Pulseheight Linearization Table” clarified Name changed to “Pulseheight Conversion Table”
	3.7.5.2.9			Shutdown/Recovery description updated
	3.7.5.4			Placeholder added for legal commands versus JEM-X state
	3.7.5.5			Table added with telemetry versus JEM-X state
	3.7.6.1 & 3.7.6.2			Software integer and float parameter description updated
	3.7.7.13			Content of DFEE HK data modified. Note in particular the changes/updates between byte positions 106 to 193 TM reference numbers added
	3.7.7.14			Format for OEM messages revised to be consistent with the Packet Structure Definition Document
	3.7.7.16			Description of Test TM format added
	3.9			Description of Science Data Analysis Software Updated

DOCUMENT CHANGE RECORD (OLD)

EID-B issue 5.2 to 5.4, 2001-10-01

Page	Section	Table/Fig.	ECR grp.	Remarks
	1.3.2.1			Baseline detector pressure reduced to 1.5 bar. Gas mixture: 90% Xenon + 10% Metane
	1.3.2.1.4			Figure 6 updated (new microstrip layout)
	1.3.2.1.6			Calibration source description updated
	2.1.5			Red tag items removed after installation on spacecraft
	2.2.1.3			HV switch-on 96 hours after launch (was 48 hours).
	2.4			Section updated (actual model situation.)
	2.5.1			Mass budget updated (actual FM values)
	3.3			Thermal Interface section text updated
	3.3.5.3	Table 7		Conductive coupling data updated
	3.3.5.3	Table 9		Radiative coupling data updated
	3.4.7			Power budget updated (actual FM-values)
	3.7.5.2.1.26			New command to modify CPU frequency
	3.7.5.2.1.27 3.7.5.2.1.28			New commands to upload and expand a position lineariztion table for the X-coordinate
	3.7.5.2.1.29 3.7.5.2.1.30			New commands to upload and expand a position lineariztion table for the Y-coordinate
	3.7.5.2.3.6			Modification of cmd. to initiate Diagnostic state
	3.7.5.2.4.x			Included 22 new DFEE memory load cmds
	3.7.5.4			New table with "Legal commands vs State"
	3.7.7.4			Modified time words in Restricted Imaging fmt.
	3.7.7.10			Updated description of Diagnostic Dump fmt
	3.7.7.13			Updated content of HK data, K5125 and K5100 (bytes 106-107 and 114-115)
	3.7.10.1.1			Autonomous undervoltage protection disabled.
	Appendix A			Mechanical ICD updated. (Instrument mass, moment of inertia, power consumption, footprint tolerances)

DOCUMENT CHANGE RECORD (NEW)

EID-B issue 5.4 to 5.6, 2002-03-08

Page	Section	Table /Figure	ECR group	Remarks
	1.2			Updated value for detector/mask separation
	1.3.2.1.4			Figure added, showing signal and HV connections to MS plate
	1.3.2.1.6		S/W	Special calibration sources (Fe^{55}) used in the QMR-instru-ment
	Entire sect. 3.7		OPS S/W	Specific references to K and L commands everywhere. Where relevant a distinction os made between the K-com-mands for the FM-1 unit and the QMR-unit The planned exchange of the FM1with the QMR-unit will introduce many changes to parameter values and procedures. Search for the text strings "QMR" or "FM-1" to locate chan-ges.
	3.7.4.1.1			Updated to clarify Grey filter function and visibility in HK data
	3.7.4.2.1.1			Description of timing aspects of calibration spectra added
	3.7.4.4			Updated description of software parameter control
	3.7.4.5		OPS	Description of IASW/CSSW conflict added
	3.7.4.6.11			CPU state control command description added
	3.7.5.2.1.5&6			Updated HV setting values (QMR-unit)
	3.7.5.2.1.7&8			Description of "arm and fire" condition added
	3.7.5.2.1.10			Updated detector pressure limit values (QMR-unit)
	3.7.5.2.1.11			K/L60 command described (detector temperature threshold)
	3.7.5.2.1.14		OPS	CPU state recovery limitations elaborated
	3.7.5.2.1.16			Corrected TC_ID and PREF values
	3.7.5.2.1.20 21,27,28,30			Updated memory locations
	3.7.5.2.1.23 & 3.7.5.2.2.8			Corrected description of grey filter parameters
	3.7.5.2.1.31			Added description of HV-off via mini-RTU command
	3.7.5.2.1.32			Added description of HV-off via RTU relay command
	3.7.5.2.1.33		OPS	Command for HV-control during autonomous recovery added
	3.7.5.2.2.11			K/L61 command described (detector temperature threshold)

	3.7.5.2.2.12			Reporting for HV-control during autonomous recovery added
	3.7.5.2.2.23 to 25		OPS	New memory patch commands added
	3.7.5.2.3.4			Corrected wrong parameter value (FF00 instead of 00FF)
	3.7.5.2.3.6		OPS	Updated description of Diagnostic State command. Introduction of recommended values
	3.7.5.2.3.4 & 7,8,9			Test data state description updated
	3.7.5.2.3.8&9			Updated description of Test Calibration State & Test Diagnostic State commands
	3.7.5.2.4..23 & 24			QMR (K-command) added
	3.7.5.2.4.26 &27, 28&29		OPS S/W	Code patches to improve monitoring of the amplifier offsets
	3.7.5.2.4.28			Code patch to improve the read-out of the HV-monitors
	3.7.6.1			Section rewritten to include all integer S/W parameters
	3.7.6.2			Section rewritten to include all memory load S/W parameters
	3.7.6.3			Section rewritten to include all float S/W parameters
	3.7.7.13		OPS	Revised PREF values for bytes 114-115, and description of byte 190 (external HV-off flag)
	3.7.7.14		OPS	OEM 241 added. Corrected description of OEM 254 [189] Information added to OEM 191.
	3.7.7.15 & 17			APID numbers added
	3.7.7.17			Test data state description updated.
	3.7.10.1.2		OPS	Updated descr. of ratemeter function and inhibit possibilities
	3.9			Text revised to reflect deveæopments in ISDC software & documentation

1 INSTRUMENT DEFINITION

1.1 Scientific Objectives

The purpose of the INTEGRAL mission is to study celestial objects in great detail in the gamma-ray region of the electromagnetic spectrum. INTEGRAL comprises two main instruments, the SPECTROMETER (SPI) covering the energy range 20 keV - 8 MeV and the IMAGER (IBIS) covering 15 keV - 10 MeV that will provide unique opportunities to detect and identify celestial gamma-ray sources and to resolve spectral features.

In order to fully exploit the information about the physical conditions in the sources provided by the two main instruments, it is essential to have simultaneous observations both in the X-ray region and in the optical region. Therefore the INTEGRAL payload includes both an X-ray monitor, JEM-X, and an optical monitor, OMC. JEM-X will play a very significant role in the detection and identification of the gamma ray sources and in the analysis and scientific interpretation of the gamma ray data.

JEM-X will make observations simultaneously with the main gamma ray instruments and provide images with arcminute angular resolution in the 3 - 35 keV band. The instrument consists of two identical high pressure imaging Micro Strip Gas Chambers that view the sky through coded masks located about 3.4 m above the detectors.

1.1.1 Active Galactic Nuclei

1.1.1.1 Introduction

Active Galactic Nuclei (AGN) are among the most luminous objects in the Universe. Most AGN emit approximately equal luminosity per decade of frequency from the IR to hard X-rays. Since the X-ray band covers three (0.1-100 keV) out of those ten decades of frequency, AGN emit up to 30 % of their bolometric luminosity as X-rays. Observations in the X-ray band exhibit the most rapid time variations, an indication that their origin lies at the most central part of the AGN. The determination of the nature of the processes that drive the energy emission from the core of an AGN requires, therefore, spectroscopic and time variability studies in both X-rays and soft gamma-rays.

The only viable and sufficiently efficient mechanism to explain the enormous power output from an AGN is the release of gravitational energy as matter falls into the deep potential well of a central massive black hole. The actual geometry and physical state of the accreting gas flow is uncertain, but it may be that most of the gas accretion takes place in a relatively cold (10^5 K) accretion disc. Most of the accreting energy is released just outside the black hole and here (possibly in a disk corona) part of the accreting matter is heated to high temperatures (10^9 K), i.e., hot enough to allow for the efficient emission of X-rays.

The existence of different classes of AGN now seem to be largely due to different viewing directions of the observer. According to the Unified Model for AGN (e.g. Antonucci, 1993) the central black hole and the accretion disk as well as broad line emitting gas are surrounded by a molecular and dusty torus that obscures the view for some observers. Among the radio-quiet AGN, Seyfert 2s are simply Seyfert 1s viewed through the torus. Radio-quiet QSOs would be the more distant or luminous counterparts. Among the radio-loud AGNs, blazars, radio-loud quasars and broad line radio galaxies, and narrow line radio galaxies also form a sequence of different viewing directions and obscuration. High resolution spectroscopic and variability studies in the X-rays and gamma-rays will be very important in determining the physical properties and geometry of the torus and the accreting gas close to the black hole, as well as other diffuse gas components.

The X-ray spectra for different classes of AGN seem to be different (Mushotzky, Done, and Pounds 1993). Most spectra are known only over a limited energy range and that precludes a detailed physical interpretation. The most well studied class, the typical Seyfert 1, has power law spectra with photon index -1.7 in the 2-20 keV range. Twelve co-added Ginga-spectra of Seyfert 1s showed that the X-ray spectrum is not a simple power law but consists of an intrinsic power law component of index -1.9 and a component peaking at 20-30 keV that is due to reflection (or reprocessing) of the intrinsic power law by cold opaque matter (Pounds *et al.* 1990). Later analysis of 60 spectra from 27 Seyferts (Nandra and Pounds 1994) confirms these conclusions. The reflecting matter must intercept about half of the intrinsic X-rays, but otherwise its location and spatial distribution is not yet known.

The reflection component shows strong spectral features such as an Fe K-shell absorption edge in the 7.1-9.3 keV range and an associated Fe Kα fluorescence line in the 6.4-6.9 keV range (e.g. George and Fabian 1991). The higher the ionization state of Fe, the higher is the energy of the edge and the line. The actual shape of the reflected spectrum and the equivalent widths (E_W) of the lines from an X-ray ionised accretion disk depend strongly on the classical ionization parameter of the gas being exposed to the primary intrinsic X-ray spectrum (Ross and Fabian 1993, Matt, Fabian, and Ross 1993b). The varying ionization parameter across such a disk gives rise to complex line shapes containing important diagnostic information about the geometry (Matt, Fabian, and Ross 1993a). Detailed theoretical studies have been made of the contribution to the X-ray spectrum from both transmission through, and reflection from, the obscuring torus (Ghisellini, Haardt, and Matt 1994). They show that the variability pattern as function of wave-length is an important diagnostic for the column depth of the torus. Fe lines may finally be produced in any warm or cold dense material partially covering the X-ray source (such as the broad line region, Yaqoob *et al.* 1993). Finally, sufficiently hot material of sufficient column depth may scatter and broaden the line.

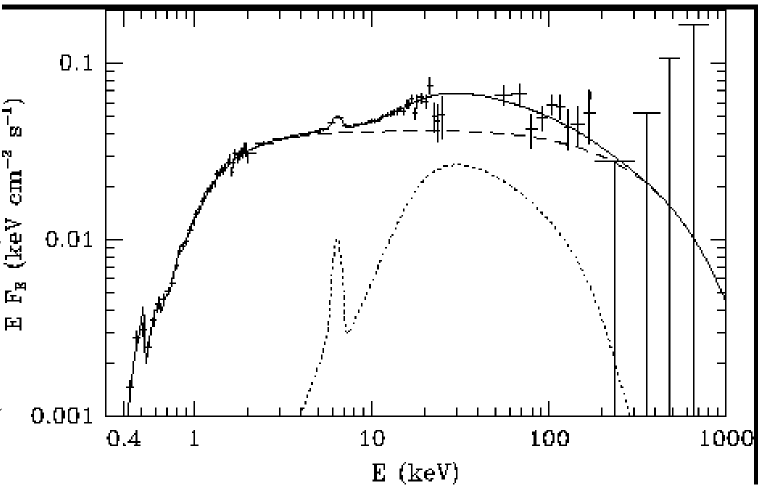
Ginga observations (Nandra and Pounds 1994) show that Seyfert 1s have, in general, a Fe Kα line at 6.4 keV with an E_W consistent with reflection. In about 40 % of the sources, there are indications of a warm absorber of N_H . 10^{23} cm^{-2} that causes an absorption edge at 8 - 9 keV and complex soft X-ray absorption. In Seyfert 2s, on the other hand, the Fe line has very large E_W. The few moderate resolution BBXRT spectra show narrow (< 300 eV FWHM or, equivalently, 7500 km/s in NGC 4151; Weaver *et al.* 1992), sometimes complex lines (NGC 1068, Marshall *et al.* 1992) that exclude an origin in a relativistic accretion disk and indicate the presence of both fluorescence and recombination photons. In the unified model, the large E_W is explained by torus obscuration of the X-ray continuum, while the Fe line originates in any reflecting gas.

A major result from GRO OSSE and BATSE is that the soft gamma-ray spectra of Seyferts have, on average, a photon index of -2.2. The spectra must, therefore, show a break from the X-ray index of -1.7 to -2.2 at about 50 keV. The detailed shape of this important break is not known for any source. Theoretical studies of the generation of X-ray spectra in AGNs over the last decade has resulted in two types of models, thermal and nonthermal, depending on whether the dissipated power is channeled to most of the electrons or just a few of them. Both models make detailed predictions regarding spectral shape and other spectral features, e.g the nonthermal pair cascade models predict an annihilation line having a few per cent of the X-ray luminosity. JEM-X together with IBIS and SPI will for the first time provide the detailed spectral shapes needed for a useful theoretical interpretation.

1.1.1.2 Role of JEM-X

GINGA showed that the apparent X-ray power law spectra of Seyfert 1 galaxies, one of the most well studied class of AGNs, consist of two spectral components, one intrinsic power law of photon index -1.9 and one component, supposedly peaking at 30-40 keV arising from reflection (or reprocessing) of the intrinsic power law by cold opaque matter. The reflected component falls off both towards lower energies (due to photoelectric absorption) and higher energies (due to Compton downscattering). Knowing the equivalent width (E_W) of the fluorescent Fe-line at 6.4 keV in the reflected spectrum is of primary importance when making the two-component fit. Detailed X-ray to gamma-ray spectra, 2-500 keV (with large spectral gaps) have been obtained for only two Seyfert galaxies, IC 4329A (Madejski *et al.* 1995, see Figure 1) and NGC 4151 (Zdziarski *et al.* 1993, Maisack *et al.* 1993). They show different cutoff behavior for each source in hard X-rays and gamma rays. For IC 4329A, simultaneous ROSAT and GRO OSSE data have been supplemented with archival GINGA data. For NGC 4151 non-simultaneous GINGA and GRO OSSE data are used. It is clear from Figure 1 that using only the GRO OSSE data covering the range 60-500 keV does not allow the separation of the intrinsic component from the reflected one. Knowledge of the spectrum below about 10 keV, where the reflected component only makes a small contribution is required. Similarly, for NGC4151 the GRO OSSE data does not allow meaningful modelling using any physical process since the low energy power law below the break at 70 keV is not known. For INTEGRAL, the 20 keV-10 MeV spectra from IBIS must be supplemented with X-ray spectra down to and including the Fe line at 6.4 keV before any meaningful analysis of the Seyfert spectra is possible.

Figure 1. Model fits (curves) of the broad-band spectrum (crosses) of IC 4329A. The data are from a simultaneous ROSAT/OSSE observation (M95) and a Ginga observation. The upper limits here are 2σ. The dashed curve represents the best-fit absorbed power law ($\alpha = 0.99$) with an exponential cutoff ($E_c = 480$ keV). Absorption is due to both an ionized medium with $n_H = 3.4 \times 10^{21}$ cm^{-2} and $\zeta = 1.7$ and a neutral medium with $n_H = 2.3 \times 10^{21}$. The dotted curve represents the absorbed reflected component (R = 1.28; the reflected spectrum includes a fluorescent Fe Kα line). The solid curve is the sum.



1.1.1.3 PI Team Science with JEM-X

The PI team intends to study, in great detail, a set of AGNs containing both Seyfert 1s and Seyfert 2s. Spectral monitoring from 3 keV-35 keV and for stronger sources up to 60 keV, with JEM-X together with simultaneous data from the IBIS and SPI will allow the various continuum components to be separated. Of particular importance is the determination of the spectral shape of the intrinsic continuum and its time-dependent behaviour in different classes of objects.

Detailed spectral modelling of the intrinsic continuum will be performed by the PI-team using state-of-the-art thermal and non-thermal models that allow for the determination of model parameters and their time evolution. In the same process, the time dependent behaviour of the reflected component and the Fe line will be obtained. Correlation studies between the various components including the intrinsic one will set constraints on the geometry of the matter responsible for each component.

Data of poorer quality from a larger sample of AGNs will be used to make a statistical analysis, to compare the properties of different classes of AGN, and to test the predictions of the unified model. Knowing the spectral shape from 3 - 120 keV for a larger sample of Seyferts will allow the PI team to address the question of the origin of the Cosmic X-ray background and whether or not it is mainly due to Seyfert 2s, a recently fashionable suggestion.

1.1.2 Accreting X-Ray Pulsars

1.1.2.1 Introduction

X-ray pulsars are binary systems where a magnetized neutron star having magnetic fields of order 10^{12} gauss accretes matter from a companion star (for a brief review, see Parmar 1994). The dipole field of the neutron star disrupts the accretion disk flow and channels the matter onto the magnetic poles where a luminosity of up to 10^{38} ergs s^{-1} is released. The heated matter radiates in a beamed pattern probably along the field lines in low luminosity sources (where the accretion column has a pill-box shape) and perpendicular to the field lines in high luminosity sources (where the accretion column is narrow). The neutron star rotation, together with this beaming and further effects, is thought to be responsible for the various X-ray pulse profiles.

To date, more than 30 X-pulsars are known (see review by Parmar 1994). Their X-ray continuum spectra are fitted with power laws having an (exponential) high energy cutoff at about 15 keV. The most well studied object is Her X-1 (discovered in 1972) from which additional spectral features are detected. Pre-eclipse dips are also observed and are thought to be caused by X-ray absorption in clouds near the point where the gas stream from the companion impacts on the disk. Detailed analysis of GINGA data (Choi *et al.* 1994) shows that during the absorption dips another (unpulsed) spectral component becomes dominant, caused, most likely, by the primary unobscured spectrum scattering in an optically thin corona. A fluorescent Fe line at 6.4 keV also shows the same pre-eclipse absorption as the pulsed X-ray beam.

Early balloon experiments by Trümper *et al.* in 1977 (see Voges *et al.* 1982 for final analysis) showed the existence of a shoulder in the spectral tail above the spectral cutoff in Her X-1. It was interpreted as a cyclotron feature either in emission at 52 keV or in absorption at 38 keV, with the line centroid varying sinusoidally during the pulsar period. This discovery confirmed the existence of 10^{12} gauss magnetic fields in pulsars. The detailed analysis and spectral fitting by Soong *et al.* (1990) of phase-resolved spectroscopy in the 12-180 keV range, seen by HEAO 1 in 1978, favours the absorption interpretation, as does most theoretical modelling. LAC on GINGA could be used up to 60 keV in a low gain mode allowing the highest energy resolution studies (8% at 35 keV) of the cyclotron feature in Her X-1 to date (Mihara *et al.* 1990). Resolving the cyclotron resonance scattering feature allowed Mihara *et al.* to favour the absorption line interpretation with greater certainty. GINGA increased the number of X-ray pulsars with known cyclotron features from 2 to 9 (e.g review by Parmar 1994). The cutoff energies are typically around 15 keV with the cyclotron line energy between 20 and 40 keV.

CGRO BATSE with its continous monitoring was able to obtain the light curve of Her X-1 for the full 35 day precession cycle in hard X-rays (15-70 keV), pulse profiles up to 200 KeV, and a phase averaged spectrum from 15 to 200 keV (Wilson *et al.* 1993). The quality of the spectral data were such that a power law of index -4.5 was an adequate fit with no need for any cyclotron feature. Her X-1 was also observed at three different times by CGRO OSSE (e.g. Kurfess *et al.* 1993). Although the OSSE threshold at 40-50 keV does not allow the cyclotron line, to be observed, the OSSE data will be analysed for the existence of higher cyclotron harmonic features.

1.1.2.2 Role of JEM-X

The hard X-ray emission from accreting X-ray pulsars will be observed by INTEGRAL's main instruments. For the presently known sample of sources, SPI will be able to obtain phase resolved spectroscopy down to energies covering the cyclotron line energies (20-35 keV) as well as to search for higher cyclotron harmonics. JEM-X will be a crucial supplement for the extension of the spectra to lower energies. It is of great importance to have a full knowledge of the behavior of different spectral components when analysing the phase dependent behavior of the cyclotron line features and of any hard X-ray and soft gamma-ray emission.

1.1.2.3 PI Team Science with JEM-X

The PI team intends to perform phase-resolved spectroscopy on most of the 9 X-ray pulsars known to have cyclotron lines in order to better determine the spectral shapes as function of phase and to search for higher harmonic features and their phase dependent characteristics. Searches for cyclotron features in additional X-ray pulsars will be also made. The lack of detection by Ginga may simply be due to the limited energy range of LAC (even in the low gain mode).

Detailed theoretical interpretations will be made using both the phase dependent spectral shapes and the pulse profiles in various energy ranges. The cyclotron features will be fitted with the standard analytical shapes that have been sufficient thus far (or with improvements if necessary). The fits will be interpreted in terms of recent radiative transfer models in highly magnetized media.

1.1.3 X-Ray Transients and Galactic Black Hole Candidates

1.1.3.1 Introduction

Several binary X-ray sources in our Galaxy (and nearby galaxies) show strong evidence that their X-ray emitting component is matter accreting into a black hole. Studies of these objects are very important for establishing the existence of black holes of stellar mass and for probing the near environment of a black hole where gravity is in the strong field limit. The clearest evidence that black holes are involved was obtained first from X-ray observations of an unusual X-ray source and second from optical measurements that the companion star is orbiting a mass larger than 3 $M_{À}$, this being the maximum accepted mass for a neutron star. The nature of the X-ray source is unusual in the sense that there are no pulses attributable to the spin of a rigid body (such as a neutron star) - the X-ray light curve is often chaotic in form - and the spectrum is particularly hard, better fitting the expectation of accretion onto a body with no hard surface. Indeed, most of the objects detected by the instrument HEAO-1 A4 at energies between 50 - 100 keV are considered to be Black Hole Candidates (BHC), the most famous of which is Cygnus X-1. The hard tail to the spectrum is remarkably similar in shape to that observed from AGN.

Another notable feature of many BHC is that they show a number of separate intensity states; many of them are transient, being undetectable between outbursts that may last a few months and recur every few decades.

To date, almost a dozen good BHC have been identified. Some of these orbit massive stars and are persistent in the sense that they can always be detected in X-rays e.g. Cyg X-1, LMC X-1 and LMC X-3. Some are X-ray transient BHC which orbit low mass stars e.g. A0620-00, GS2023+338 (V404 Cyg) and GRS1124-68 (Nova Muscae). These last 2 are perhaps the best candidates of all since their mass functions are 6.1 and 3.1 $M_{Å}$ respectively. There are also many other possible BHC (objects which have similar X-ray properties to the established candidates) which are difficult or currently impossible to study optically because of obscuration due to their location in the Galactic Plane or near the Galactic Centre where they are highly obscured.

Hard X-ray data from HEAO-1, Ginga, SIGMA and OSSE show that BHC have particularly hard spectra, or at least hard tails. In some cases, spectral features are seen which have been attributed to electron-positron annihilation in the accreting material (Sunyaev *et al.*, 1992; Goldwurm *et al.*, 1992). Rapid variability, showing time lags between different spectral bands, is common. Broad iron line and/or edge features are also common (Tanaka, 1992). Studies of these bright objects and comparison with AGN (which are much fainter and have much longer time scales) should reveal the emission processes and behaviour of matter accreting into a black hole, and hopefully the nature of the hole itself. The transient BHC also show a much larger range of intensity in a single object compared with AGN, so providing an extra dimension for study.

1.1.3.2 Role of JEM-X

The hard spectrum of BHC will make them important targets for INTEGRAL. Possible annihilation features and the spectral break seen around 100 keV or so, which is important for understanding the emission mechanisms, will make spectra of these objects a high priority. The whole X-ray/soft gamma-ray spectrum is essential here and it is vital that JEM-X provides coverage down to 3 keV.

1.1.3.3 PI Team Science with JEM-X

The PI team intends to make detailed spectral and variability studies of the persistent BHC; Cygnus X-1, LMC X-1 and LMC X-3, as well as some candidate BHC such as GX339-4. The transient sources are more difficult to schedule since they do not recur in a predictable manner. Nevertheless we intend to study any that occur in the first years of operation of INTEGRAL.

The INTEGRAL core program including repeated surveys of the galactic plane and the central radian favours this type of source monitoring and spectral analysis.

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1.2 Scientific Performance Summary

The key properties for the scientific capabilities are: Field of view, source detection sensitivity, angular resolution, point source location accuracy, and spectral resolution as listed in **Table 1**.

The Field of View has been dimensioned to allow the 2E dithering steps required by the gamma-ray instruments. A source, offset 2E with respect to the instrument axis, will still be inside the fully illuminated[1] field of view .

Table 1: JEM-X Specifications

Active mask diameter	535 mm
Active detector diameter	250 mm
Distance from mask to detector entrance window	3401 mm
Energy range	3 - 35 keV
Energy resolution	$\Delta E/E = 0.47\ (E/1\ keV)^{-1/2}$
Angular resolution	3 arcmin
Field of view (diameter)	Fully illuminated 4.8E Partially illuminated *) 7.5E Zero response 13.2E
Relative point source location error	< 30 arcsec (10σ source)
Narrow line sensitivity (isolated source)	$2.5\ 10^{-4}$ photons $cm^{-2}\ s^{-1}$ @ 6 keV $2.5\ 10^{-4}$ photons $cm^{-2}\ s^{-1}$ @ 30 keV for a 5σ line detection in a 10^5 s observation
Continuum sensitivity (isolated source)	$7\ 10^{-6}$ photons $cm^{-2}\ s^{-1}\ keV^{-1}$ @ 6 keV for a 3σ cont. detection in a 10^6 s observation
Timing accuracy	122 µs (1/8192 s)

**) At this angle the sensitivity is reduced by a factor 2 relative to the on-axis sensitivity.*

[1] We use the term “fully illuminated field” here rather than the more conventional “fully coded field” because the JEM-X detector does not cover, even for an on-axis source, the complete code pattern of the mask.

1.3 Instrument description

The complete JEM-X instrument consists of two nominally identical units, Jem-X1 and JEM-X2. In most of the following descriptions only one unit is described. Both units are built to identical specifications. Where differences exist in the detailed detector performances, they are clearly marked in the text of this document.

1.3.1 Measurement principle

The JEM-X instrument is based on the same measurement principle as the two gamma-ray instruments on INTEGRAL: sky imaging using a Coded Aperture Mask. An imaging X-ray detector observes the sky through a perforated mask, the hole pattern on the mask is designed to assure that each source within the Field-of-View can be recognized through its shadowgram. The dimensions of the holes in the mask and the separation between the mask and the detector determines the angular resolution of the instrument, in the case of JEM-X the angular resolution is 3 arcminutes, which is the best of the three high-energy instruments on INTEGRAL.

1.3.1.1 Functional description

The description below follows the diagram in Fig. 2 from top to bottom. The cosmic X-ray photons enters the JEM-X instrument through the holes in the coded mask situated 3.4 m above the detector entrance window. Inside the detector the photons are absorbed in the xenon gas, and resulting ionization cloud is amplified and detected on the Micro strip plate. The energy of the incoming photon and its position can be determined from the electrical signals induced on the micro strips.

Thanks to the hole pattern in the mask the photons originating from a particular point source on the sky will produce a unique pattern of illuminated spots on the detector. Sources in different positions on the sky will produce different spot patterns on the detector. These patterns can later be disentangled and the source positions and strengths can be determined from the complex image.

The Field of View of JEM-X is defined by a collimator placed on top of the detector entrance window. The collimator has an acceptance angle of 6.6E at zero response. This angle matches the angle defined by the mask-detector combination. The collimator is important for reducing the count rate caused by the cosmic diffuse X-ray background. However, the presence of the collimator also mean that sources near the edge of the Field-of-View will be strongly attenuated with respect to on-axis sources.

The photon absorption process is mostly dominated by the photoelectric absorption of the photon in the xenon gas in the detector. This process causes an electron to be emitted from the struck Xe-atom. The emitted electron will ionize other atoms along its track and thus create a cloud of electrons. An electric field between the entrance window and the micro strip plate will cause the electron cloud to drift towards the micro strip plate. When it is sufficiently close to one of the individual anode strips the electric field becomes so strong that an avalanche of ionizations is created and a significant electric charge is picked up on the strip as an electric impulse.

A capacitive read-out system is used on the Micro strip plate for determination of the avalanche position. The signals from the read-out chains delivered to the Digital Front End Electronics (DFEE) for calculation of the position of the interaction and for rejection of unwanted events. The majority of the background events will be due to cosmic ray or Solar energetic particles, but some of the high energy photons are absorbed through a two stage process, which leaves two spatially separated charge clouds in the gas. The position of the first interaction for these events is ambiguous and they will be rejected by the electronics.

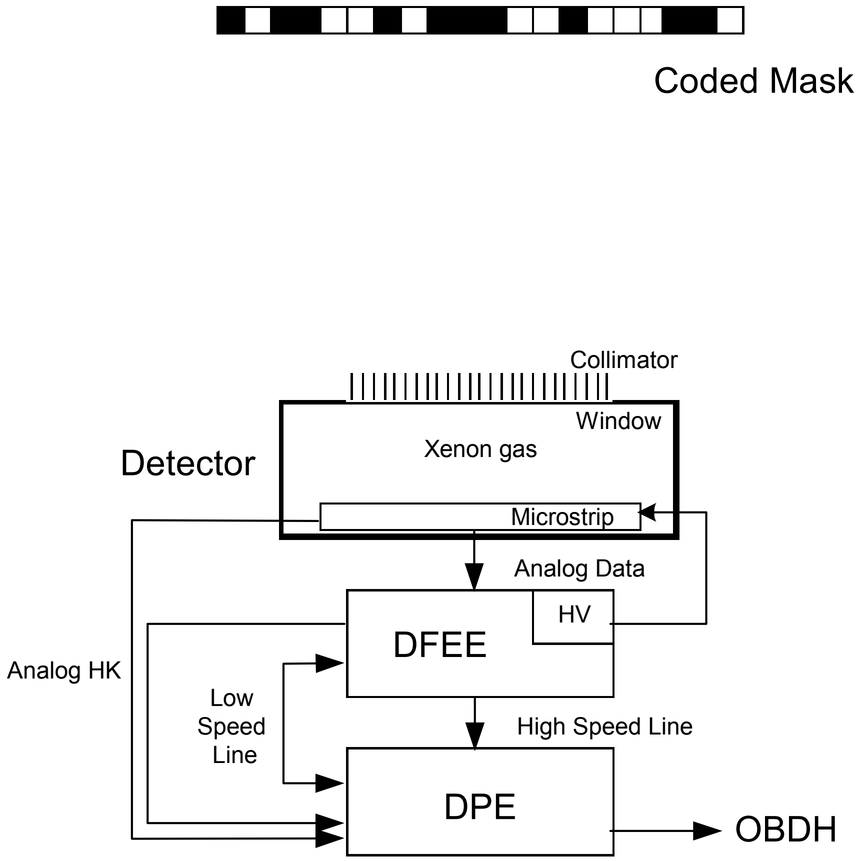

Figure 2 Functional diagram

The event data is finally passed to the Digital Processing Electronics (DPE) which formats the data for the telemetry. The full set of parameters for an event consists of arrival time, position in the detector (x and y), and pulse-height (proportional to energy). When observing source fields with integrated source fluxes exceeding about 750 mCrab (about 100 counts/s) the telemetry allocation will be fully used, and the event data must be compressed or some events rejected.

The Mask is based on a Hexagonal Uniformly Redundant Array (HURA) as described by Finger and Prince (1985), however for JEM-X a pattern with only 25% open area have been chosen, based on a so-called "Bi-quadratic Difference Residue Set" corresponding to the prime number 22501 (see in't Zand et al, 1994). In order to obtain an angular resolution of 3 arcminutes the dimension of the hexagonal cells have been chosen as 3.3 mm. measured across the hexagon faces. The total number of elements in the mask will be about 23300, so a slight repetition of the pattern will be needed at the edge of the mask.

The 25% transparent mask surprisingly achieves better sensitivity than a 50% mask, particularly in complex fields with many sources, or in fields where weak sources should be studied in the presence of a strong source. Very importantly in the case of JEM-X, the mask with lower transparency reduces the number of events to be transmitted (while at the same time increasing the information content of the remaining events!). Considering the limited telemetry allocation to JEM-X, this will mean a improved overall performance for the instrument, particularly for observations in the plane of the Galaxy.

The pointing stability if INTEGRAL is sufficiently good that the image data can be integrated directly without continuous position corrections. A new source can be located to a precision of about 1.0

arcminute including the pointing accuracy of INTEGRAL. If other, known, sources are detected in the same field, the position determination may be better, dependent on the counting statistics.

1.3.1.2 Observation strategy

When observing a source field INTEGRAL will normally execute a sequence of sub-exposures with slight changes of the satellite pointing in between. This "dithering" improves the imaging for the gamma-ray instruments. The duration of the sub-exposures will be about 1000 seconds during the Galactic Plane Scans and about 1800 s during all other observations..

1.3.1.3 On board calibration

To calibrate the energy response of the JEM-X detectors a calibration system consisting of four radioactive sources is embedded in the detector collimators. These sources will permit to monitor the gas gain of the detector continously.

The detector position determination can be calibrated in-flight by observing a strong point-like source such as the Crab. The position determination precision in the detector is best at energies between 4 and 15 keV. The count rate of the Crab Nebula in this interval is about 150 cts s^{-1}. There are about 1300 open cells positions projected from the mask to the detector. In a 1000 s observation of the Crab we will therefore get about 120 source counts in each illuminated spot on the detector and we may compare with the mask pattern to verify the position resolution.

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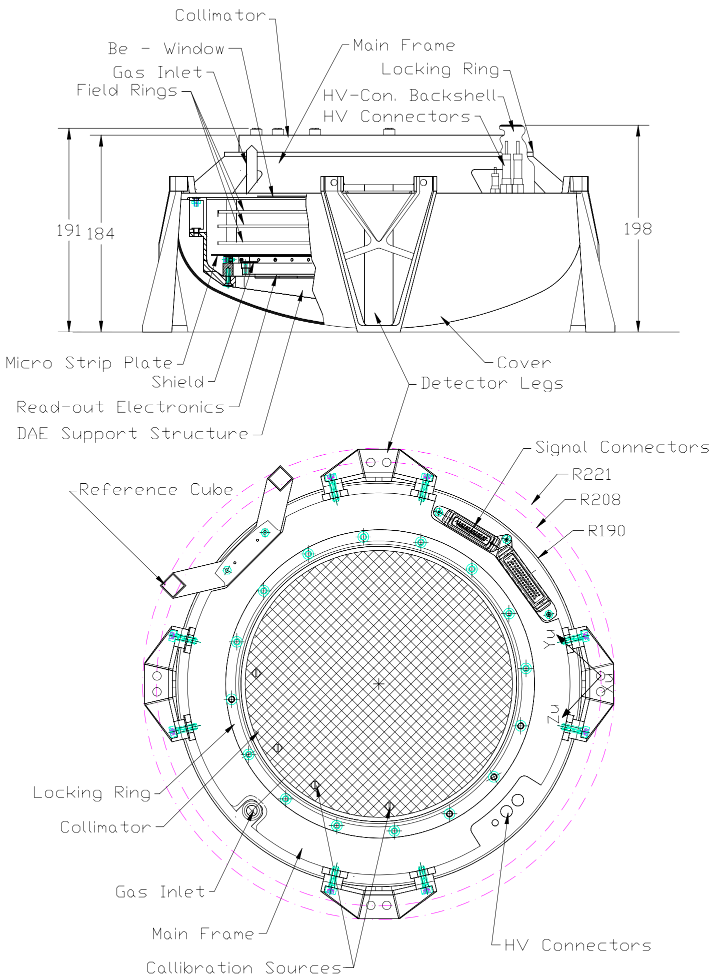
1.3.2 Hardware description

The JEM-X monitor consists of two coaligned, identical telescope units. A single JEM-X unit comprises 3 major subsystems: the detector, the associated electronics and the coded mask.

1.3.2.1 Detector

The JEM-X detector is shown Figure 4. It is a Micro strip Gas Chamber with a sensitive area of about 500 cm^2. The detector consists of the following modules: the detector vessel, the collimator, the X-ray window , the sensor package with the Detector Analog Electronics (DAE) and the calibration sources. The gas inside the detector is a mixture of xenon and methane at 1.5 bar pressure.



The diameter of the detector window is 250 mm, the height of the detector front window above the reference plane defined in the MICD is 127 mm

1.3.2.1.1 Detector Vessel

Figure 3 The JEM-X Detector box

The detector body is made of stainless steel and consists of two parts, the mainframe and the cover which are joined together by electron beam welding. There are no gaskets.

The cover is formed from 2 mm thick stainless steel plate. The shape of the cover is similar to that of the cap for a pressure vessel.

The mainframe is a cone shaped ring with a circular flange for mounting the collimator. The electrical connectors, the feedthroughs for the high voltage and the gas filling tube are welded to this mainframe. All internal structures also mounts to the mainframe. The internal structure consists of two sets of vertical stand-offs and a spider structure. The field forming rings are fixed on one set of stand-offs and the MS-sensor package and the spider structure is mounted on the other set. The spider structure carries the Detector Analog Electronics (DAE).

1.3.2.1.2 Collimator

The collimator has a dual role, it acts as a support for the thin X-ray window against the internal pressure of the detector, and it limits the field of view (FOV). The full-width-at-half-maximum of the collimator FOV is tailored to have the same zero response as that of the detector-mask combination (6.6 deg). This is the best match to maximize the instrument signal-to-noise ratio.

The collimator cell geometry is chosen to be square. This geometry is easier to manufacture than a hexagonal one and it is fully compatible with the hexagonal cell geometry of the mask as verified by numerical simulations. The material chosen for the core of the collimator is molybdenum with a thickness of 180 micrometers. This allows to obtain a close to zero collimator response for incident angles greater than 6.6 deg. The K-fluorescence photons produced by the molybdenum could contribute to the detector background. To reduce this contribution the molybdenum will be covered by 35 micrometer copper from both sides of the cell walls. Finally a 100 micrometer aluminum layer will be added on top to absorb the 9 keV K-fluorescence photons of copper.

The cells are made of crossed slats of Molybdenum covered on both sides with a bilayer of Copper and Aluminium. The Copper is fixed to the Molybdenum plates with a double side cladding process. The Aluminum layer is fixed on both sides by a diffusion bonding process. The single cells are stiffened with an eutectic Zn5Al brazing. The cell structure is contained in an external ring of Molybdenum which is brazed to the cell structure with the above eutectic.

The internal side of each cell is 6.6 mm and its height is 57.0 mm. The cell assembly is circular with a diameter of 250 mm corresponding to the beryllium window diameter. An external ring of 3 mm thick Molybdenum supports the collimator cell assembly and has the role to interface with the detector frame.

Figure 4 shows the angular response of the collimator at 60 keV

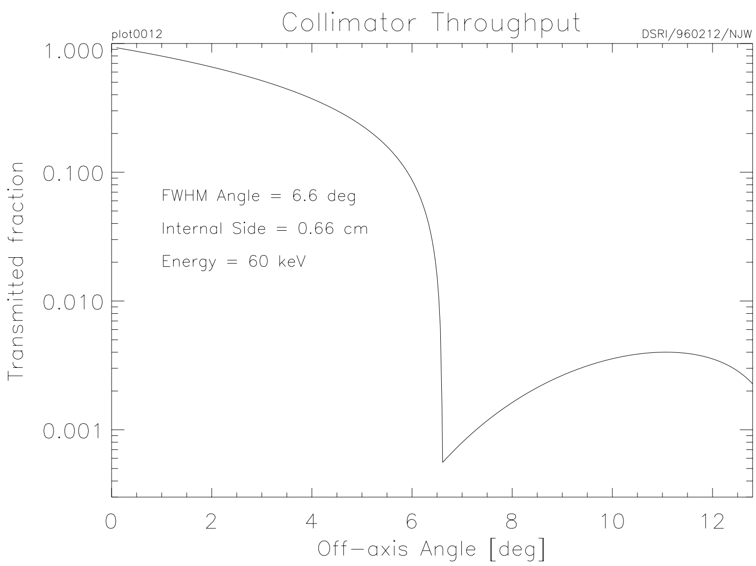


Figure 4 Angular response of the collimator

1.3.2.1.3 X-ray Window

The X-ray window of the detector must allow good transmission of low energy X-rays and be impermeable to the detector gas. The window is a 250 µm thick beryllium foil. The window is supported by the collimator structure against the internal pressure. The window is glued to a stainless steel mounting ring which is welded to the detector mainframe. The window is electrically conductive and at the same electrical potential as the detector body.

During transportation and storage the X-ray window and the collimator will be covered with a shield. This red tag item will be removed for tests and calibration and finally during the integration of the JEM-X units to the satellite.

1.3.2.1.4 Micro strip-sensor package

The Micro strip-sensor package consists of the following parts: The Micro strip plate, the support structure and the read-out electronics (DAE). The electronics is mounted on ceramic plates around and underneath the Micro strip plate. The whole sensor package can be mounted and tested in the detector as a separate module. The DAE electronics is described in 1.3.2.3.1 together with the DFEE electronics.

The capacitive read-out chains are mounted on ceramic plates which are glued on the micro-strip plate edges. The micro-strip electrodes are bonded to these chains. Signals from the capacitive chains are led through high voltage blocking capacitors to the preamplifiers on the ceramic circuit boards underneath the Micro strip plate.

The layout of the capacitive charge division read-out chains on the plate is shown in Figure 5

The Micro strip pattern is shown schematically in Figure 6. The pattern is chosen to be shaped as a regular octagon with a diameter of 292 mm. The Micro strip pattern with alternating anode strips of 10 µm and cathode strips of 458 µm has a 1.062 mm pitch. The Micro strip will be formed in a 0.2 µm thick chromium layer sputtered on the substrate, D 263 glass. The micro strips will be connected to the printed circuit of the capacitive readout by wedge bonding to gold bonding pads on the chromium electrodes.

The anode strips are connected into four groups, the signals from these "anode segments" are used for event triggering, energy determination and for pulse shape analysis. The cathode strips are read out to 11 amplifiers using the capacitive charge division chains. The position of the avalanche in the direction perpendicular to the micro-strip pattern, are determined from the centroid of the avalanche charge.

The orthogonal coordinate for an event are obtained from a set of pickup electrodes on the rear surface of the glass plate (this set of electrodes is also shown in Figure 6). These electrodes are arranged on a 2 mm pitch and read out by 20 amplifiers through capacitive chains. The pickup signal will be about 18% of the avalanche charge. This is sufficient to achieve the required position resolution.

The rear strips are surrounded by a veto-electrode which is used to suppress events caused by charged particles entering through the sides of the detector.

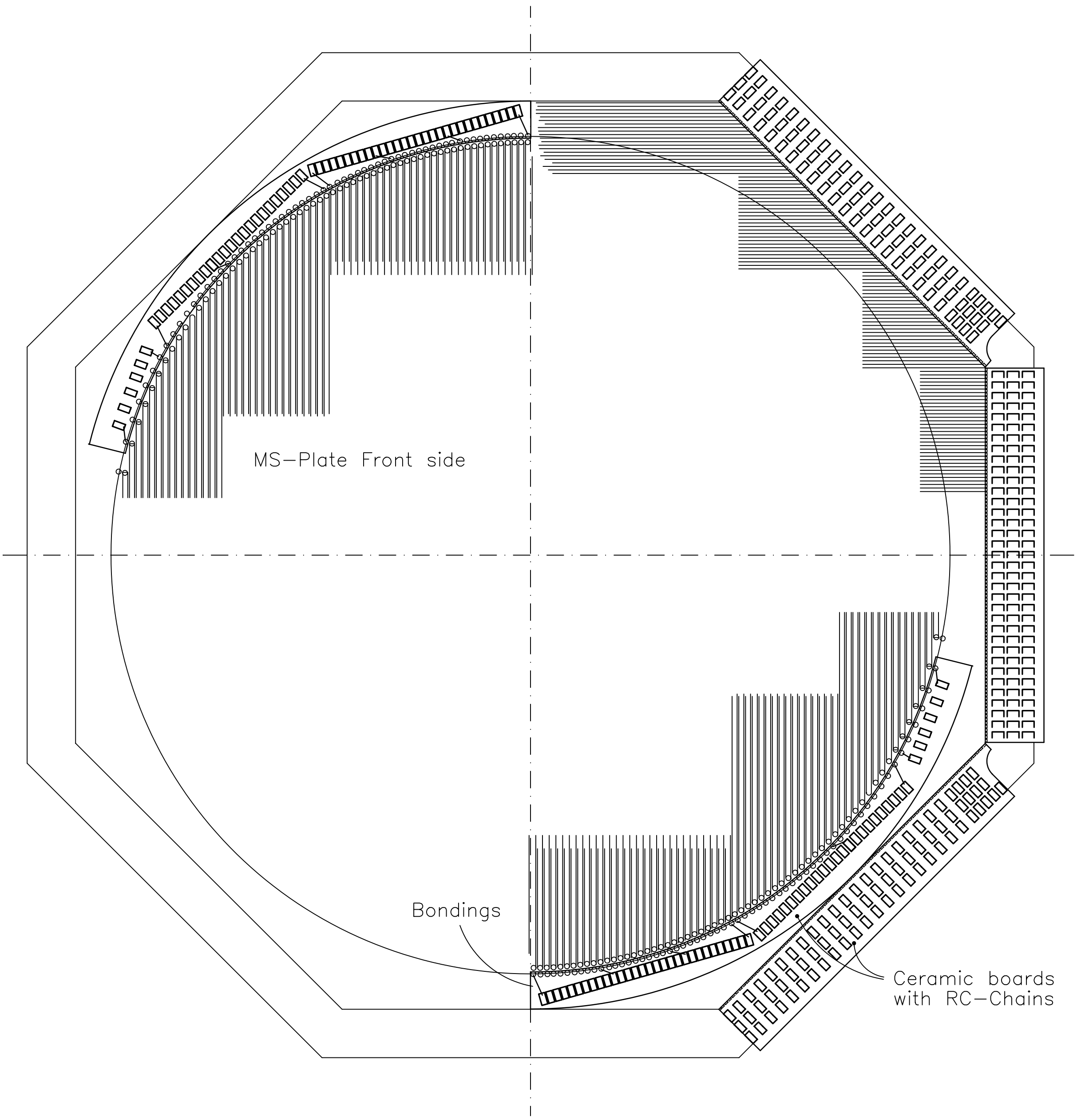


Figure 5 The electrical connections on the MS plate

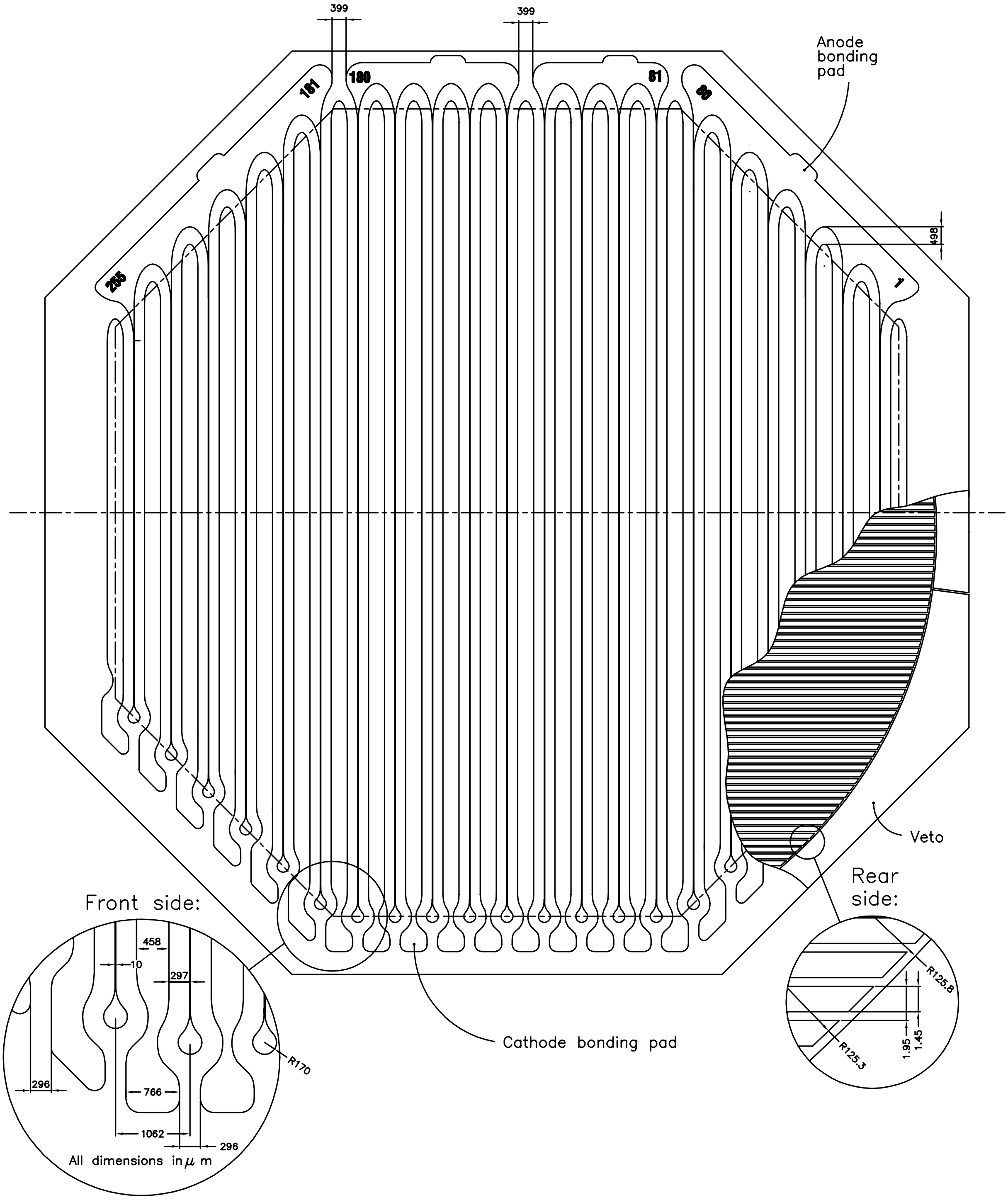


Figure 6 The JEM-X sensor plate.

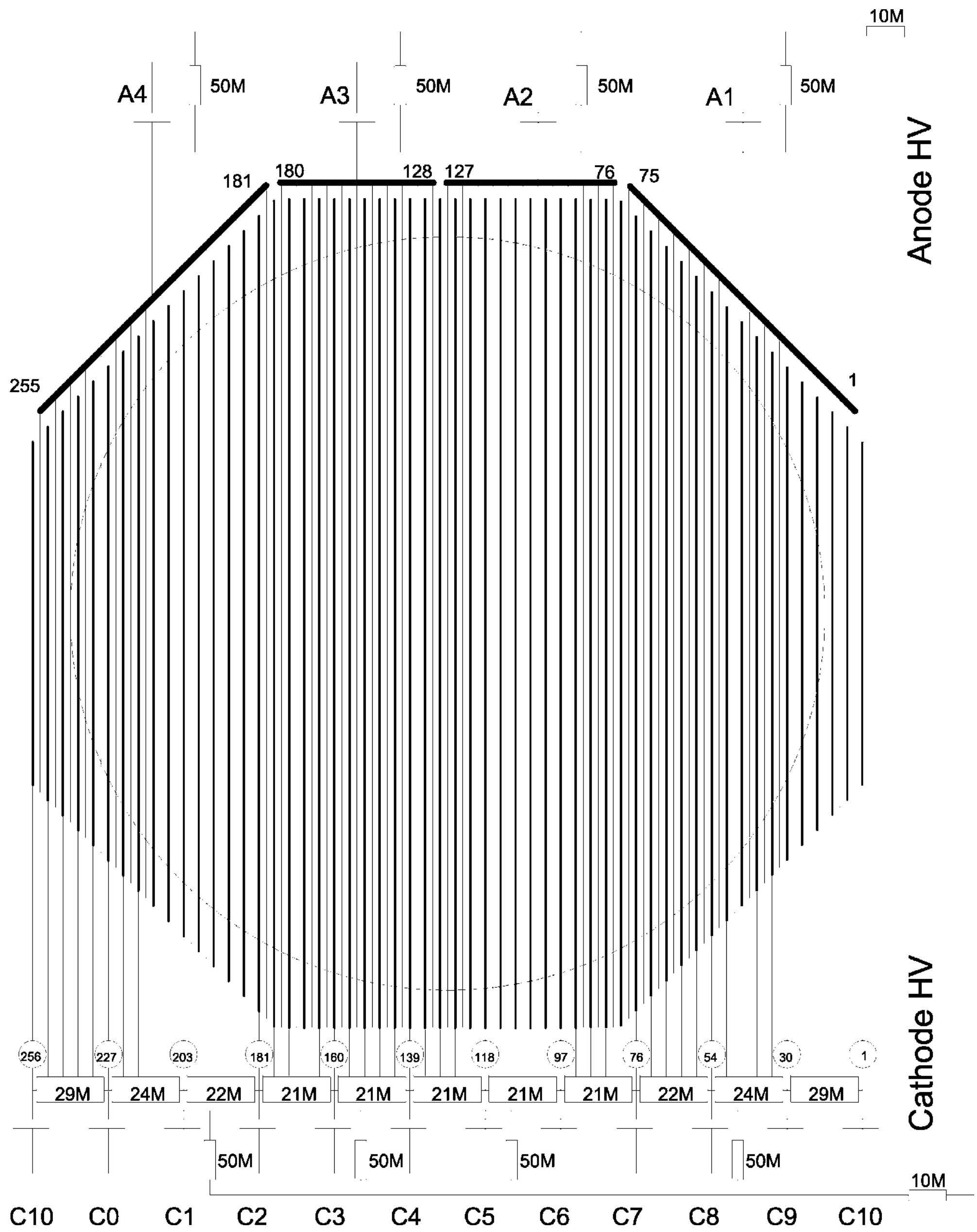


Figure 7 High voltage and amplifier connections on the microstrip plate. The strip pattern is not fully drawn. Cathode strip 1 and strip 256 are connected together. There are typically 22 cathode strips (and anode strips) between any two cathode amplifiers. A 1 MOhm resistor connects neighboring cathode strips.

1.3.2.1.6 Calibration Sources

The on board calibration system is composed of four collimated radioactive Cd^{109} sources with a nominal strength of 25 μCi (October 2002) and a decay halflife of 453 days. The sources are placed within four cells of the JEM-X collimator. The photons from the sources will a produce spot of 36 mm^2 in each of the four anode segments on the microstrip plate. The Cd^{109} sources are collimated using Au and Mo absorbers and are screwed into Al housings which are glued in their respective collimator cells. Each Cd^{109} source emits 22 and 88 keV photons and in addition they produce Ni fluorescence photons (7.5, 8.3 keV) from the source support Ni windows. The precise line energies and approximate count rates are as follows:

		X-ray energy	Expected count rate (October 2002)
Cd^{109} decay:		87.7 keV	(0.4)
	(Ag K_{beta})	25.0 keV	(2)
	(Ag K_{alpha})	22.1 keV	(10)
Ni fluorescense		7.5 keV	(- 0.4)
		8.3 keV	(- 0.04)

Note that two of the four calibration sources in the QMR instrument contain Fe^{55} sources emitting at 5.9 and 6.5 keV rather than the nominal Cd^{109} sources. The Fe^{55} sources are located above anode sections 4 and 2, (A4 and A2 indicated on Fig. 7).

The activity of the Fe^{55} sources are 45 microCi (October 2002), the half life is 2.7 years.

Note also that the rate of events collected from the calibration sources will be affected by the current transmission level of the "Grey Filter" mechanism, see section 4.1.8.5.

The calibration data are transmitted as part of the instrument housekeeping data. See note at end of section 3.7.7.13.

1.3.2.2 Coded Mask

The coded mask is a 0.5 mm thick tungsten plate. This thickness achieves the required opacities of 99.9% at 35 keV and 95% at 60 keV. The manufacturing technique chosen for the hole pattern is spark erosion using a wire electrode.

The height of the mask above the detector plane is about 3.4 m (see Table 1). A peripheral titanium ring provides pre-tension and structural support to the coded mask . The ring also acts as the mechanical interface with the INTEGRAL Payload Module, by means of 12 equally spaced bolts.

The diameter of the mask coded area is 535 mm. The mask elements are hexagonal, and their size is 3.3 mm center-to-center.

The combination of the mask height and the mask element dimension means that the angular resolution of the instrument is 3.35 arcmin.

In order to withstand a 12 g axial and a 12 g lateral acceleration, and to have a fundamental resonant frequency above 60 Hz (axial) and 120 Hz (lateral), a reinforcement structure in titanium is used to support the mask. The reinforcement structure (exo-skeleton) has three internal rings connected by radial ribs. The loss of transparency due to the exo-skeleton is less than 2 % and the additional mass is about 1.7 kg.

Figure 8 is an illustration of the JEM-X coded mask pattern layout (mechanical interface not shown). The order of the basic pattern is 22501 (see section 1.3.1). The number of open cells in the mask is 5844.

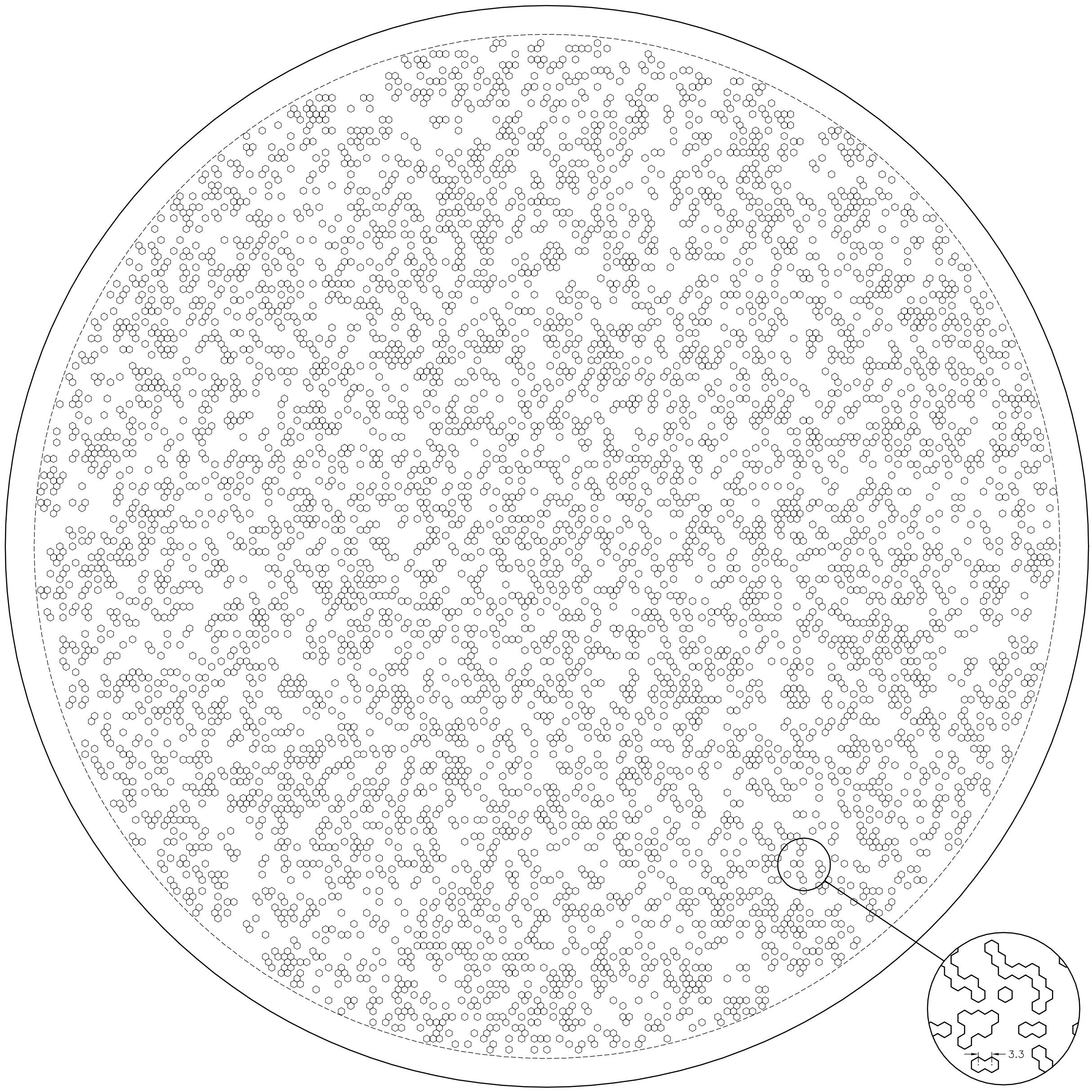


Figure 8 The JEM-X Coded Mask pattern

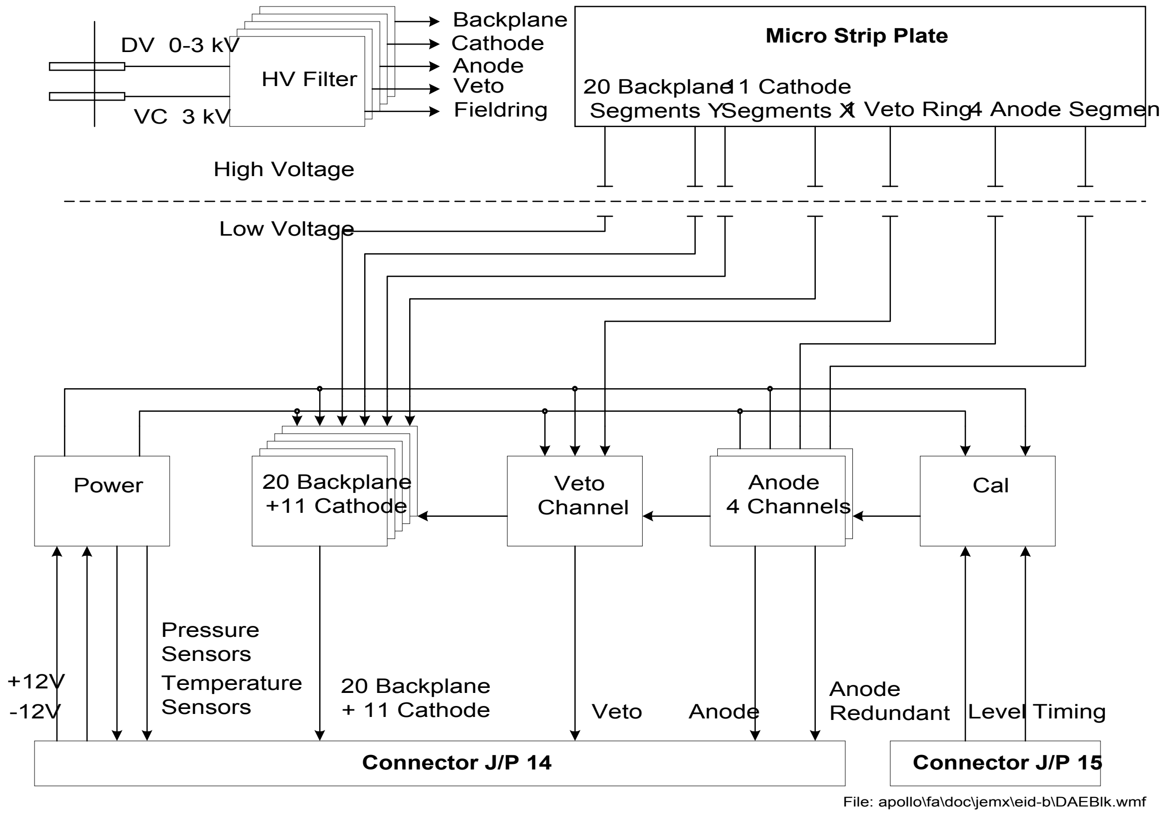


Figure 9 Detector Analog Electronics (DAE)

1.3.2.3 Electronics

The instrument contains the following two major electronic subsystems: Detector Analog Electronics (DAE), located in the detector box, and Digital Front End Electronics (DFEE), situated in the electronics box.

1.3.2.3.1 Detector Analog electronics (DAE)

See the block scheme in Figure 8.

The function of the DAE is to:

a) Distribute the high voltages to the micro-strip sensor plate and field rings,
b) Monitor the temperature and the pressure of the detector.
c) To extract the detector signals for subsequent handling in DFEE,
d) Perform electronic calibration using a special in-build calibration pulse generator

The DAE can be divided into the following sub units:

1) High voltage boards for decoupling of the drift and gas gain voltages (Vc & dV),
2) Temperature and pressure sensors.
3) Preamplifiers for the anode and veto electrodes (4+1)
4) Preamplifiers for the cathode and backplane electrodes (11+20)
5) Electronic calibration circuit delivering signals to the inputs of all 36 preamplifiers

The preamplifiers are classical charge sensitive preamplifiers (Amptek). Prefiltering and buffering will assure reliable signal transfer to the DFEE.

1.3.2.3.2 Digital Front End Electronics (DFEE)

The block scheme is shown in Figure 10:

The function of the DFEE is to:

1) Generate main event trigger, based on the anode (Energy) signal,
2) Amplify, filter and peak detect the detector signals,
3) Digitize the signals
4) Validate the events (for background rejection),
5) Calculate position and energy of valid events,
6) Communicate with the DPE,
7) Generate and control the high voltages Vc & dV.
8) Adjust the discriminator level for the main event trigger,
9) Convert the primary 27V to the instrument voltages and distribute them,
10) Perform housekeeping monitoring of voltages, currents and temperature,

The DFEE can be divided into the following subunits:

1) Anode HF and LF filter amplifiers and peak detectors,
2) Anode discriminator,
3) Cathode and rear side filter amplifiers, peak detectors,
4) Fast 12 bit ADC reading all 34 peak detector channels,
5) 16 bit MA31750 processor controlling the high speed instrument bus,
6) Interrupt controller ,Watchdog, Memory (RAM and PROM),
7) Serial RS 422 interfaces to the DPE,
8) Housekeeping (Voltages,Temperatures,Pressures) and instrument control (high voltages settings, electronic calibration control, discriminator level),
9) Low Voltage converters,
10) High Voltage converter,

The MA31750 processor controls the reading of the analog bus and communicates with all functional units via the instrument bus. Nominally the JEM-X processor will run at a clock frequency of 16 MHz and with 0 waitstates for memory accesses, however it can be commanded to run at 8 MHz, and/or to use 1 waitstate. It performs all event validation based on position signal consistency, anode energy and signal risetime acceptance criteria.

A hard-wired ratemeter circuit monitors the trigger rate of the anode signals. The circuit will switch off the high voltages in case of very high rates. The high voltages can be switched on again by command from the ground. This ratemeter operates independently of the processor, i.e. it is functional even if the processor is stalled.

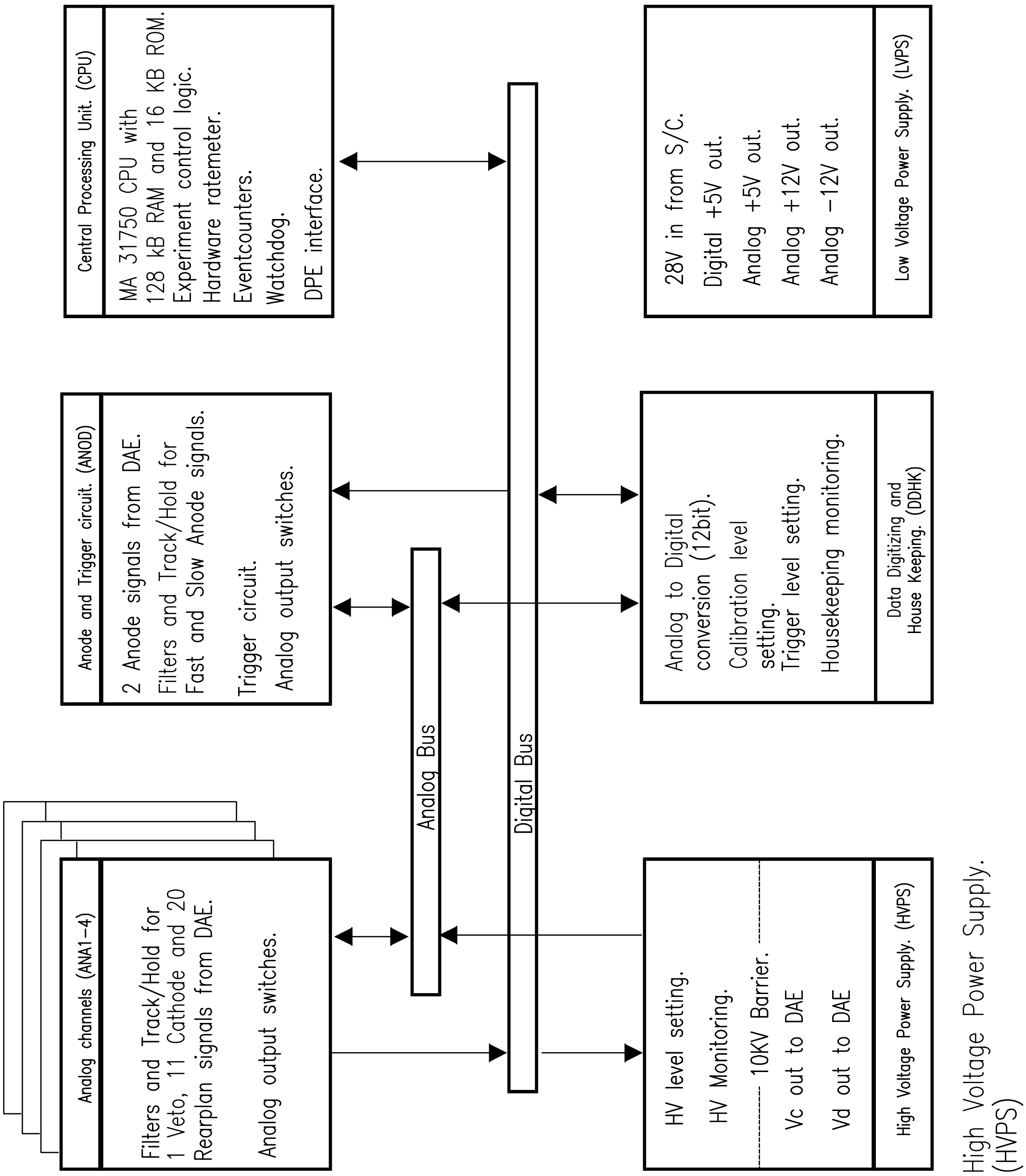


Figure 10 The Digital Front End Electronics (DFEE)

1.3.3 Software description

The JEM-X on-board software is described in section 3.7. It is distributed between the DFEE and the DPE processors.

The DFEE processor interfaces to the detector electronics and via the high speed and low speed serial lines to the DPE. The software in the DFEE processor performs the following tasks:

- Detector read-out control
- Single event evaluation
- Background rejection
- Event buffering and transmission to DPE
- Hardware parameter control.

The DPE interfaces to the DFEE processor and to the S/C OBDH. Part of the DPE software (the Common Services software, CSSW) is supplied by the INTEGRAL project. Another part, the Instrument Aplication software (IASW) is supplied by the PI-team. The IASW performs the following tasks:

- Data reception from the front-end processor and buffering of the events
- Data compression and TM-format build-up
- Housekeeping data acquisition
- Telemetry and Telecommand communication.

The on-board software will be developed according to ESA PSS-05-0. The DPE software is written in ADA and the DFEE software is written in assembler to achieve the required execution speed.

1.4 Instrument operations

The two JEM-X instrument units are operated independently. The following is a description for a single unit. Housekeeping packets are generated in all states where the DPE is ON. Science data will only be generated when the DFEE is on, however, a large data buffer exists in the DPE and therefore Science-TM packets may be generated for some time after the DFEE is switched off. Special Science TM-formats are used in the CALIBRATION and DIAGNOSTIC states.

Figure 10 illustrates the DPE and DFEE operational states as well as the type of commands that may cause a change between states - see also section 3.7.4.6.1.

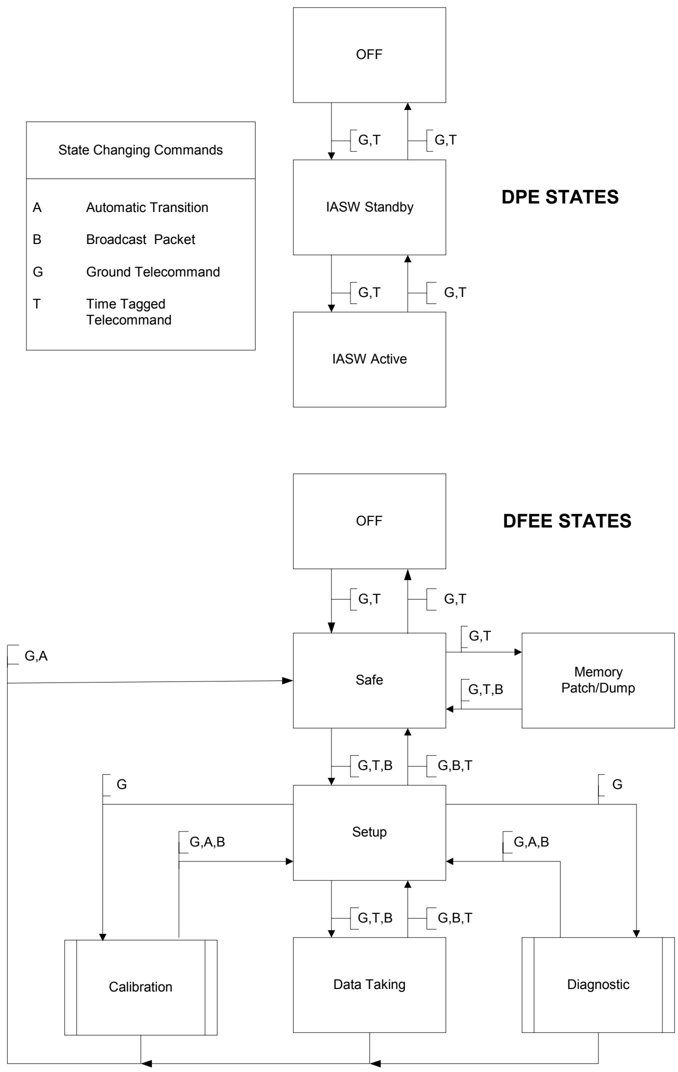


Figure 11: JEM-X State Diagram

2 COMPLIANCE OF INSTRUMENT DESIGN

2.1 Compliance with Spacecraft configuration

2.1.1 Accomodation constraint

In general the JEM-X accommodation constraints comply with the spacecraft baseline configuration, EID-A sec. 2.4.

The following points should be observed:

1. The field of view of each JEM-X unit must be free of obscuring objects. The field of view is a cone with a half opening angle of 6.6E. The apex of the cone is located on the instrument axis, 2257 mm below the mask mounting surface. (The opening of the cone is determined by the detector collimator, the diameter of the cone at the mask level is defined by the diameter of the coded mask).

2. The mounting of the JEM-X detectors must ensure that the operating in-orbit temperature stays within the limits given in section 3.3.1. Temperature change rates should not exceed 10EC per hour during operation.

3. The JEM-X detectors must be shielded against radiation from calibration sources located in other instruments.

2.1.2 FOV sensors/radiation

The zero response field of view of JEM-X is 13.2E (18.6E across the collimator diagonal).

The charged particle radiation, from the cosmic radiation and from the Sun, is the dominant source of background for JEM-X. About 1700 counts/s are expected from this source. The cosmic diffuse X-ray flux will add another 20 counts/s. To this must be added the flux from any X-ray source in the FOV.

2.1.3 Alignment requirements

Figure 12 shows the angles of importance in the alignment of JEM-X on INTEGRAL. The reference system $X_R Y_R Z_R$ is defined by the AOCS with the axis X_R / STR-LOS of the startracker. The optical axis or Instrument Line-of-Sight (ILS) of JEM-X is defined as the axis through the centers of the mask and the detector. The detector is equipped with a collimator with a direction (X_C) where the throughput has a maximum. Ideally these three axes should coincide. (X_C is not shown on Figure 11)

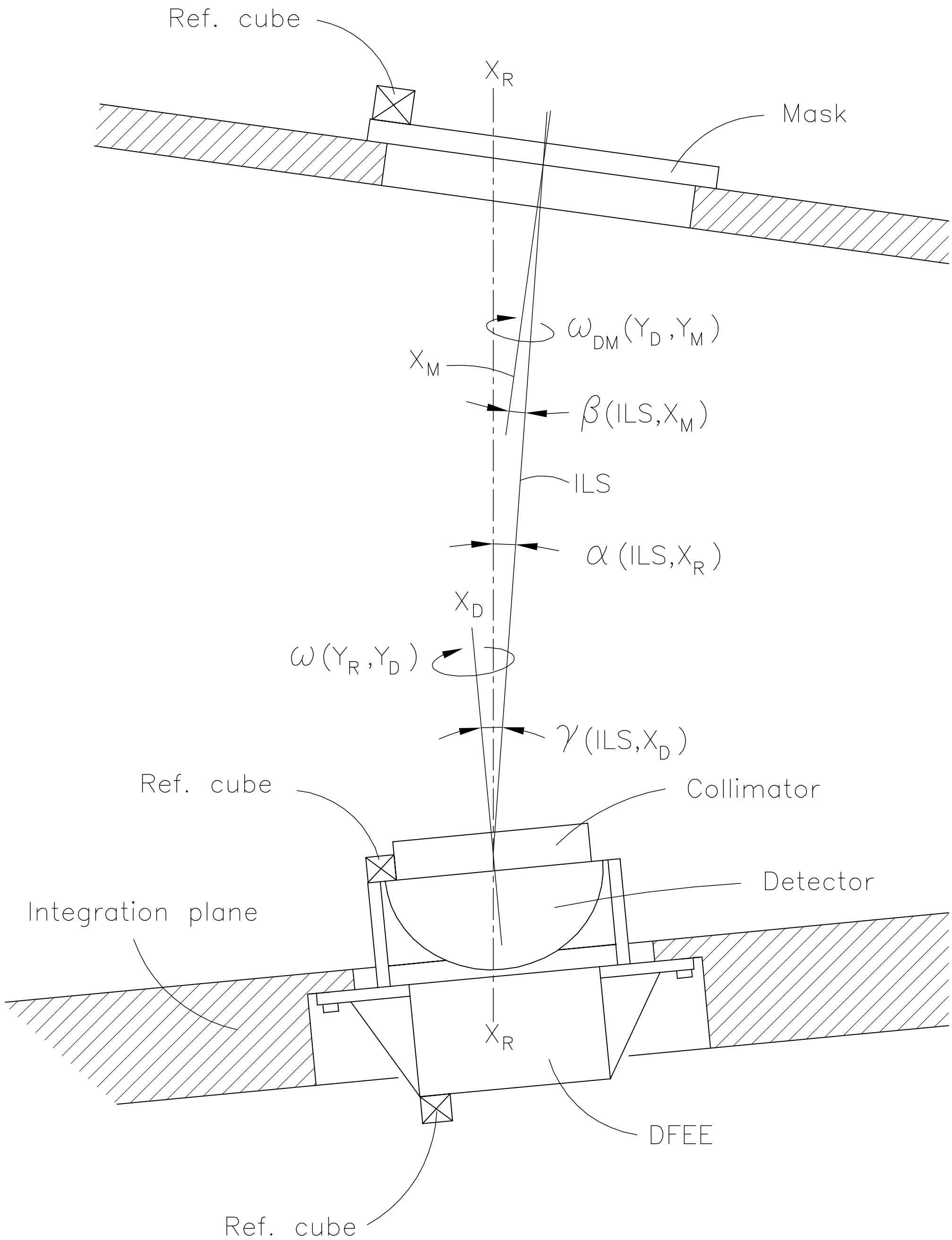


Figure 12 Definition of JEM-X alignment angles (The reference cube shown on the DFEE-box has been eliminated)

The coordinate system attached to the detector is $X_D Y_D Z_D$ and to the mask is $X_M Y_M Z_M$.

The requirements that follow apply for each of the two JEM-X units.

Here and in the following parts the tolerance with respect to the nominal setting is given as the angle itself whereas the measurement accuracy is given with a Δ in accordance with EID-A.

The alignment of the ILS and the X_R must ensure that the primary target remains within the Fully Illuminated Field-of-view during the 7-point dither pattern foreseen for observation of bright point sources. This requires that

$$\alpha(\text{ILS}, X_R) < 15 \text{ arcmin}$$

$$\Delta\alpha(\text{ILS}, X_R) < 1 \text{ arcmin (goal)}$$

$\Delta\alpha$ is directly related to the precision of the determination of a source position. In-flight calibration will give a better determination of α.

X_D, X_M, and ILS must be aligned to such a degree that the apparent shortening of pixels due to the projection effect is smaller than the error of the position determination in the detector. On the other hand the image reconstruction can take into account an apparent distortion of the mask hole shape.

The collimator transmission, T, as a function of the incoming direction with respect to the collimator axis, X_C, has a triangular shape. The JEM-X collimator system will be designed to have zero response at the same angle where the mask-detector combination have zero response. In order to make an X-ray flux determination to a precision of 1 %, the direction of the X_C must be known to a precision of 5 arcmin relative to the source direction. The direction of the X_C-axis relative to the detector axis X_D has been obtained from optical measurements i the laboratory..

There will be two optical reference cubes on the top of the detector and one on top of the mask as indicated on Figure 12 and on the ICD. The angle between X_D and ILS is $\gamma(\text{ILS},X_D)$, the angle between X_M and ILS is $\beta(\text{ILS},X_M)$, and the condition mentioned above leads to

$$\gamma(\text{ILS},X_D) < 40 \text{ arcmin}$$

$$\Delta\gamma(\text{ILS},X_D) < 5 \text{ arcmin}$$

$$\beta(\text{ILS},X_M) < 75 \text{ arcmin}$$

$$\Delta\beta(\text{ILS},X_M) < 15 \text{ arcmin}$$

This ensures that for deviations in opposite directions, the projected position errors on the detector will be no larger than 0.5 mm and will be known to 0.1 mm. A change in $\gamma(\text{ILS},X_D)$ changes T, the collimator transmission coefficient, of a source at the nominal pointing direction. T should be known to a precision of 1% and, therefore, $\Delta\gamma(\text{ILS},X_D)$ must be less than 5 arcmin. $\gamma(\text{ILS},X_D)$ itself is limited to 40 arcmin to ensure that T is greater than 90% of its maximum for an on-axis source.

With regard to the rotational precision of the detector around the reference axis X_R a similar condition should be met

$$\omega(Y_R,Y_D) < 30 \text{ arcmin}$$

$$\Delta\omega(Y_R,Y_D) < 5 \text{ arcmin}$$

In addition, the rotation of the mask relative to the detector has influence not only on the source position determination but also on the source detection since an error in this angle will lead to erroneous assignment of photons to an allowed or forbidden region on the detector, when a particular point on the sky is analyzed.

Thus,

$$\omega_{DM}(Y_D,Y_M) < 30 \text{ arcmin}$$

$$\Delta\omega_{DM}(Y_D,Y_M) < 1 \text{ arcmin (goal)}$$

2.1.4 Max distance between units

N/A

2.1.5 Red tag items

2.1.5.1 Detector windows

The detector windows are mechanically protected with covers at delivery. The covers are marked as red tag items and can be removed after the installation in the spacecraft according to the installation procedure.

2.1.5.2 Coded mask

The coded mask will be mechanically protected with covers on both sides at delivery. The covers are marked as red tag items and can be removed after the installation in the spacecraft according to the installation procedure. The covers will be made to withstand the environmental conditions for ground operations stated under section 3.1.1 in the EID-A

2.2 Compliance with System Requirements

2.2.1 Environment

2.2.1.1 Ground operations

With respect to the environmental conditions under section 3.1 in EID-A: All electronic circuits in the DFEE’s will be made to meet the humidity conditions under 3.1.1.2.1 and 3.1.1.2.2 in EID-A, and no special action has to be taken.

No special mechanical environment precautions have to be taken for the detector units, since the environment stated under 3.1.1.1 in EID-A is less severe than the qualification ranges.

2.2.1.2 Launch Phase

The detector windows will be made to withstand the ascending static pressure during launch as stated under section 3.1.2.3 in EID-A.

The DFEE and the detector unit will be made to meet the frequency loads during launch.

The mask units will be made according to the stiffness and strength requirements shown in Table 4.2.2 and 4.2.3 in EID-A.

2.2.1.3 Orbit Phase

Both the DFEE and the interior electronic of the detectors will be made according to the recommendations with respect to radiation dose, proton flux and energetic particles under section 3.1.3.3 in EID-A.

The HV supplies must be allowed to outgas in space for a few days before they can be switched on. The final duration of the outgassing period will be decided after the thermal-vacuum testing of Flight Model 1. As a baseline 96 hours of delay must be assumed.

2.2.2 Attitude control

The specification of the INTEGRAL Attitude Control system given in EID-A Section 3.2 fulfills the JEM-X requirements.

2.2.3 Flight operations

This chapter follows the outline in EID-A, section **3.5.5**. The instrument configurations, however, are discussed in section **1.4.**

JEM-X Instrument mode in the different mission phases.

Mission Phase:	**JEM-X Mode:**
Launch	OFF
Early orbit phase	OFF
Commissioning	Any mode
Eclipse	DFEE OFF
Radiation Belt	DFEE SAFE
Operations	Any mode

Contingency

The basic contingency action will be to switch-off the high voltage i.e. go to SAFE mode. A contingency can be initiated from the spacecraft or from the count rate monitor.

2.2.4 Fault tolerance

JEM-X consist of two independent, identical instruments. In each of these instruments possibilities for single point failure of the instrument function do exist.

All interfaces to the spacecraft will be designed such that failure cannot propagate to the spacecraft or to other instruments.

The dual instrument design concept ensures that 50% throughput is maintained even in case of catastrophic failure of one of the units. In terms of the scientific value of the data, we estimate that 75% of the results can be obtained using only one instrument.

2.3 Compliance with PA requirements

2.3.1 Materials and Processes

2.3.1.1 Selection and Evaluation of Materials and Mechanical Parts

Materials will be selected according to ESA requirements PSS-01-70, PSS-01-700, and PSS-01-701.

No materials or mechanical parts of JEM-X have been identified which do not comply with the INTEGRAL PA requirements.

2.3.1.2 Selection and Evaluation of Processes

No processes have been identified which do not comply with the INTEGRAL PA requirements.

2.3.2 EEE Parts

2.3.2.1 General

ESA PSS-01-60 will be used for the definition of components requirements for JEM-X EEE parts. It will be applicable for all EEE parts for the FM and FS and for all parts coming in direct contact with FM and FS units, such as test cables.

2.3.2.2 Procurement

The procurement activities will be an integral part of the design work and will be coordinated within the JEM-X PI and Co-I institutes by named persons. The coordination with ESA will be by the DSRI contact person.

2.3.3 Cleanliness

Cleanliness will be enforced according to ESA PSS-01-20 Issue 1.
The assembled JEM-X system will, at most, require cleanliness levels of clas 100000.
(ISO x4644-1, class 8)

2.3.4 Reliability and Safety

Each JEM-X detector will have 4 radioactive calibration sources built into the collimator. The sources are shielded so they only irradiate the detector volume. There are therefore no particular safety precautions to be taken. The calibration system is described in section 1.3.1.2.

The detector vessel with an internal pressure of 1.5 Bar is not classified as a pressure vessel in the sense of the EID-A section 5.4.4.5.1.

2.4. Compliance with Development and Verification Requirements

2.4.1 General

The Coded Mask model philosophy is defined in IN-JX-UV-PLN-0002. The main features are given below. The Detector/DFEE unit model philosophy is described below.

2.4.2 Math Model Definition

2.4.2.1 Structural Math Model

The design of the Detector unit and the mask has been based on and followed by several multi nodal FEMs.

For the Detector see document: JMX-TRA-QM01-SA-002 issue1/0 issued by Ideal Engineering, Finland.

For the Coded Mask see document: IN-JX-SR-NOT-002 made by SENER, Spain, included (on paper only) in the JEM-X CDR package.

Section 5.3.1.5 of the EID-A is not applicable, since there are no mechanisms in JEM-X.

2.4.2.2 Thermal Math Model

A simplified TMM for JEM-X QM/FM Detector/DFEE is given in section 3.3.5.

2.4.3 Instrument Model Definition

Development Models (DM) of the different subunits of JEM-X has been made to verify function, manufacturing processes and mechanical properties of these subunits. The DMs are not deliverable units.

The following deviations from the EID-A model requirements are identified:
- Only one JEM-X model was provided to support the INTEGRAL EM programme.
  The detector EM was used for this purpose.
  This model is equipped with a collimator dummy.
- No Engineering Model of the Coded Mask was prepared.
- The Coded Mask STM1 is the refurbished QM.
- The Coded Mask STM2 is a dummy unit (Steel Plate).
- A Spare Model of the Coded Mask will be manufactured only if need be.
  It will be done with a short turn around time.
- Both STM1 and STM2 collimators are mock-ups.

2.4.3.1 Structural Thermal Models (STM)

Both STM's are deliverable units.

2.4.3.1.1 Detector Units

Based on the results of the pressure test carried out on a development model detector vessel it was found necessary to redesign the mainframe of the detector and the detector support structure. This redesign took place after the STM test campaign was completed. The redesign have lead to an increase of the detector mass, but have not changed the power dissipation inside the detector vessel. As a result of the thermal tests at system level the thermal properties of the vessel have been modified to increase the emissivity of the mainframe towards the payload module.

Other remarks to the Detector Unit STMs:

-There are no mechanisms or pyrotechnical devices in JEM-X,
- Both Detector Unit STMs have been tested according to EID-C 1.3.4.3.

2.4.3.1.2 Coded Mask

One structural thermal / qualification model (STM/QM) has been manufactured and qualified in Spain before delivery to ESA as the first STM. It was built and tested according to EID-C 1.3.4.3 and is mechanically and thermally fully representative of the flight design and was built using flight standard materials, parts and components.

The second structural thermal model (STM2) is a dummy unit representative in terms of mass and mechanical I/F. It is a bolted steel plate. It has been tested according to EID-C 1.3.4.3

The deviation of STM2 from the EID-A requirements has been coordinated with ESA.

2.4.3.2 Engineering Model (EM)

The JEM-X EM has been used in the INTEGRAL EM program. One unit has been delivered.

2.4.3.2.1 Detector and Electronics unit (DAE/DFEE assembly)

This assembly is not flight standard.

2.4.3.2.2 Coded Mask

There has been no engineering model of the coded mask. This deviation from the EID-A requirements has been coordinated with ESA.

2.4.3.3 Qualification Model (QM)

The QM is not a deliverable unit. One complete model was manufactured and tested according to EID-C 1.3.4.2. The build standard was flight standard for the mechanical parts and a mixture of Hi-Rel and Commercial EEE components.

Due to contamination of the QM-detector it was found to be noisy. Therefore the thermal balance and thermal vacuum testing of this model was only partially successful and the EMC test programme was not carried out.

The QM is being refurbished as the Flight Spare model.

2.4.3.4 Flight Models (FM)

Both FM's are deliverable units. FM1 have been tested to protoflight levels. FM2 and FS will be tested to flight levels.

2.4.3.4.1 Detector Units

Two complete flight models will be manufactured, tested and delivered. They will both be to full flight standard and will be tested according to EID-C 1.3.4.5. FM1 have been tested to protoflight levels.

2.4.3.4.2 Coded Mask

Two complete flight models have been manufactured, tested and delivered. They are both to full flight standard and has been tested to protoflight levels.

2.4.3.5 Spare Model (FS)

2.4.3.5.1 Detector and DFEE Units

The QM-detector will be refurbished with flight standard EEE parts and tested to FM levels. The Spare DFEE electronics will use the QM-mechanical structure (flight standard, including the motherboard) and a complete set of flight standard PCB’s.

2.4.3.5.2 Coded Mask

No complete flight spare is foreseen. A spare code plate has been completed, and if necessary, a replacement flight model mask can be delivered at short notice.

2.4.3.6 EGSE system

Three complete EGSE units have been build to support the instrument development and tests.

2.4.4 Model Summary

The JEM-X models are summarized in the following table:

Coded Mask	DM	STM1	STM2	EM	QM	FM1	FM2	FS
Coded Mask UV	Repre- sentative samples	QM refurbis- hed	Dummy (Steel plate)	N/A	Flight represen- tative	FM	FM	Not foreseen but will be made in time if ne-cessary

Detector	DM	STM1	STM2	EM	QM	FM1	FM2	FS *)
Collimator UoF	Dummy	STM	STM	EM	QM	FM	FM	FM
Window Metorex	DM	STM	STM	QM	QM	FM	FM	FM
Detector vessel Metorex	DM	STM	STM	EM	QM	FM	FM	FM/QM refurb.
Microstrip Metorex	DM	Dummy	Dummy	QM	QM	FM	FM	FM
DAE DSRI	DM	Dummy	Dummy	EM/QM	QM	FM	FM	FM
Detector Internal Structure Metorex	DM	STM	STM	QM	QM	FM	FM	FM/QM refurb.
Detector connectors Metorex	DM	STM/ Dummy	STM/ Dummy	QM	QM	FM	FM	FM
DFEE Electronics DSRI	DM	Dummy	Dummy	QM/Com	QM/Com	FM	FM	FM
DFEE HVPS IAS	DM	Dummy	Dummy	QM	QM	FM	FM	QM refurb.
DFEE box DSRI	DM	STM	STM	N/A	QM	FM	FM	FM/QM refurb.
DFEE connectors DSRI	DM	STM/ Dummy	STM/ Dummy	QM	QM	FM	FM	FM
DFEE S/W DSRI	DM	no	no	EM	QM	FM	FM	FM
DPE H/W ESA	no	no	no	QM	QM	FM	FM	FM
DPE S/W ESA/DSRI/SRC	DM	no	no	EM	QM	FM	FM	FM
EGSE & EGSE S/W SRC	no	no	no	QM	QM	QM	QM	QM

*) Detector FS fully verified & calibrated, DFEE spare boards + refurbished box.
DM: Development or Breadboard Model, also named Laboratory Model.
QM: Qualification Model, build standard: Flight
QM/Com: Qualification Model, build standard: Flight, but using flight like parts to some extend
STM: Structural Thermal Model, build standard sufficient to support STM program
FM: Build standard: Flight.

2.5 Compliance with resources

2.5.1 Mass Budget

This paragraph provides the detailed mass breakdown for the sub-units. All weights are in kg.

Mass budget for one unit of JEM-X			
Measured FM1 mass data, August 2001			
H/W Item	Measured weights, FM components [kg]		
1. DETECTOR	17.88		
1.1 Main-frame-assembly		8.43	
1.1.1 Main-frame			5.85
1.1.2 Window			0.22
1.1.3 Internal structure			0.21
1.1.4 Sensor package			1.90
1.1.5 HV parts			0.25
1.2 Cover		2.81	
1.3 External parts		1.94	
1.4 Collimator and calibration sources		4.50	
1.5 Gas		0.20	
2. DFEE BOX	8.92		
2.1 Electronic boards		2.10	
2.2 HV-Supply		1.34	
2.3 Mother board		0.70	
2.4 Box structure		4.78	
3. CODED MASK	5.85		
3.1 Coded plate		1.80	
3.2 Mounting ring		1.33	
3.3 Re-enforcing structure		1.37	
3.4 Pretension Plates		0.92	
3.5 Misc.		0.43	
4. DFEE/DAE HARNESS AND BOLTS	0.76		
Total	33.41		
Margin (unused)	0.59		
Total for one unit of JEM-X	**34.00**		

Table 2 Mass Budget for JEM-X, one unit

The table includes only the unit internal harness. It is assumed that the electrical interface between the JEM-X experiment and the satellite is located at the DFEE connectors.

2.5.2 Power Budget

See § 3.4.7 Power Budget.

2.5.3 Data rate TM, TC

JEM-X will use all allowed TM data rate. The expected maximum TC rate is 1 packet/sec.

JEM-X Experiment, both units			
Modes:	Off	Standby	Operation
Nominal TM data rate	0	0.25 pckt/s (HK only)	2.25 pckts/s

Table 3 The JEM-X TM rates

3 INTERFACE DEFINITION

This chapter relates to the Mechanical Interface Control Drawings (ICDs) for the separate units in the experiment. The name of the pdf-files of these drawings are:

JEMX-MASK: Mechanical ICD for the Coded Mask Interface.
(PDF file: j-mask-i.pdf on DSRI JEM-X FTP)

JEMX-DETECTOR: Mechanical ICD for the Detector/DFEE assembly.
(PDF file: j-det-i_d.pdf on DSRI JEM-X FTP)

(See 3.2.7 for Drawing Change Record Sheets).

The drawings can be found in A4 size in Appendix A.

For each of the major sub-units a specific unit number has been defined. The numbers are:

Unit numbers		
Number	Name	Number location
130000	JEM-X Experiment	N/A
130100	Detector/DFEE assembly	- on the DFEE connectors plate
131000	Detector unit	- on the main-frame
131100	Collimator unit	- on the edge of the wall on the support ring
131300	Mirror cubes	- on mirror cube bracket
132000	DFEE unit	- on the DFEE connectors plate
133000	Coded mask unit	- on the ring, 180 degrees from a corner cube

The numbers are implemented as defined in the section 4.2.13 ‘Equipment identification’ in EID-A.

3.1 Definition of coordinate system for instrument.

The unit coordinate systems is defined on the ICDs.

3.2 Mechanical interfaces

3.2.1 Definition of structural dimensioning load cases

Structural dimensioning load cases have been defined for the Coded Mask and for the Detector interior/exterior according to the stiffness and strength requirements stated under section 4.2.2 and 4.2.3 in EID-A, and the structural test requirements in section 5.4.4. These load cases have been the design drivers for the current design.

3.2.2 Mechanical description of the instrument

Each JEM-X experiment consists of two units. The Detector/DFEE unit and the Coded Mask unit.

The Detector/DFEE unit is defined as the assembly of the detector vessel with legs, the collimator, the DFEE box containing electronics and HV supplies and the unit interconnecting harness, and optical reference cubes.

The Coded Mask unit is defined as the tungsten plate containing the hexagonal mask coding, a surrounding titanium mounting ring with elastic pretension devices, and the optical reference cubes.

3.2.2.1 Detector

The detector, which is shown in Figure 3, consists of the following modules: detector vessel, collimator, X-ray window and MS-sensor package. The gas inside the detector is at 1.5 bar pressure.

3.2.2.1.1 Detector Vessel

The detector body is made of stainless steel and consists of two parts, the mainframe and the cover which are joint together by electron beam welding. There are no gaskets.

The mainframe has a conical shape with a circular flange in the middle for mounting the collimator. The gas filling tubes and vacuum tight signal connectors and high voltage feedthroughs are welded to this mainframe.

The cover is formed from 2 mm thick stainless steel plate. The shape of the cover is similar to a pressure vessel cap form minimizing the weight and maximizing the strength. The detector cover is shown in Figure 13.

The total volume of the gas in the detector is about 11 litre.

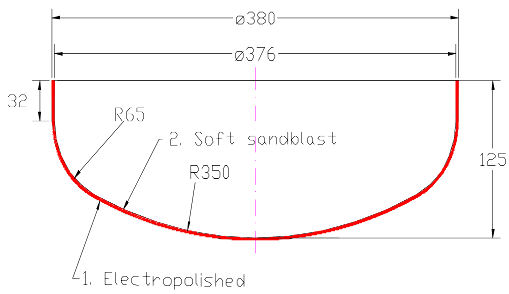


Figure 13 The Detector Cover

3.2.2.1.2 Detector window

The detector window is a 0.25 mm thick beryllium foil. The window is supported by the collimator structure against the internal operating pressure of bar. The window is glued to a stainless steel mounting ring which is welded to the detector main-frame.

3.2.2.1.3 Collimator

The collimator consists of an array of brazed lamellae forming an array of square tubes of molybdenum with a wall thickness of 0.45 mm, a center-to-center spacing of 7.05 mm and a cell height of 57.0 mm. The lamellae are covered on both sides with layers of copper and aluminum. The collimator weight is about 4.4 kg including the outer support ring which is also made of molybdenum. The collimator is mounted from top and down into the detector main-frame During transportation and storage the collimator will be covered with a protection cover.

The centre of the collimator top surface is indicated by a white cross.

The collimator is shown in Figure 14.

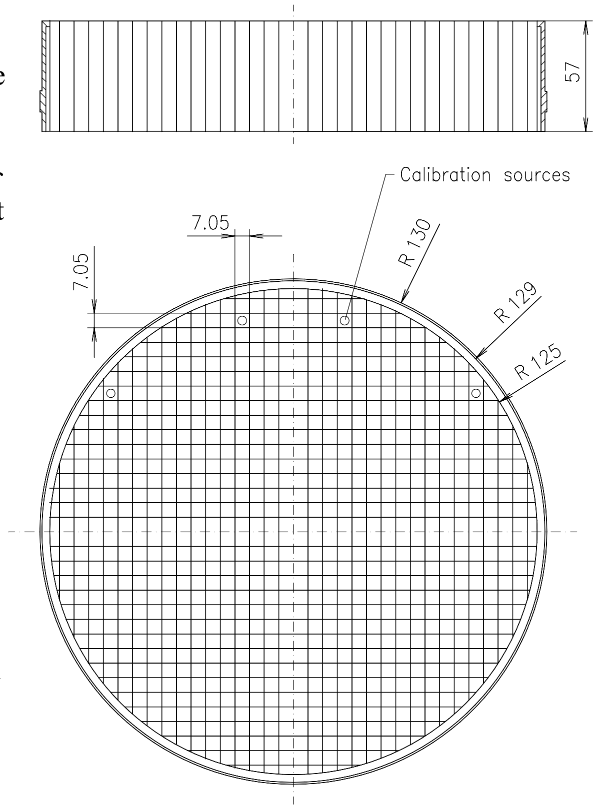


Figure 14 The Collimator layout

3.2.2.1.4 Calibration sources

There are four radioactive calibration sources in each JEM-X experiment. The sources ares mounted into four cells of the collimator and each illuminate a well defined spot on the microstrip plate. The sources are placed so that each illuminate one of the four anode sections in the detector. The sources are shielded so all radiation is kept within the detector volume. The source locations are indicated in figure 13.
The weight of the sources, including shielding is about 100 g.

3.2.2.2 DFEE box

The Detector Front End Electronics is located in a box just below the detector vessel. The box and its support brackets are machined from a single piece of aluminium. All electronics boards are mechanically clamped along three edges for optimizing the mechanical support and facilitating the heat conductance.
The Detector Front End Electronics occupies eight circuit boards, a mother-board and a HV supply. Four brackets on the DFEE box form the interface between the Detector/DFEE assembly and the PLM. The brackets transfer the loads during launch and they also provide heat conductance to the PLM.

The box is shown on the MICD in Appendix A.

3.2.2.3 Coded Mask

The coded mask is realized as a pre-stressed membrane mounted in a peripheral ring and supported by an exo-skeleton in order to have the required strength and stiffness during launch. The exo-skeleton will be made of titanium. The active diameter of the coded mask is 535 mm and the ring around it is 15 mm wide and approximately 70 mm high. Excluding the alignment cubes the envelope for one mask is: Ø565 with a height of 110 mm.

The code pattern is cut in a 0.5 mm thick tungsten plate. The hexagonal holes have a centre-to-centre separation of 3.3 mm. The interface drawing can be found in the MICD in Appendix A.

3.2.3 Mounting concept

JEM-X will arrive for integration as two identical sets each consisting of a Coded Mask unit and a Detector/DFEE unit.

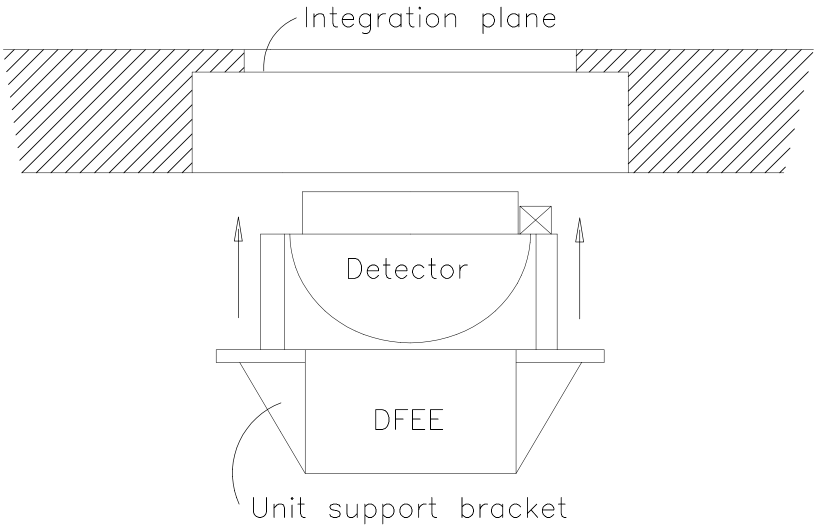


Figure 15 Mounting the JEM-X Detector/DFEE unit in the integration plane.

The Detector/DFEE unit will be mounted bottom up in its transportation box. When released from the box the unit can be lifted out, and mounted into the integration plane as shown in Figure 15. The installation procedure will be defined by DSRI and Metorex and coordinated with Alenia.

The position of the center of each detector is indicated by a white reference cross located on the central ribs on top of the collimator.

3.2.4 Mechanisms design

There are no mechanisms on JEM-X.

3.2.5 Alignment requirements/stability

See section 2.1.3 for alignment requirements.

3.2.6 Structural Math Model

A simplified SMM for the Detector/DFEE assembly can be found in document: 'Simplified SMM for the JEM-X-STM Detector/DFEE assembly' (IN-RP-JM-0001, v 1.0, 980609). This document describes a reduced nodal model in ANSYS of the STM Detector/DFEE assembly, and in greater terms it is valid for FM/QM also. The model can be converted and merged into the general S/C SMM.

For the Coded mask see documents from Univ. de Valencia: IN-JX-SR-RPT-002 (24/09/97) and IN-JX-SR-NOT-002 (02/06/97).

3.2.7 Mechanical ICD for the units.

The ICD for the JEM-X unit is shown in Appendix A. The Drawing Change Record Sheets for the drawings are given below.

DRAWING CHANGE RECORD SHEET			
DRAWING NUMBER: JEMX-MASK-n, where n is Issue No.		ORIGINATOR	
TITLE: Coded Mask Interface		Uni. de Val./DSRI	
ISSUE	DESCRIPTION OF CHANGE	AUTH.	DATE
A	Banner added for the appendix version.	DSRI	12.9.95
D	Strong-back system added. Envelope changed to Ø565, height: 110 mm, one unit. Corresponding JEM-X EID-B drawing number added.	Uni. de Val DSRI	17.02.96 18.02.96
E	No change		
F	Single-sided strong-back changed to double-sided exo-skeleton. A second ring has been introduced in the reinforcement structure in order to be able to support the acoustic and the sine spectrum environment during launch. Exo-skeleton rotated approx. 4 deg. around X axis. Coded Membrane Plate height changed from 58.0 to 60.0 mm	Uni. de Val.	12.01.97
G	Interface bolts changed to: M5.0, see location K11 - L11 on drawing	Uni. de Val	14.04.97
H	No change	Uni. de Val	05.11.97
I	In order to add more strength to the central area of the CM membrane the open area is reduced from 50% to 25% by closing some of the open pixels located in the central area and under the re-enforcement structure. A third ring is introduced in the re-enforcement structure. Optical cubes for alignment are added to the Masks. RTV 566 silicone used for re-enforcement structure bonding to coded membrane.	Uni. de Val. - SENER	08.06.98

Table 4 DCRS for JEMX-MASK-n.

Drawing Change Record Sheet for JEM-X QM and FM Detector Block			
Drawing Number: 130100-n, where n is Issue No.		Originator DSRI	
Issue	Description of Change	Auth.	Date
A	New MICD corresponding to new detector and DFEE box design.	DSRI	24-09-1999
B	Mass & COG updated. Moments of Inertia updated. Missing dimensions and tolerances added. Definitions of I/F flatness and roughness added. Erroneous indication of drawing number (130010) corrected to 130100.	DSRI	22-12-1999
C	COG position updated Mass updated Position tolerances for interface holes updated Power consumption updated Origo indication in X coordinate added Thermal properties text updated	DSRI	07-06-2001
D	COG position updated Mass updated Moments of Inertia updated Power consumption updated	DSRI	31-08-2001

Table 4a DCRS for JEM-X ICD 130100-n

3.3 Thermal interfaces

3.3.1 Definition of thermal requirements and design drivers

Qualification Test Thermal Conditions at Temperature Reference Points					
Unit	Ref. Point	Operational		Non-operational	
		Cold case	Hot case	Cold case	Hot case
Detector/DFEE	Conducting Sink PLM Baseplate	-30EC	+40EC	-45EC	+55EC
	Radiating Sink S/C internal shroud	-70EC	+25EC	-70EC	+55EC
	Radiating Sink PLM structure	-70EC	+25EC	-70EC	+55EC
Mask	Conducting Sink Mounting Ring	-55EC	+30EC	-55EC	+30EC

The instrument temperatures will be monitored by 13 thermal sensors accessible through the RTU and the instrument housekeeping data.

3.3.2 Instrument thermal design description

Each JEM-X instrument is composed of three major subsystems: the coded mask, the detector and the electronics box. Electrical power is dissipated within the detector and the electronics box. The coded mask is a passive device in which no power is dissipated.

The temperature of the coded mask is controlled passively: a thermal protection foil prevents the top side of the mask from radiating directly into free space, the lower side of the mask exchanges heat radiatively with the payload module.

Inside the detector vessel power is dissipated in the 16 electronics boards mounted underneath the microstrip sensor plate. The heat produced will primarily be conducted away to the heavy top plate of the detector, the "mainframe", via the electronics support structure. The conduction through the detector gas (1.5 bar of a Xenon/Methane mixture) will be negligible under zero gravity conditions. From the detector mainframe the heat will be radiated from the detector surface to the payload module sink or conducted to the payload module baseplate via the four detector legs. The detector legs do not interface directly to the PLM, but to the electronics box supports, in close proximity to the instrument mounting points on the PLM baseplate.

The heat produced in the electronics box will be conducted from the circuit boards to the box mechanical structure. The electronics boards are thermally connected on three sides to the box structure. The box and its supports is machined from a single block of aluminium, thus good heat conduction to the supports is assured. The thermal-mathematical model discussed below indicates that most of the heat will be radiated from the surface of the box to the spacecraft module cavity and a smaller fraction will be conducted to the payload module.

With this design there is no need for substitution heaters on JEM-X.

3.3.3 Temperature and Energy Budgets

The operating temperatures boundaries for the JEM-X detector and electronics are -35EC to +35EC. For the coded mask the operating temperature environment is -55EC to +30EC.

The power budget for the detector and the electronics box can be found in table 10 of section 3.3.5.3.

3.3.4 Thermal hardware.

There will be 9 thermistors and four temperature sensors in each JEM-X unit. All thermistors are YSI 44908. All thermal sensors are type AD590.

Thermal sensors in JEM-X					TM PREF	
Sensor De-signat.	Type	Location	Node	Comment	JEM-X1	JEM-X2
THA	YSI44908	LVPS PCB	(EB)	RTU HK	T5108	T5115
THB	YSI44908	Connector J06	EB	RTU HK	T5033	T5037
THC	YSI44908	Connector Board	EB	RTU HK	T5034	T5038
TH0	YSI44908	Connector J01	EB	JEM-X HK	K5113	L5113
TH1	YSI44908	CPU Board	(EB)	JEM-X HK	K5114	L5114
TH2	YSI44908	LVPS Cooling Bridge	(EB)	JEM-X HK	K5115	L5115
TH3	YSI44908	DDHK Board	(EB)	JEM-X HK	K5116	L5116
TH4	YSI44908	Motherboard at ANOD	EB	JEM-X HK	K5117	L5117
TH5	YSI44908	Motherboard at ANA2	EB	JEM-X HK	K5118	L5118
TH6	AD590	HVPS Board	(EB)	10mV/K, JEM-X HK	K5379	L5379
TH7	AD590	HVPS Board	(EB)	10mV/K, JEM-X HK	K5380	L5380
TH8	AD590	Detector PWR Board	DE	10mV/K, JEM-X HK	K5103	L5103
TH9	AD590	Detector PWR Board	DE	10mV/K, JEM-X HK	K5104	L5104

The node names in the table refer to the TMM described below. Names in parentheses are nodes inside the DFEE electronics box, close to power dissipating components.

The conical part of the top surface of the detector mainframe is covered by Sheldahl silver/FEP adhesive tape (5 mil FEP +vacuum deposited silver) to increase the thermal emission (g -0.75).

The coded mask is covered on the outside by a thermal protection foil provided by the INTEGRAL project.

The location of the thermistor locations in the DFEE box is shown in Figure Figure 16 below.

The thermal sensors in the detector vessel are located on internal spider structure, on the power board.

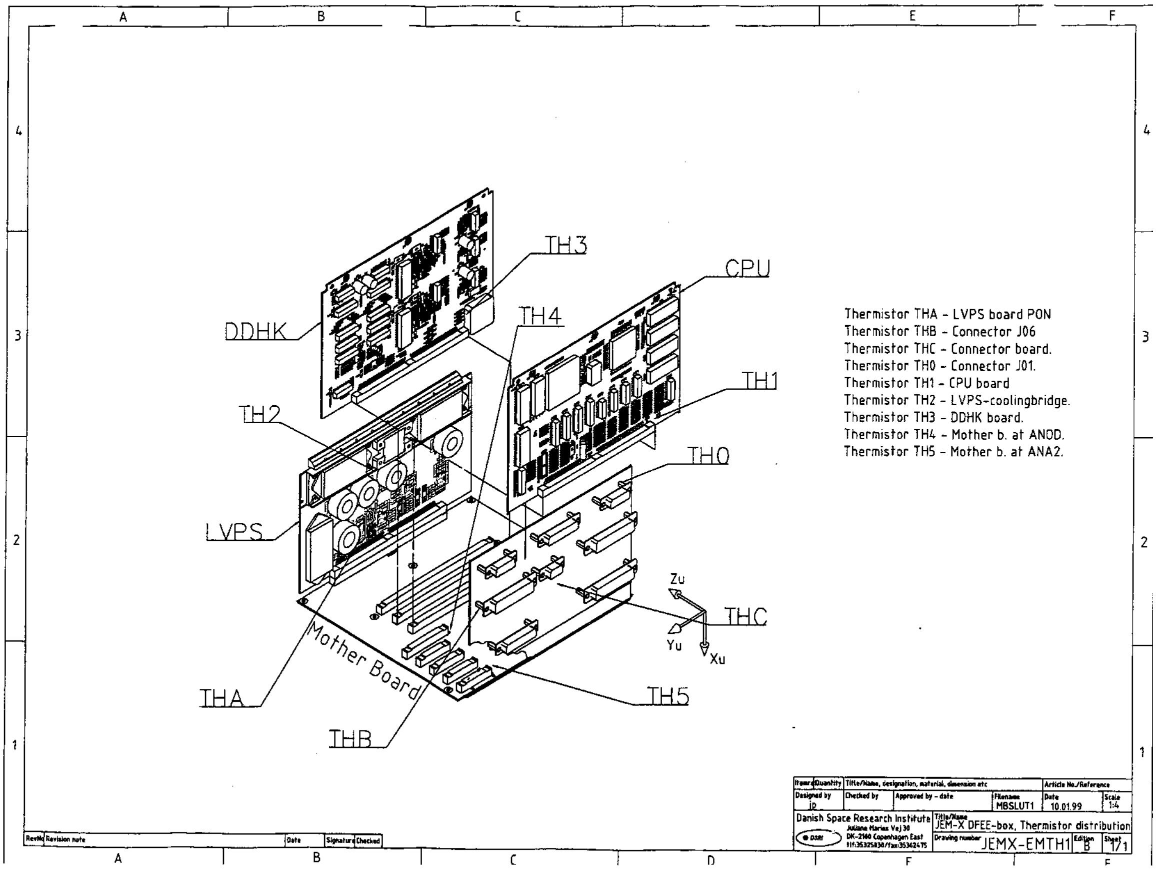


Figure 16 The DFEE motherboard and some circuitboards with the thermistor locations
Figure showing the location of 9 of the 11 thermosensors (THA, THB, THC and TH0-5) located inside the DFEE box. The last two sensors in this box, TH6 and TH7, are located in High Voltage Supply, which occupies the space next to the LVPS Board.

3.3.5 Thermal Mathematical Models

A thermal-mathematical model (TMM) has been defined for the detector/electronics box assembly. The model is defined as a condensed nodal sub-level input for a general TMM at satellite level.

For the thermal analysis of the coded mask see Univ. de Valencia documents: IN-JX-INT-NOT-001 (10/02/97).

3.3.5.1 Analysis requirements

The TMM for the Detector/DFEE can be input to the software ESARAD and ESATAN.

3.3.5.2 Modelling description and main assumptions

A simplified TMM model of the JEM-X detector/DFEE electronics box assembly is shown in Fig 16. It contains ten nodes that links to each other either via radiative areas (shown with coil symbols) or conductive areas (shown with spring symbols). The list of links is shown in **Table 5**

Node Acronym	Description	Radiative coupling with nodes	Conductive coupling with nodes
DE	Detector Electronics		VS
VS	Detector Vessel	S1	P1 to P4
P1	Support Structure 1		VS, EB, PM
P2	Support Structure 2		VS, EB, PM
P3	Support Structure 3		VS, EB, PM
P4	Support Structure 4		VS, EB, PM
PM	PLM Detector Bench		P1 to P4
EB	DFEE Electronics Box	S2	P1 to P4
S1	Payload Module Radiative Sink	VS	
S2	Spacecraft Module Radiative Sink	EB	

Table 5 JEM-X detector/electronics box node definition summary

The model makes use of the symmetry of JEM-X, only one node is defined at each level, except for the four support structures, which are modelled separately to maintain compatibility with the earlier JEM-X thermal models.

A heat capacity is assigned to each JEM-X node according to the specific material and mass. The sub-division is described below.

DE: The **Detector Electronics** node includes both the detector internal electronics and support structures, the field forming rings, the microstrip plate and the gas. Power is dissipated by the electronics and conducted via the internal supports to the vessel, **VS**. Conduction through the gas is insignificant under zero gravity conditions. The effect of the radiative transfer from the electronics to the vessel is included in the heat conduction term, the value of this term is determined from a test with the vessel evacuated, i.e. the effect of convective heat transfer was eliminated.

VS: The **Detector Vessel** consists of a massive steel ring, the mainframe, on which the collimator, the bottom cover and the detector legs are mounted. The radiative area of the structure towards the Payload Module Radiative Sink (node **S1**) is taken to be the top surface of the mainframe plus the collimator. The detector legs do not have their own node, the heat capacity of the legs have been allocated partly (50%) to the detector vessel node, and partly to the support structure nodes, **P1** to **P4**.

P1 to **P4:** The **Support Structures** are the four extensions of the electronics box which interfaces to the PLM detector bench and to the detector legs. The peripheral parts of the support structures connects to the satellite sink nodes, **PM**, and to the detector mainframe, **VS**, via the legs. The material is aluminium.

EB: The **DFEE Electronics Box** is an aluminium box housing the main electronics (the DFEE). Most of the electrical power is dissipated in this node. Heat is conducted to the support structure, **P1** to **P4**. The lower face and part of the sides of the electronics box radiates to the spacecraft module sink, **S2**. The side faces of the electronics box and the unit supports are machined from a single block of aluminium, thus the heat conductivity is optimized. The box is painted with Chemglaze Z306.

PM: The **PLM Detector Bench** is the conductive sink for JEM-X

S1: The **Payload Module Radiative Sink** is the sink for the topside of the detector vessel.

S2: The **Spacecraft Module Radiative Sink** is the sink for the lower face of the electronics box.

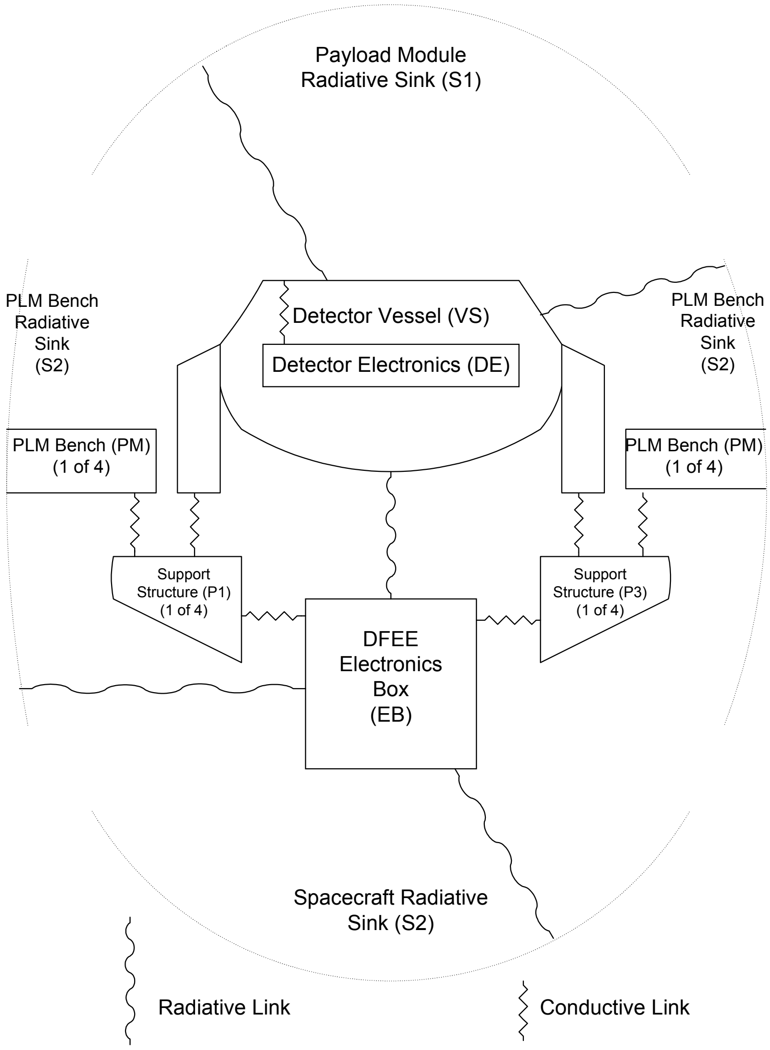


Figure 17 Simplified Thermal Model for JEM-X

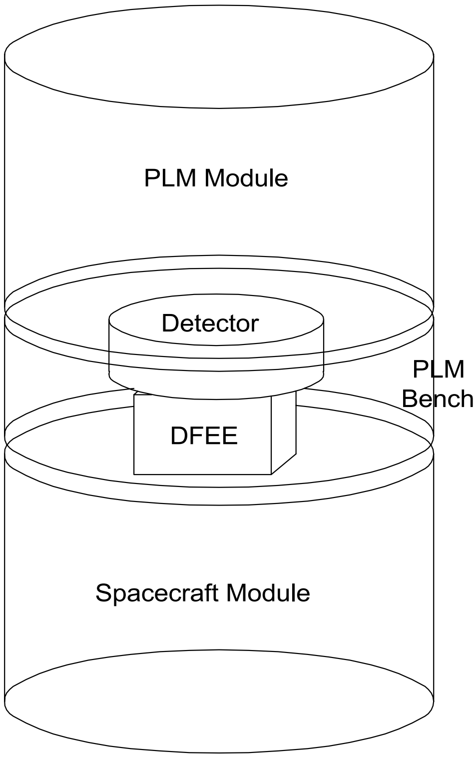


Figure 18 Radiation environment of JEM-X

The radiation environment of JEM-X is illustrated in the diagram shown here. The top surface of the detector facing the payload module has a high emissivity (g-0.85) whereas the sides and bottom facing the payload bench and the DFEE box is electropolished steel with (g-0.35). The DFEE box is painted with Chemglaze Z306 on all six faces.

3.3.5.3 Model file

The model is described in the tables below.

From node	To node	K[W/EK]
DE	VS	0.55
VS	P1 to P4	0.16 (each of 4)
P1 to P4	PM	0.5 (each of 4) (including contact resistance)
EB	P1 to P4	1.15 (each of 4)

Table 7. Detector and DFEE conductive coupling data

Node	Thermal capacity [J/EK]	Material
DE	1450	Xe-gas, Al51S, ceramics, glass electronics
VS	7000	AISI 316
P1 to P4	460 (each of 4)	Al 51S
EB	7300	Al 51S, glass fibre

Table 8. Detector/DFEE thermal capacities and materials

Node	Area [m^2]	g	Surface treatment
VS top (R = 19 cm)	0.11	0.70	Silver/FEP tape and collimator
VS side and bottom (R=19, H=12 cm)	0.26	0.35	Electropolished steel
EB (24×24×16 cm)	0.27	0.85	Chemglaze Z306
PM	N/A	0.80	CFRP (Both the detector side and bot-tom and the DFEE siades are as-sumed to view the PLM bench node)

Table 9. Detector/DFEE radiative coupling data

Node (acronym)	Power [W]
Detector electronics (DE)	5.8
DFEE electronics (EB)	24.1

Table 10. JEM-X power dissipation

3.4 Electrical power supply

3.4.1 Instrument power supply

The DC/DC power converter(s) will give galvanic insulation between primary power lines, secondary power lines and equipment structure (bonding stud) in accordance with EID-A 4.4.3.1 and 4.6.2.1.

Any persistent voltage on the main bus power line in the range between 16 V and 30 V, (including a short circuit of the power line), is harmless to the instrument.

The interfaces will be designed such that no instrument failure can propagate into spacecraft subsystem. Protection against failures in the harness connection between the PDU and the JEM-X power input is ensured by the current limitation circuitry in the PDU.

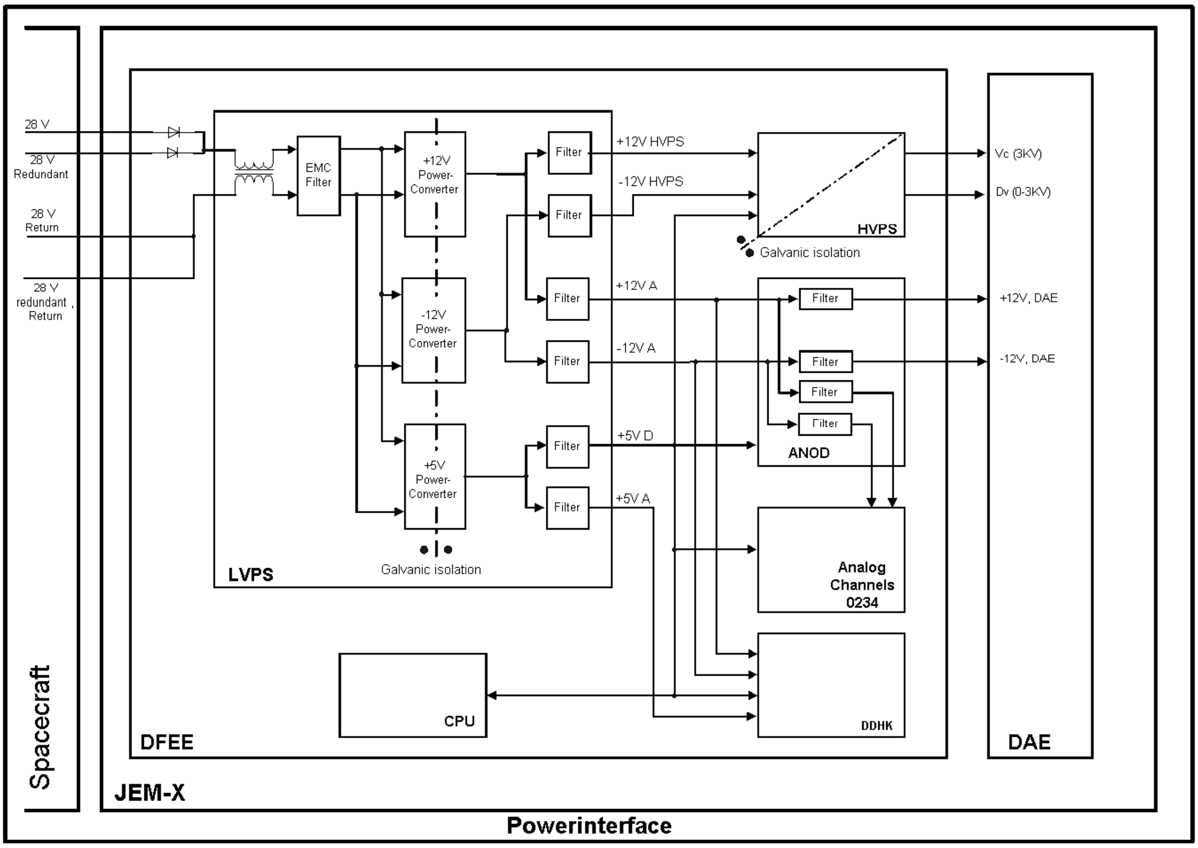


Figure 19 Power interface

3.4.2 Power supply block diagram

Figure 19 shows the power supply block diagram.

3.4.3 Required power lines

<u>3.4.3.1 Power bus lines for DFEE & DAE (PDU)</u>

+28 V. Redundant LCL connection.
GND. Redundant connection.

3.4.4 Pyrotechnic interfaces

There are no pyrotechnic devices in JEM-X.

3.4.5 Power profile

There are 3 power modes:

- Power Mode 1: DFEE OFF, HVC OFF
- Power Mode 2: DFEE ON, HVC OFF
- Power Mode 3: DFEE ON, HVC ON

Switching between Power Mode 1, Power Mode 2 and Power Mode 3 will give inrush current below the values given in EID-A, section 4.4.2.2.

After inrush, there will be only small fluctuations in power consumption in each of the functional, scientific modes.

3.4.5.1 Power requirement for each of two identical instruments

See table 11, Power budget.

3.4.6 Electrical ICD

The electrical ICD according to DRD44-1 is provided in EID-B Appendix B

3.4.6.1 Power connector J07 and J08

Power interface to the PDU is via 2 Cannon connectors Royal-D-9P:

- Signal names and pin connections in EID-B Appendix B.

3.4.7 Power Budget

The power budget for the main JEM-X subunits is given in table 11. This power budget is based on measurements on the FM1-model.

DFEE + DAE	CPU: 8 MHz	CPU: 16 MHz
	V=26.8V	V=26.8V
Current	A	A
Stand-By	1.028	1.059
Operation	1.086	1.117
Power	W	W
Stand-By	27.6	28.4
Operation	29.1	29.9
DAE		
Power	W	
All Modes	5.8	

Table 11. JEM-X Power Consumption

The maximum power consumption at beginning of life is 29.9 W per JEM-X unit. Adding a 3% degradation due to ageing we arrive at an expected power consumption at end-of-life of 30.8 W for one unit or 61.6 W for both units together.

3.5 EMC-Design

3.5.1 Instrument Design Concept

The experiment consists of two units:

1: A detector in a pressurized enclosure together with front end electronics DAE. This enclosure is described 1.3.2.1. The entire enclosure, including the beryllium window is electrically conducting.

2: The main electronics circuitry is contained in a box, which is milled from a solid aluminium block with an aluminium cover at the top and bottom. The high voltage supplies and the DC/DC converters are situated in this box.

Electrical connections between JEM-X and the satellite will be implemented in accordance with paragraph 4.5.2.3 (Electrical Interfaces) of the INTEGRAL EID-A.

Only one connection exists between instrument signal GND and structure GND. The most noise sensitive elements in the JEM-X instrument are the preamplifiers connected to the electrodes on the microstrip plate. The location of the connection between signal GND and structure GND are located inside the detector vessel in order to prevent capacitive pick up of noise signals from the vessel to the circuits inside.

3.5.2 Instrument Block Diagram

Figure 20 shows the instrument grounding scheme. An important feature in the grounding scheme is, that circuit GND is connected to structure in the DAE. This is necessary, because any noise voltage between the detector window and the micro-strip plate will be seen as a signal by the pre-amplifiers.

3.5.3 Susceptibility to EMC-Interference

JEM-X does not include items, that are susceptible to EMC-interference to a higher degree than what is normally expected for electronic circuits.

3.5.4 Possible High EMC-Emission

JEM-X will use switch-mode low voltage and high voltage power supplies.

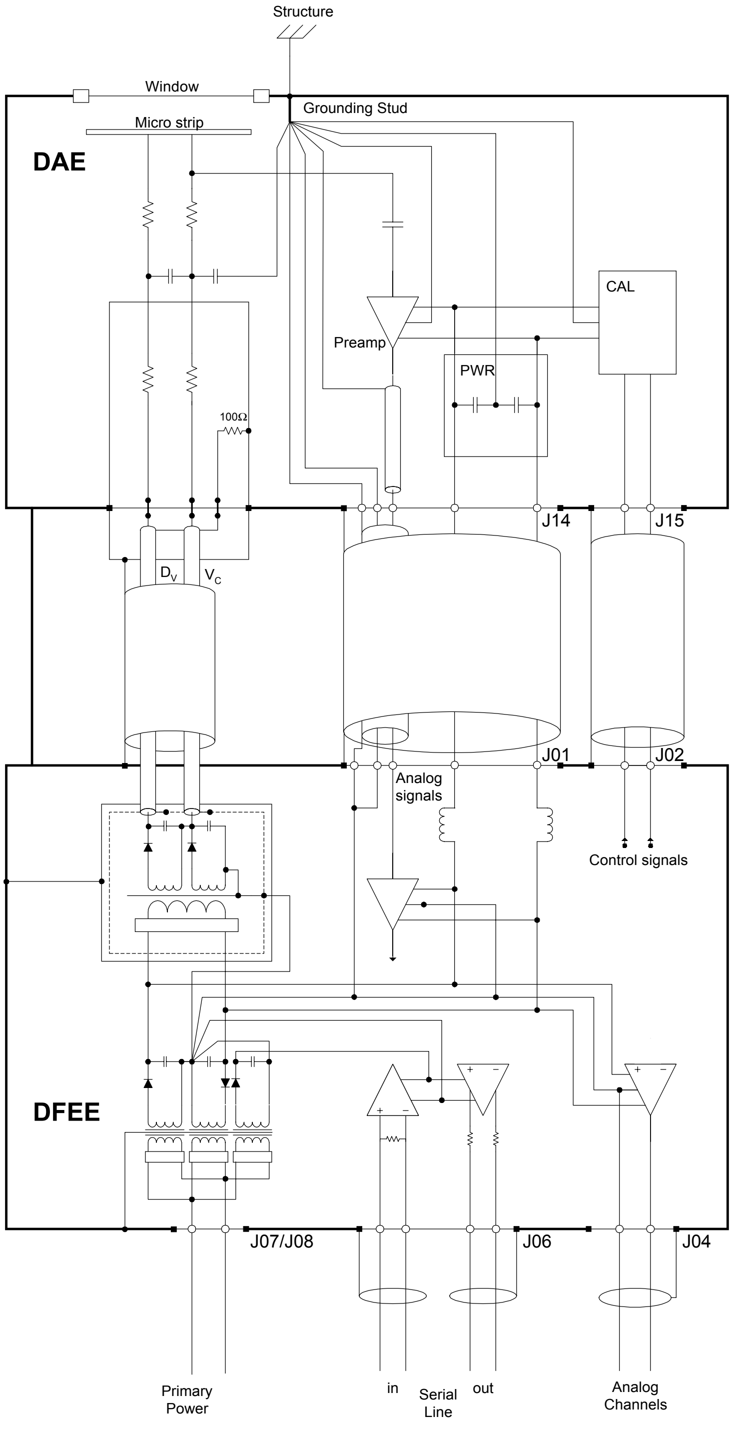


Figure 20 Instrument grounding scheme

3.6 Data handling interfaces.

3.6.1 Instrument data handling design definition.

The JEM-X on-board software will be distributed between the DFEE and the DPE processors. The DFEE processor will interface to the detector read out electronics on one side and to the DPE on the other. The software in the DFEE processor will perform the following tasks:

- Software initialization and code corrections according to instructions from the DPE (on power-up)
- Detector read-out control
- Single event evaluation
- Identification of X-ray events from the radioactive sources
- Background rejection
- Event statistics collection
- Event buffering and transmission to DPE
- DFEE HK collection and transmission to DPE
- Hardware parameter control.
- Transmission of Memory Dump data according to requests received from the DPE

The DPE will interface to the DFEE on the one side and to the OBDH on the other. The IASW software supplied by the PI-team will perform the following tasks:

- Data reception from the front-end processor (via High Speed and Low Speed link)
- Data compression and build-up of science TM-packet data fields, last 430 bytes,
  (very last two bytes used for CSSW generated CRC)
- Generation of On-Request TM-packet data fields according to TC requests, last 430 bytes,
  (very last two bytes used for CSSW generated CRC)
- Housekeeping data acquisition and build-up of HK-packet data fields, about 262 bytes,
  leaving room for DPE internal HK data and On-Event Reports (80 bytes)
- Telemetry transfer to CSSW
- Telecommand reception, decoding and execution/rejection
- Safe storage of instrument parameters (H/W and S/W) as well as code correction sequences

The development of the on-board software will comply with ESA PSS-05-0. The DPE software will be written in ADA, but for reasons of processing speed the DFEE software will be written in assembler.

The software will be placed in ROM and downloaded to RAM before execution. Code, fixed constants and variable parameters will be placed in distinct areas in memory. It will be possible to uplink corrections to the code from the ground prior to execution. For the DFEE software the code corrections are stored in the DPE and transferred to the DFEE as part of the DFEE software initialization process on power-up.

3.6.2 Internal timing concept.

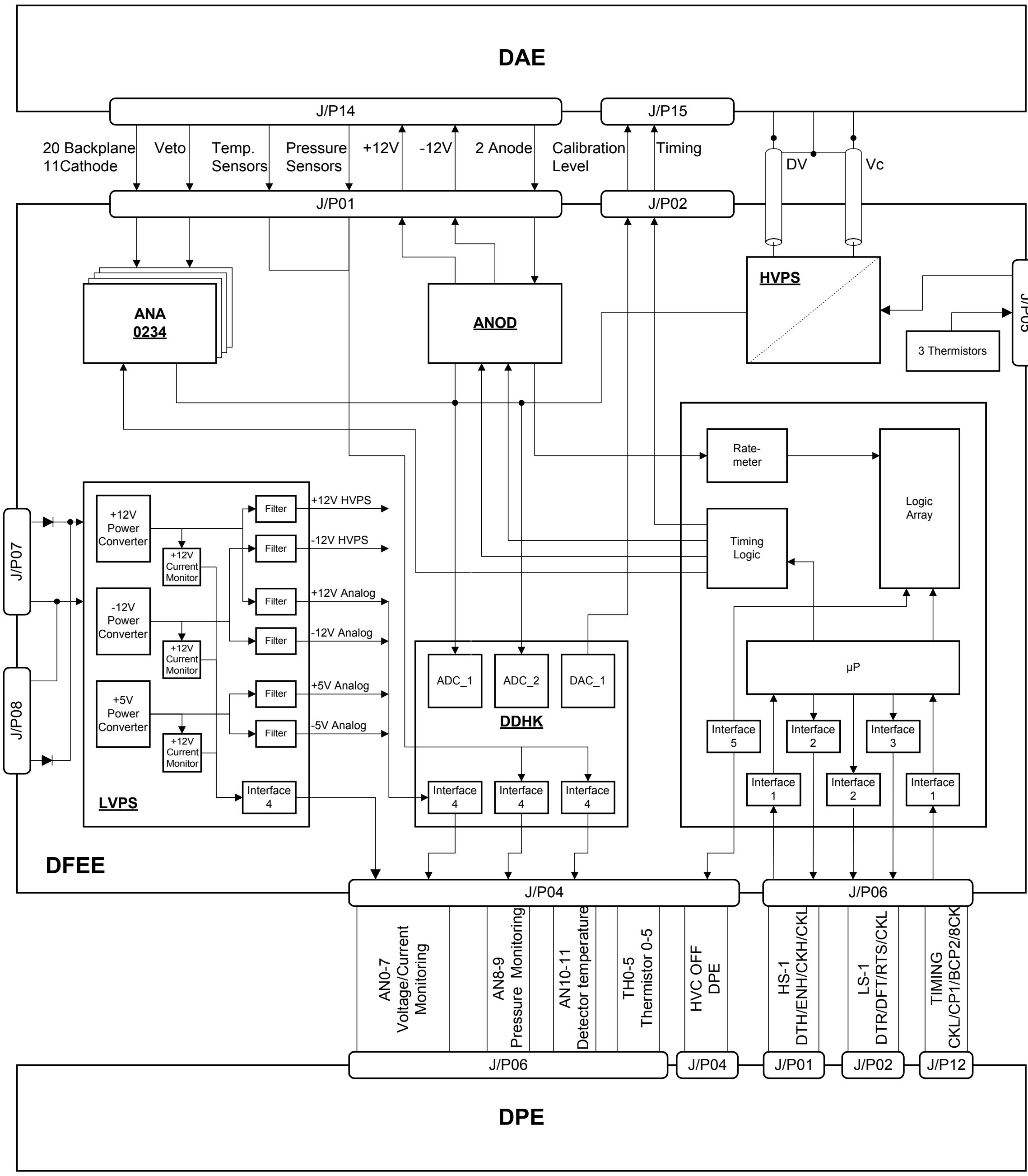
The DFEE will have an internal clock driven by a 8192 Hz signal derived from the 4.194304 MHz signal provided through the DPE. Thus the timing accuracy for the JEM-X is 122.07 microseconds. The DFEE clock will be reset every 8 seconds. The clock reset signal is derived from the BCP2 signal (1 Hz), which is stable with respect to the 4 MHz master signal. The BCP1 signal is used as a gate for the BCP2, limiting the reset frequency to 1/8 Hz.

The events transmitted from the DFEE to the DPE will be time stamped using two 16 bit words, one containing the reading of the DFEE clock (advancing every 122.07 microseconds) and another word counting the number of clock resets.

The DPE will read the “freeze register 1” in the Remote Bus Interface (RBI) every 8 s in synchronism with the clock reset operation in the DFEE. The DPE is therefore able to correlate the event time stamps from the DFEE to the OBT readings from the RBI. (See the IASW SSD version 1.18 section 1.25.5.3 for details).

Due to the existence of the “higher order time words” in the event timing, there will not be any 8 s ambiguity in the correlation between DFEE time and OBT.

3.6.3 Instrument level command diagram



3.6.4 Interfaces per instrument unit

3.6.4.1 DPE channels

1 discrete command line (DPE HVC OFF)
1 low speed serial line (TC)
1 high speed serial line (TM)
16 analogue lines (HK data)
6 thermistor lines (HK)
4 timing lines (4.194304 MHz, 8Hz, 1Hz, 1/8Hz)

3.6.4.2 RTU channels.

3 thermistor channels
1 discrete command line (S/C HVC OFF)

3.6.5 Definition of TM packet rate per instrument mode.

The nominal allocation of telemetry packets for JEM-X is 18 packets per polling cycle (8 seconds). Each packet has a total length 440 bytes of which 12 bytes are used for headers and CRC, leaving 428 bytes available for instrument data. Each JEM-X unit will use one (and only one) TM packet for HK information for every polling cycle. This leaves 16 packets for science. The 16 packets may be distributed evenly to the two instruments, this will typically be the case when observing source fields with low X-ray activity, or the packets may be distributed unevenly in order to exploit better the telemetry allocation, in case different formats are selected for the two instruments.

When observing intense X-ray sources JEM-X will generate data at higher data rates than the transmission allocation will allow. Then on-board data reduction must take place. This part of the on-board processing is designed to exploit effectively the available transmission capacity. Therefore JEM-X will fill the allocated TM capacity most of the time. Both the DFEE and the DPE software will be able to handle data congestion gracefully, for instance in case the data read-out from the DFEE or from the DPE hangs up.

On-Request telemetry packets will be used only for diagnostic purposes, and will not affect the average telemetry budget in a significant way.

If data are available each JEM-X unit will be able to support all packet rates between 1 and 184 packets per cycle as long as the DPE is on and the IASW is active. One packet per cycle is guaranteed to be a HK packet.

In case the DFEE is inactive the DPE will still fill part of the HK Package with meaningfull data. If the DFEE is inactive because the Low voltage is off, then the only valid data will be the DPE internal data and the data read through the mRTU.

Thus, the packet rate will be one packet/8s (the HK-packet) from each DPE as soon as the CSSW is running. The IASW will populate its section of the HK-packet as soon as the IASW has been activated, and the DFEE sections will be populated when the DFEE is switched on. The packet rate will be defined by the polling sequence in all other modes where the IASW is active and data from the DFEE are available - possibly as stored data in the IASW buffer.

3.6.6 Data handling interface.

3.6.6.1 Housekeeping Connector J04

Housekeeping monitor channels are connected to the DPE via a Cannon connector Royal-D - 37S:

This connector also carries the "FIFO half full flag". The interface circuit is unbalanced with the "off" state corresponding to a voltage <0.5 V and the "on" state to >2.5 V. The receiving circuit in the mRTU is analog channel #12. This channel is monitored by the IASW and the "software threshold" corresponds to 1.5 V.

Signal names and Pin connections in EID-B Appendix B.

3.6.6.2 Serial communication connector J06

The serial communication channels are connected to the DPE via a Cannon connector Royal-D-37S:

Signal names and Pin connections in EID-B Appendix B.

3.6.6.3 Discrete commands connector J05

The discrete commands are connected to JEM-X via a Cannon connector Royal D-37:

Signal names and Pin connections in EID-B Appendix B.

3.7 Instrument Software and Interfaces

3.7.1 Instrument software architecture

The JEM-X On-board Software can be divided into two major components:

- The DFEE software, and
- The DPE IASW.

Each part of the software will run on a 1750A CPU.

The DFEE software consists of the following main components:

-Data Acquisition
Read the event data from the hardware.
--- In State: Science Data Acquisition
Perform event selection according to current Grey Filter Algorithm
Perform event selection according to signal amplitude and interaction type
Calculate XY-coordinates of event in detector
Identify X-ray calibration source events and accumulate spectra
Store time, pulseheight and position for selected events in the output FIFO buffer
Compile event statistics
--- In State: Diagnostic Event Dump
Perform event classification according to signal amplitude and interaction type
Calculate XY-coordinates of event in detector
Identify X-ray calibration source events and accumulate spectra
Store full event information (raw+derived data) in the output FIFO buffer
Compile event statistics
--- In State: Electronic Calibration
Store full event information (raw ADC data only) in the output FIFO buffer
Compile event statistics

-DFEE-DPE data transfer interface
Control the High Speed Serial line,
-Hardware control
Obtain hardware settings from the DPE and transmit to the hardware registers,
-High Voltage monitoring
Read the HV monitor values through 12 bit signal ADC and transmit result as part of the DFEE housekeeping data,
-Software services
Synchronize the DFEE local clock with the OBT,
Obtain software parameters from the DPE and echo parameter values back
Transmit DFEE HK values to the DPE via the low speed line
Perform DFEE memory load and dump via the low speed line (memory mode only)

The overall layout of the DFEE RAM is shown in the following figure.

JEM-X DFEE Memory Map

Memory region	Address
	8000
Variable Monitor and Interrupt Structure	
	9000
Command and Control Program	
	A000
Variable Data for Command and Control	
	B000
Event Analysis Program	
	C000
Not Used	
	D000
Variable Data for Event Analysis	
	D500
Software Parameters and Rejection limits	
	E000
Variable Energy Conversion Table	
	F000
Variable Rejection limits and Stack	
	FFFF

Memory in 4K word Segments

The DPE IASW consists of the following components:

-Data Acquisition:
Obtain event data blocks from the DFEE and store events in the event buffer,
-Data Format and Grey Filter selection according to the degree of filling of the event buffer
-Data compression, TM packet building and storage in TM-buffer
-HK monitoring: Obtain HK data directly or through DFEE, prepare HK-packets
-TC handling: Obtain TC packets, validate the contents and execute or reject
-Broadcast Packet monitoring:
Obtain the Broadcast Packet, validate the contents and react to information on:
- Emergency and Switch-off Flags
- Eclipse/Radiation Belt Entry/Exit
- Radiation Monitor count rates
- ACS mode, On Target Flag and Slew Flag
- Telemetry allocation information
-Instrument state control: Control the execution of the state changing commands
Update the instrument state table,
-Software services: Support the DFEE software, control the software parameters,
Execute memory loads and dumps.

3.7.2 Common Service Software (CSSW)

The JEM-X Onboard Software are using the CSSW version 1.9b for flight. All of the CSSW services are used.

3.7.3 Instrument specific application software (DPE IASW)

The event stream on the High Speed Line have characteristics which can be used for consistency checking and synchronization of the data stream:

- Event marker word: F000[Hex]
- The HK Cycle Counter increments slowly (every 8 seconds)
- The HK Cycle Counter is also transmitted in LS HK

The IASW part of the program for JEM-X/DPE is composed of the following packages:

Routine name	Addr. State	Main functions
DPE_IASW	AS0	Initialisation of the IASW
IASW_MAIN	AS1	Time synchronisation of actions of the program. Reception and distribution of telecommands
IASW_TM	AS1	Filtering of Telemetry Packets and On Event Messages
IASW_MODES	AS1	Switching between modes of operation
IASW_EVENTS	AS1	Definition of events and dummy events
IASW_EVSORT	AS1	Sorting of events collected in the buffer
IASW_HSL	AS1	Receiving event-records from DFEE via High Speed Line
IASW_BUFFER	AS1	Access to the large buffer of event-records
IASW_SUBBUFFER_1..10	AS2 .. AS11	Storing of up to 50000 event-records, with 10 identical routines
IASW_SC_OUT	AS1	Producing of Science TM Packets
IASW_REQ_OUT	AS1	Producing of On Request TM Packets
IASW_HK	AS1	Collection of Housekeeping information
IASW_DFEE	AS1	Dialog with DFEE via Low Speed Line
IASW_TIME	AS1	Recalculation of DFEE time to the OBT scale
IASW_MRTU	AS1	Facilitates the contact with Analog/Digital Converter
IASW_COMMON	AS1	General purpose functions and definitions
IASW_STATE	AS1	Autonomous actions of IASW (TBW - not yet implemented)
IASW_PATCHES	AS12	Storing of RAM patches directed to DFEE

IASW runs seven concurrent tasks:

Name of the Task	Code in Routine	TID	Priority	Initial State	Stack Size
TASK_MAIN	IASW_MAIN	1	15	STARTED	400
TASK_TC	IASW_MAIN	2	11	STARTED	1250
TASK_HSL	IASW_HSL	3	4	STARTED	700
TASK_SC_OUT	IASW_SC_OUT	4	3	STARTED	700
TASK_HK	IASW_HK	5	13	NOT_STARTED	650
TASK_REQ_OUT	IASW_REQ_OUT	6	10	NOT_STARTED	1200
TASK_STATE	IASW_STATE	7	12	NOT_STARTED	1000

3.7.4 DFEE Software

The DFEE software is written in assembler. Task switching is not used. The various configurations of the DFEE software is handled by State changing commands that select interrupts and set software switches.

The main tasks of the DFEE On-Board Software are

- to capture the events,
- to determine the event class,
- to process the events,
- to transmit the events for further processing by the DPE software.

In this context four different operational states of the software must be distinguished:

- trigger system inactive,
- normal data taking,
- electronic calibration,
- diagnostic event dump.

The event trigger logic can be activated by four different classes of events:

- celestial x-rays,
- calibration source x-rays,
- background events,
- electronic calibration events.

The relation between the event classes and the operational states can be determined from the following schematic presentation:

	Trigger System Inactive STATE < 10	Normal Data Taking STATE = 10	Electronic Calibration STATE = 20	Diagnostic Event Dump STATE = 40
Celestial X-rays	Not seen	Detect and transmit	Detect and reject	Detect and transmit
Calibration X-rays	Not seen	Detect and accumulate spectra	Detect and reject	Detect and transmit
Electronic Calibration Pulses	Not Generated	Not generated	Detect and transmit	Not generated
Particle events (background)	Not seen	Detect and reject	Detect and reject	Detect and reject or transmit according to parameter setting see text in 3.7.4.1.3

The description of the DFEE software is divided into the following sections:

- 3.7.4.1 Single Event Capture Routines
- 3.7.4.2 Event analysis Routines
- 3.7.4.3 Routines for processing counters
- 3.7.4.4 Description of the controllable parameters
- 3.7.4.5 The Software Interface between the DPE and the DFEE
- 3.7.4.6 Low speed link data from the DPE to the DFEE
- 3.7.4.7 Low speed link data from the DFEE to the DPE
- 3.7.4.8 Data exchange sequences between the DPE and the DFEE

3.7.4.1 Single Event Capture

When the interrupt system is active and an event trigger is detected an interrupt is generated and the interrupt handler will normally read in the event, store it in temporary storage and reactivate the interrupt system. The number of triggers will be counted and shown in the DFEE HK data [K/L5119].

3.7.4.1.1 Grey Filter event rejection.

During observations with high count rates it may not be possible to transmit all events to the ground. Some on-board rejection of events must take place. The “Grey Filter” mechanism is responsible for this rejection.The rejection takes place in the DFEE already during the handling of the the event trigger interrrupt in order to minimize the processing time waisted on useless events.

The Grey Filter consists of a string of 32 numbers which can assume the values one or zero. Running cyclically through this string, advancing one element for every event interrupt, we reject an event every time a one is encountered. Thus the transmission value F, of the grey filter can assume the values 1/32, 2/32, 3/32, ..., 30/32, 31/32, 32/32. (A zero transmission filter is not implemented). The values of the filter to be used is determined autonomously by an algorithm in the DPE software (the IASW), according to the degree of filling of the DPE data buffer and the time evolution of this filling. The instantaneous value of the grey filter is reported both in the housekeeping packet (“Commanded Grey Filter, K5402” and "Reported Grey Filter", K5364) and in the science telemetry packets. Note that the "Reported" filter value may lag the "Commanded" value by several HK-cycles due to the event buffering in the DFEE output FIFO.

The number, N, reported is related to the current filter transmission fraction F, by: $F = (N + 1) / 32$

To minimize the effect of the recurrent pattern of length 32, the rejection takes place at the input where the interesting X-ray events are randomly distributed among a large number of particle background events (~1700 events/second). The number of rejected events will be counted and shown in the DFEE HK data [K/L5121].

When the automatic Grey Filter adjustment algorithm is enabled the grey filter will be initialized to 100% transmission at the beginning of each new pointing (identified through the information in the Broadcast packet, see section 3.7.5.2.8).

3.7.4.1.2 Limitations imposed by the Temporary Event Buffer

In order to get the interrupt system back to active status as soon as possible only the actual reading of the event data will be performed with the interrupt disabled. As soon as the event has been read and transferred to one of the 5 slots in a Temporary Buffer, the interrupt system is reactivated. This means that the event analysis will be performed simultaneously with a possible arrival of new events.

The read-in of an event takes less than 100 microseconds whereas the analysis of an event can take up to 500 microseconds. At high counting rates the Temporary Buffer can therefore be filled. Events lost due to this condition will be counted and shown in the DFEE HK data [K/L5136].

When the instrument is in the Diagnostic Event Dump State it may be configured to allow all events (also the particle background events) to go through detailed processing, and in this case the condition of “Temporary Buffer Full” can be expected to occur very frequently.

3.7.4.1.3 Data read-in during Data Taking.

In order to remove background events as quickly as possible from the data stream the read-in process itself contains a few tests of the data quality. Most particle background events will cause a high pulseheight value in the anode channel. Immediately after reading the anode signal it will be checked against a maximum allowed value and the read-in will be terminated if the upper limit condition is exceeded. Events having an abnormally low anode pulseheight are also rejected. This will keep the amount of time used on an event rejected in this way down to approx 50 microseconds. The anode amplitude rejects (both high and low) will be counted and shown in the DFEE HK data [K/L5123]. The upper limit for the anode signal is adjustable by command (via integer software parameter 80).

A third check done at this stage is a crude test on the risetime of the anode signal. Particle signals will usually have much longer risetimes than signals corresponding to X-ray events. Slow rising events will be rejected as well. The risetime rejects will be counted and shown in the DFEE HK data [K/L5128]

These simple rejection mechanisms can be enabled during Diagnostic Event Dump by requesting a negative number of events when invoking the Diagnostic State, see 3.7.5.2.3.6.

3.7.4.1.4 Data read-in during Electronic Calibration

The electronic calibration may be performed with the high voltage on (although this is not the default) to see if the noise characteristics of the amplifiers are affected by the voltage. In this case normal events (X-rays and background) must be prevented from filling up the data stream. This is achieved by keeping the interrupt system disabled most of the time. An electronic calibration event is then captured in the following way:

- enable interrupt
- generate a calibration pulse
- detect a trigger
- disable the interrupt
- read in the event.

It can still happen that an outside event triggers the system before the calibration pulse arrives at the amplifiers. On-board analysis of the data will remove most of these events from the data stream.

3.7.4.1.5 Reading of the HV monitoring values

The HV monitoring values are normally captured as a part of the read-out of a event trigger.

When the trigger system is disabled a special event trigger will be generated to allow the read-out of the HV values at least once every 8 seconds.

These values will be placed in the normal HK data block. [K/L5001+ K/L5002].

3.7.4.2. Event analysis

The event data prior to the DFEE processing consist of the following items:

1: Timer value + HK cycle counter (2×16 bit)
2: Slow Anode Pulseheight
3: Fast Anode Pulseheight
4: Veto Signal
5-24: Back Plane signal 1 to 20 (20 words)
25-35: Cathode Plane signal 1 to 11 (11 words)

The ADC data are placed in the 12 least significant bits of a 16 bit word with an overflow indication (12 bit raw pulseheight + 1 overflow bit) in the most significant bit.

Once an event has been placed in the temporary buffer it will be analysed to determine its class. Depending upon the operational state of the software this analysis will have different aims:

- Normal Data Taking: extract X-ray events, reject events classified as background.
- Electronic Calibration: extract electronic calibration events, reject “real” events.
- Diagnostic Event Dump: extract and classify all events.

The extracted events will be placed in the output FIFO.

3.7.4.2.1 Normal Data Taking

The events to be classified as X-ray events have to pass several tests, of which the test on the anode signal amplitude and a crude risetime check have already been performed during data capture. The tests listed below are more complex in that they depend on the XY-position of the event or on the energy deposited in the detector. The ratio of the fast anode signal to the slow anode signal is a measure of the risetime of the anode signal.

Further tests are:

- The ratio of the veto signal to the anode signal should be below an upper limit
  Number of rejects shown in the DFEE HK data [K/L5130]
- The ratio of the fast anode signal to the slow anode signal should be within a defined range
  Number of rejects shown in the DFEE HK data [K/L5128]
- The ratio of the cathode signal to the slow anode signal should be below a defined value
  Number of rejects shown in the DFEE HK data [K/L5133]
- The ratio of the cathode signal to the slow anode signal should be above a defined value
  Number of rejects shown in the DFEE HK data [K/L5131]
- The ratio of the backplane signal to the slow anode signal should be below a defined value
  Number of rejects shown in the DFEE HK data [K/L5134]
- The ratio of the backplane signal to the slow anode signal should be above a defined value
  Number of rejects shown in the DFEE HK data [K/L5132]

All condition limits are given as tables which may be updated from ground.

When an event has passed all these tests the event position has also been calculated. If the position falls within one of the 4 footprints of the calibration sources, it will be classified as a X-ray calibration event and shunted to the calibration energy spectra which are transmitted as part of the HK-data..

Normal events will be stored in the FIFO buffer. A fixed data format will be used:

- Event Start Mark (= F000 [Hex])
- HK Cycle Counter (16 significant bits)
- Timer value (16 significant bits)
- Anode signal
  (16 bit word with the ADC readout in the least significant 12 bits.bits and an overflow indicator in the most significant bit position)
- X position (16 bit word with the X-position in the least significant 10 bits)
- Y position (16 bit word with the Y-position in the least significant 10 bits)

3.7.4.2.1.1 X-ray calibration events

The X-ray calibration events will be accumulated by the DFEE software in four spectra whenever the DFEE is in the Data-Taking or the Diagnostic state. For each of four radioactive calibration sources a 256 channel spectrum will be generated. These spectra will be transmitted in the DFEE-section of the HK blocks. In each HK block a "partition" of 8 channels will be transmitted from each of the four spectra together with a partition number indicating the position of the 8 channels in the complete 256 channel spectrum. This means that a full spectrum will occupy 32 HK blocks. [K/L5200 to K/L5238].

A double buffer system will be used. Thus the collection time for each spectrum will be 32 HK cycles i.e. the time resolution in the X-ray calibration is 256 seconds. The collection of data into one set of four spectrum buffers is terminated when the partition number "wraps" from a value of 31 to 0. At the same time the collection of data into the other set of buffers will begin. All this happens at the moment where the DPE requests the HK data from the DFEE. This scheme implies that the calibration data corresponding to X-ray photons recorded at time, T; will appear in the HK data over a 256 s period between time $T+t$ and $T+t+256$ s, where t lies between 2 and 258 s. The minimum delay, 2 s, is the time between the DPE request for DFEE HK-data and the transmission of the completed HK block from the DPE.

Note that the rate of events collected from the calibration sources will be affected by the current transmission level of the "Grey Filter" mechanism, see section 4.1.8.5.

3.7.4.2.2 Electronic Calibration

During the calibration state the interrupt logic will select primarily the electronic calibration events.

The electronic calibration consists of a number of pulses (commandable but nominally 10) sent to the amplifiers for each of the 16 calibration levels evenly distributed over the operating range of the amplifiers.

The signals from all 34 amplifier channels will be transmitted to the ground. The calibration will be repeated four times, during each run only one of the four anode sections will be selected. This procedure allows to monitor independently the four anode sections even though their signals are added and transmitted as a single signal during normal operations.

3.7.4.2.3 Diagnostic State

The event analysis in this state is similar to the analysis in Normal Data Taking. The only differences are that all input data as well as the results will be transmitted to ground and that also rejected events will be transmitted. X-ray calibration events will also be included among the diagnostic data.

The diagnostic data format is used to monitor and verify the correct functioning of the on-board background rejection criteria. We will normally be most concerned about the “fine” criteria listed in 3.7.4.2.1 above. Then we are not interested in the large background of particle events, most of which can be rejected by the crude criteria applied already during the data read-in process. The default mode of operation in the diagnostic state is to accept all events. This will be the preferred mode during the ground testing.

But in-flight the particle background will be much larger that on the ground , and the rejection by the crude criteria can be enabled to increase the fraction of X-ray events among the transmitted events.

3.7.4.3. Processing counters

There are three ways to obtain information about the processing done by the DFEE software:

- the event data transmitted
- the JEM-X HK data
- OEM messages

The event data contains the accepted events, the HK block contains a series of counters indicating the number of events failing various tests and the system messages identifies unexpected or rare situations encountered during processing.

The HK counters contain processing information about the previous HK cycle i.e. the last 8 seconds.

All counters except the first in the list below are reset to zero after each read-out. The counters are:

- # of hardware event triggers	[K/L5449]
- # of software processed event triggers	[K/L5119]
- # of software accepted events	[K/L5377]
- # of events accepted as events from the calibration sources	[K/L5100]
- # of events rejected by Grey Filter	[K/L5121]
- # of events rejected due to lack of space in Temporary Buffer	[K/L5136]
- # of events rejected by anode signal amplitude selection	[K/L5123]
- # of events rejected by crude risetime condition	[K/L5128]
- # of events rejected by fine risetime condition	[K/L5127]
- # of events rejected by fine veto signal condition	[K/L5130]
- # of events rejected by too high signal in the back plane peak	[K/L5134]
- # of events rejected by too low signal in the back plane peak	[K/L5132]
- # of events rejected by too high signal in the cathode peak	[K/L5133]
- # of events rejected by too low signal in the cathode peak	[K/L5131]
- # of events rejected due to output FIFO full condition	[K/L5135]

The counters are placed in the HK Block (see 3.7.7.13)].

3.7.4.4 Controllable software parameters

The processing of the events are controlled by a large number of parameters which can all be adjusted from the ground. Except for the grey filter pattern, which may be changed autonomously by the IASW software, all of the parameters listed below are “engineering” parameters, i.e. once they have been adjusted they are not supposed to be changed as long as the instrument performs nominally. The following parameters are used during the analysis of an event:

	# of params used
- Grey filter 32-bit pattern	[2]
- Slow anode upper and lower limits	[2]
- Fast anode/slow anode ratio lower limit tables	[21+19]
- Fast anode/slow anode ratio upper limit tables	[21+19]
- Back plane peak signal/slow anode signal ratio lower & upper limit tables	[41+41]
- Cathode peak signal/slow anode signal ratio lower & upper limit tables	[56+56]
- Fine veto signal/slow anode signal ratio lower & upper limit tables	[56+56]
- anode/cathode coupling constants	[66]

For each of the 34 amplifier channels:

- channel offset	[34]
- channel gain	[34]

Each of the four anode amplifier chains can be individually switched on/off:

- amplifier On/Off.	[4]

All of these parameters can be adjusted by commands from the ground, the commanding mechanisms are detailed in section 3.7.6.

3.7.4.5 DFEE to DPE High Speed Link

The High Speed Link is unidirectional from the DFEE to the DPE. It is used to transfer a stream of event data blocks. Typically a HSL data transfer will take place every few seconds.

Every 125 ms the DPE will interrogate one of the RTU data lines which carries the Half-Full-Flag from the output FIFO in the DFEE. When the flag is detected the DPE reads a data block. The length of the data block is no more than half of the buffer length (4096 words). There is no requirement to transmit only complete event blocks. The DPE software will correctly handle events split between two transfers on the High Speed Line.

From time to time a conflict may arise between the CSSW and the IASW trying to access the RTU simultaneously. Unfortunately the CSSW does not handle such conflicts in a cordial way, but instead issues "on-event messages" (often many of them in rapid succession) signalling unavailability of the RTU. These CSSW on-event messages can safely be neglected. If the IASW should find itself prevented from accessing the RTU it will just delay the request and try again later.

Besides the normal events the HS stream will also contain “marker”-events used as grey filter indicators and fillers at the end of an observation. As the HS transfer is from a FIFO to a FIFO it is important to maintain synchronisation. When the special markers are sent via the HS line they will have the normal event length corresponding to the data taking state in use.

There are three different HSL formats used:

- 1. Normal Data Taking format,
- 2. Electronic Calibration format,
- 3. Diagnostic Dump format.

One HSL block will contain about 680 events in Normal Data Taking format, about 110 events in Electronic Calibration format and about 100 events in Diagnostic Dump format.

3.7.4.5.1 Normal Data Taking Format.

Each event consists of 6 16-bit words.

1: Event Start Mark = F000[Hex]
2: HK Cycle Counter
3: Timer Value
4: Processed Anode Pulseheight
5: Back Plane Position
6: Cathode Plane Position

At the end of data taking period marker events will be used to fill the DFEE output FIFO in order to ensure that the last events are flushed to the DPE. Finally marker events will be used to indicate changes of the grey filter which may occur in the middle of an observation.

The format for the marker events is:

1: Event Start Mark = F000[Hex]
2: HK Cycle Counter
3: Timer Value
4: Marker event indicator = FFFF [Hex]
5: Type
    = 1 Filler
    = 2 Grey Filter change
6: Parameter
    if Type = 1 this word = 0000 [Hex]
    If Type = 2 this word = Grey Filter number, N (range: 0 to 31)

The filler type is used for buffer flush at the end of an observation.

3.7.4.5.2 Calibration Format

Each event consists of 37 16-bit words.

1: Event Start Mark = F000[Hex]
2: HK Cycle Counter
3: Timer Value
4: Slow Anode Pulseheight (raw)
5: Fast Anode Pulseheight (raw)
6: Veto signal
7-26: Back Plane signal 1 to 20 (20 words)
27-37: Cathode Plane signal 1 to 11 (11 words)

Marker events will be used as fillers. A new type is used to indicate the change from one calibration level to the next.

The format for a marker event is:

1: Event Start Mark = F000[Hex]
2: HK Cycle Counter
3: Timer Value
4: Marker event indicator = FFFF [Hex]
5: Type
  = 1 Filler
  = 3 Calibration change
6: Parameter
  If Type = 1 this word 0000 [Hex]
  If Type = 3 this word = Calibration amplitude
7: Parameter
  If Type = 1 this word 0000 [Hex]
  If Type = 3 # of triggers/level
8-37: these words = 0000 [Hex]

3.7.4.5.3 Diagnostic Dump Format

Each event consists of 43 16-bit words.

1: Event Start Mark = F000[Hex]
2: HK Cycle Counter
3: Timer Value
4: Processed Anode Pulseheight
5: Back Plane Position
6: Cathode Plane Position
7: Risetime
8: Slow Anode Pulseheight (12 bit raw pulseheight + 4 ADC flag bits)
9: Fast Anode Pulseheight (12 bit raw pulseheight + 4 ADC flag bits)
10: Veto Signal (12 bit raw pulseheight + 4 ADC flag bits)
11-30: Back Plane signal 1 to 20 (20 words) (12 bit raw pulseheight + 4 ADC flag bits)
31-41: Cathode Plane signal 1 to 11 (11 words) (12 bit raw pulseheight + 4 ADC flag bits)
42: Processing Status Word (see 3.7.7.10)
43: Calibration Event Marker Word

If the event has been accepted by the DFEE analysis the Processing StatusWord will be set to 0. In this case the format contains the DFEE output (the first 6 words) + the corresponding DFEE input.

If the event has been rejected by the DFEE analysis the Processing Status Word will be nonzero.The detailed interpretation of the Processing Status Word can be found in section 3.7.7.10. For such events the calculated positions and the risetime values may be meaningless.

The last word in the format indicates if the on-board analysis has classified this event as coming from one of the four radioactive calibration radioactive sources.If so, the Calibration Event Marker is set to the number of the source. These are numbered 0, 1, 2, and 3. For normal (non-calibration) events the Calibration Event Marker is set to -1.

Marker events will be used as fillers.

The format for a marker event is:

1: Event Start Mark = F000[Hex]
2: HK Cycle Counter
3: Timer Value
4: Marker indicator = FFFF [Hex]
5: Type = 1 (Filler)
6-43: these words = 0000 [Hex]

3.7.4.6 Low Speed Link from the DPE to the DFEE.

The Low Speed Link is bidirectional. It is used to transmit infrequent messages back and forth. It is also used to transmit the DFEE HK data. The HK blocks comes once every 8 second period.

The Low Speed Link is half duplex only.

There are 17 different formats used to transfer requests and data from the DPE to the DFEE:

- a. State Change Command
- b. Parameter Change Commands (2 types)
- c. Memory Uplink Command
- d. Hardware Command
- e. Memory Dump Request
- f. Set CPU State Command
- g. HK Block Request.
- h Transfer and expand pulseheight translation table (3 types)
- i Set the Grey Filter
- j Request for software parameter reporting (4 types)
- k Memory CRC Request

The State Change command moves the DFEE software between the major activities. The only state changes accepted when in the Data Taking state is to stop, ie. STATE_SETUP or STATE_SAFE..

Parameter change commands, hardware commands and reporting commands will only be accepted in the SETUP state. The only exception to this rule is the Set Grey Filter command which is only accepted in the Data Taking state.

Memory Uplink Commands will only be accepted in the MEMORY PATCH/DUMP state of the DFEE software. This state can only be reached from the SAFE state.

This allows for two ways of changing the parameters that control the data analysis. Change of one or a few parameters will be done using Parameter Change Commandt. If a large set of parameters are to be changed this can be done by the Memory Uplink Command. The selection of which method to use will be determined by operational considerations - one of these must be the upper limit of 150 memory patches which can be handled by the IASW.

To improve the reliability of the communication each command on the low speed link from the DPE to the DFEE is enclosed by an envelope consisting of two start words (=DDDD[Hex], DDDD[Hex]) preceeding the command and two termination words (=3333[Hex], 6666[Hex]) trailing the command.

No corresponding envelope is required for the response messages generated by the DFEE as the DPE knows beforehand the type and length of the response messages expected for each command.

3.7.4.6.1 State Change Command

This command can be executed autonomously by the IASW, as a consequence of information in the TC(15,1) Broadcast packet or as requested by a TC(5,5) Mode Change command from the ground.

This command consists of 4 16-bit words.

1: State Change Command Indicator = 1234 [Hex]

2: The State number wanted
3: State parameter
4: CRC check word

The State Parameter have the following uses:

- # of Calibration triggers/level
- # of Events to be Dumped

The correlation between the DFEE STATE and the state number is:

- SAFE	1
- MEMORY PATCH/DUMP	2
- SETUP	5
- DATA TAKING	10
- CALIBRATION	20
- DIAGNOSTIC DUMP	40

(Note that all state numbers are decimal!)

This command will generate a Command Acknowledge from the DFEE.

3.7.4.6.2. Parameter Change Command

There are two commands for this purpose, one for setting integer values, the other for float values. Both commands can be executed autonomously by the IASW, as a consequence of information in the TC(15,1) Broadcast packet or as requested by a TC(5,3) Load Task Parameter command from the ground.

The command for integer parameters consists of 4 16-bit words.

1: Parameter Change Command Indicator = 8642 [Hex]
2: # of Parameter to be changed
3: Parameter: integer value
4: CRC check word

The command for float parameters consists of 5 16-bit words.

1: Parameter Change Command Indicator = 8765 [Hex]
2: # of Parameter to be changed
3: Parameter: float value (2 words)
4: CRC check word

Both types of commands will generate a Command Acknowledge from the DFEE.

3.7.4.6.3. Memory Uplink Command

This command can be executed autonomously by the IASW, as a consequence of information in the TC(15,1) Broadcast packet or as requested by a TC(6,1) Load Memory of DFEE command from the ground.

This command consists of 5 - 260 16-bit words.

1: Memory Uplink Command indicator = ABCD [Hex]
2: Start Address of the Block
3: Length of the Block
4 - 4+N: N Words (N=1 to 256)
5+N: CRC check word

This command will generate a Command Acknowledge from the DFEE.

3.7.4.6.4. Hardware Command

This command can be executed autonomously by the IASW, as a consequence of information in the TC(15,1) Broadcast packet or as requested by a TC(5,3) Load Task Parameter command from the ground.

This command consists of 4 16-bit words.

1: Hardware Command Indicator = AAAA [Hex]
2: Command Address
3: Command Value
4: CRC check word

The Hardware Command addressing system is:

Command Address	Command Value	
0	4	HV_READY
0	5	HV_ON
0	6	HV_OFF
1	value of Anode Settings. Legal range, see below.	
2	value of Low Level Discriminator. Legal range: 0-255.	
3	value of HV_DELTA. Legal range: 0-255.	
4	value of HV_CATHODE. Legal range: 0-255.	

The Anode Settings is a 4-bit pattern (in bit 12 to 15), indicating the on-off status of the four anode sections. The bit values are inverted so a value 0000 [Bin] indicates that all anodes are on.

This command will generate a Command Acknowledge from the DFEE.

3.7.4.6.5. Memory Dump Request

This command can be executed as requested by a TC(6,2) Dump Memory of DFEE command from the ground.

This block consists of 4 16-bit words

1: Memory Dump Request Indicator = CADB [Hex]
2: Start Address of the Block
3: Length of the Block
4: CRC check word.

This request will generate a dump block from the DFEE.

3.7.4.6.6. Memory CRC Request

The DFEE Memory CRC is used by the DPE software to verify the integrity of the DFEE software after a DFEE power-up following an eclipse period.

This command can be executed autonomously by the IASW, as a consequence of information in the TC(15,1) Broadcast packet or as requested by a TC(6,3) Calculate CRC of Memory of DFEE command from the ground.

This block consists of 4 16-bit words

1: Memory Dump Request Indicator = 7F7F [Hex]
2: Start Address of the Block in the DFEE memory
3: Length of the Block in the DFEE memory
4: CRC check word.

This request will generate a CRC block from the DFEE.

3.7.4.6.7. HK Block Request

This command is executed autonomously by the DPE every 8 seconds.

This block consists of 3 16-bit words

1: HK Block Request Indicator = 4711 [Hex]
2: 0000 {Hex]
3: CRC check word

This request will generate a HK block from the DFEE
.

3.7.4.6.8. Pulseheight conversion table commands

The conversion table is uplinked from the ground to the DPE using four TC(5,3)-commands as described in section 3.7.5.2.1.20. The 256 values in the table contains the (nonlinear) conversion between the 12 bit output from the ADC's and the 8 bit pulseheight scale used for telemetry transmission.

For events transmitted via the high speed line the conversion takes place in the DPE, however for the events identified as coming from the radioactive calibration sources, and transmitted as part of the DFEE-generated HK data, the conversion must be done already in the DFEE. The table is therefore needed both in the DPE and the DFEE.

The table is transferred from the DPE to the DFEE using two commands on the low speed line. These two commands are generated by the DPE when the DPE receives the TC(5,3)-"expand" command from the ground. See section 3.7.5.2.1.21. When the two table halves have been transferred to the DFEE a third command on the low speed line will prompt the DFEE to expand the table from a 256 entry table to a 4096 entry version which is faster to use during actual event processing.

The sequence of three commands on the low speed line can be generated autonomously by the IASW, as a consequence of information in the TC(15,1) Broadcast packet or as requested by a TC(5,3) Load Task Parameter command from the ground.

The first two commands each consist of 130 16-bit words:

1: Pulseheight translation table indicator: 4644[Hex] for part 1 and 4645[Hex] for part 2.
2 - 129: 128 values of the table
130: CRC check word

The “expand” command consists of 3 16-bit words:

1: Pulseheight translation table expansion indicator: 4646[Hex]
– Command value = 0
3: CRC check word

Each of the three commands will generate a Command Acknowledge from the DFEE.

3.7.4.6.9. Set Grey Filter

This command can be executed autonomously by the IASW or as requested by a TC(5,3) Load Task Parameter command from the ground. The command will only be accepted by the DFEE in the Data Taking state.

The command consists of 3 16-bit words:

1: 2468[Hex]
– Command value = Number id of Grey Filter, N.
3: CRC check word

This command will generate a Command Acknowledge from the DFEE.
Note that a filter number of N corrsponds to a filter transmission value F, of: F = (N + 1) / 32

3.7.4.6.10. Request for parameter reporting

There are four commands in this group:

- Report software integer parameter. Request indicator: FDB9[Hex].
  Command value: identification number of the parameter to be reported.
- Report software float parameter. Request indicator: FEDC[Hex]
  Command value: identification number of the parameter to be reported.
- Report all software integer parameters. Request indicator: BBBB[Hex]
  Command value = 1.
- Report all software float parameters. Request indicator: BBBB[Hex]
  Command value = 2

These four commands can be executed as requested by a TC(5,4) Report Task Parameter command from the ground or autonomously by the IASW when going to SETUP for the first time.

These requests will generate a parameter report block from the DFEE.

3.7.4.6.11 Set CPU State

By default the DFEE CPU starts up running at 8 MHz and using the one memory wait state. This is considered the most safe condition which should survive even serious component degradation, but is inadequate for handling the expected event rates. The CPU-board hardware is therefore designed to operate at 16 MHz and with zero waitstate. Using this command the CPU can be set to one of the following four states:

0. 8 MHz, 1 waitstate. (power-up default)
1. 8 MHz, 0 waitstates
2. 16 MHz, 1 waitstate
3. 16 MHz, 0 waitstates (nominal operational state)

3.7.4.7 Low Speed link data from the DFEE to the DPE

All data transfers or requests from the DPE to the DFEE will generate either a Command Acknowledge or an answer block back from the DFEE. There will be a delay between request and response of at least 100 microseconds.

3.7.4.7.1 Request Acknowledge

1. Packet identifier: F00F [Hex]
2. Request status value: 0: Request executed normally
   1: CRC error
   2: Request not recognized
   3: Request not valid
   4: State # or Parameter # not valid
   5: Parameter value out of range
   6: DFEE busy. DPE will keep trying
3. CRC

3.7.4.7.2 DFEE Status Block

1. Packet identifier: 0F0F [Hex]
2. Last H/W command received
3. Last parameter change. Parameter #
4. System error #
5. HK cycle counter
6. Timer value
7. CRC

3.7.4.7.3 Memory CRC Block

1. Packet identifier: F7F7 [Hex]
2. Start address
3. Length
4. CRC of memory block
5. CRC of message

3.7.4.7.4 Memory Dump Block

1. Packet identifier: 0FF0 [Hex]
2. Start address
3. Length (N)
4 to 3+N: Memory block
4+N. CRC

3.7.4.7.5 Report Integer S/W parameter

1. Packet identifier: 1357 [Hex]
2. Parameter #
3. Value
4. CRC

3.7.4.7.6 Report Float S/W parameter

1. Packet identifier: 147A [Hex]
2. Parameter #
3 and 4. Value
5. CRC

3.7.4.7.7 Report all Integer S/W parameters

1. Packet identifier: BC01 [Hex]
2. Length = 100
3 to 102. 100 Integer parameter values
103. CRC

3.7.4.7.8 Report all Float S/W parameters

1. Packet identifier: BCEF [Hex]
2. Length = 200
3 to 202. 100 Float parameter values
203. CRC

3.7.4.7.9 DFEE HK data block

1. Packet identifier: 7777 [Hex]
2 to 57. 56 parameter words (see section on DFEE HK in 3.7.8.14)
58. CRC

3.7.4.8 Data exchanges between the DPE and DFEE

3.7.4.8.1 Housekeeping Sequence

Once per polling cycle the DPE will request HK data from the DFEE. The DFEE will collect the data from its hardware and software sources and transmit a HK data block to the DPE on the low speed serial line. The DFEE will start to collect HK data on reception of the HK request.

3.7.4.8.2 Normal Event Data Transfer

This transfer is described in section 3.7.4.5

3.7.4.8.3 Calibration sequence

The calibration sequence is initiated via a STATE_CALIBRATE command from the ground. The DFEE will switch on the electronic calibration generator and generate 16 times N calibration pulses of increasing amplitude according to a parameter table. (N is the number of pulses per step as specified in the command, see 3.7.5.2.3.5). The calibration pulses will generate normal event triggers, but the data will not be analyzed in the DFEE, rather the full set of 34 raw detector outputs will be transferred to the DPE via the high speed link. After completion of the calibration sequence the DFEE will autonomously switch off the calibration generator and return to the SETUP state.

3.7.4.8.4 Diagnostic Sequence

The diagnostic sequence is initiated via a STATE_DATA_DUMP command from the ground. The DFEE will switch to its DATA_DUMP state in which all 34 raw detector outputs are send to the event output FIFO together with the results of the normal event processing (checking of rejection criteria, position determination). The START_DATA_DUMP command contains as a parameter the desired number of events to be processed in this state. When the prescribed number of events have been recorded the DFEE will autonomously return to the SETUP state.

3.7.5 TC packet structure definition and content

The detailed TC packet definitions are given in the Satellite Data Base.

3.7.5.1 Hardware and Software parameter settings

a) Hardware settings:

-High Voltage ON/OFF. (Both dV and V_C)
-Set Detector Gas-gain Voltage, dV
-Set Detector Drift Voltage, V_C

-Enable/Disable Anode Strips,

-Set Event Discriminator level,

b) Software parameter settings:

-Parameters for the event rejection criteria,

-Select Primary and Secondary Telemetry Formats

-Detector pulseheight to output channel conversion table
-Parameters for the position determination algorithm on the MS-plate front side (X).
-Parameters for the position determination algorithm on the MS-plate back side (y).

-Ratemeter cut-off value to be used by the DFEE

A complete copy of all parameters are stored in a dedicated area of the DPE-memory to be used in autonomous recovery after passage of the radiation belts and after eclipses. The parameters will be validated during uplink by the DPE and DFEE software so the stored copy will always be valid.

3.7.5.2 Telecommands

Each telecommand and telemetry packet carry an 11-bits target address called Application Identifier. To each of the units in the Integral system a range of APID is assigned. The Base APID defines the range of possible APIDs - BASE_APID .. BASE_APID+127.

JEM-X ID	BASE_APID [Binary]	BASE_APID [Dec]
"K"	1100 0000 000	1536
"L"	1101 0000 000	1664

Base APID for JEM-X**.**

Telecommands directed to IASW will have APID = BASE_APID+1. (EID-A, chapter 4.5.3.1)
IASW for JEM-X accepts and executes the following telecommands:

TC(5,3) - Load Task Parameters
TC(5,4) - Report Task Parameters
TC(5,5) - Mode Transition
TC(6,1) - Load Memory of DFEE
TC(6,2) - Dump Memory of DFEE
TC(6,3) - Calculate CRC of Memory of DFEE
TC(13,1) - Test command
TC(15,1) - Broadcast Packet.

3.7.5.2.1 TC(5,3) - Load Task Parameters

The following description uses terms like: TID, FID, Param#n, which are described in IPSD, the location of the TID and FID parameters are illustrated in the following table[2].

<table>
<tr><td colspan="5">Header (3 words)</td></tr>
<tr><td>00[Bin]</td><td>Chk-type</td><td>Ack=0000[Bin]</td><td>5</td><td>3</td></tr>
<tr><td colspan="3">TID</td><td colspan="2">FID</td></tr>
<tr><td colspan="5">Data Field (the number of parameters depends on the TID and FID values,
but the data field must always contain an integer number of 16 bit words)</td></tr>
</table>

3.7.5.2.1.1 **Set DFEE's SW Integer Parameter** **TC_ID K/L14**

TID = 0
FID = 1
Param #1 - SW Integer Parameter Identifier ***K/L13***
Param #2 - SW Integer Parameters Value ***K/L14***

The identifier is in a range 0..99. Its value corresponds to a position of the parameter in the Integer Parameters Table. The address of the table in the RAM of DFEE is D500(Hex).

3.7.5.2.1.2 **Set DFEE’s SW Float Parameter** **TC_ID K/L15**

TID = 0
FID = 2
Param #1 - SW Float Parameter Identifier ***K/L15***
Param #2 - SW Float Parameter Value (32 bits) ***K/L16***

The identifier is in a range 0..99 Its value corresponds to a position of the parameter in the Float Parameters Table. The address of the table in the RAM of DFEE is D600[Hex].

3.7.5.2.1.3 **Set Anode Configuration Command** **TC_ID K/L5**

TID = 0
FID = 31
Param #1 - (bit 12) anode 1 ***K/L3***
Param #2 - (bit 13) anode 2 ***K/L4***
Param #3 - (bit 14) anode 3 ***K/L5***
Param #4 - (bit 15) anode 4 ***K/L6***

The four least significant bits of the parameter word may disable the corresponding anodes when set:

bit value = 1: anode OFF
bit value = 0: anode ON (default)

3.7.5.2.1.4 **Set Low Level Discriminator Command** **TC_ID K/L6**

TID = 0
FID = 32
Param#1 - Low Level of Discriminator (range 0..255) ***K/L7***

The default value of the discriminator setting is 15. This is somewhat higher than the nominal operational value, which we expect to be around 12. But we dont want the instrument to count very fast just after switch-on as this may make an orderly switch-on procedure more difficult to realize.

Once the operational value has been established (as a result of the activities in the commissioning phase) this new value will remain the new default as long as the DPE memory is not modified or

[2] ALENIA, INT-RP-AI-0030, Issue 03, 22 Sep'97, „INTEGRAL Packet Structure Definition”.

erased.

Discriminator values smaller than 10 (TBC for the flight units) may lead to excessive count rates and should not be used except for hardware diagnostic purposes.

3.7.5.2.1.5 **Set HV-delta (dV) Command** **TC_ID K/L3**

TID = 0
FID = 33
Param#1 - HV-delta (range 18 to 91) ***K/L1***
(the lower limit is set by the HV-converter start voltage, the upper limit is set as a protection measure by the DFEE software).

No default value is required since the high voltage unit is Off in the default state.

Specific maximum limits for dV exist for each JEM-X unit.

The current baseline is that JEM-X FM-2 unit will be controlled by the JEM-X2 DPE (responding to the "L-commands") and JEM-X QMR unit will be controlled by the JEM-X1 DPE (responding to the "K-commands")

Please note that the voltages quoted below are for reference only, they can not be used to generate commands. The controlling parameters are the raw command values, only these have been used during the development of the instruments.

FM1: Maximum allowed dV command: *K1* = 91 [dec]. (about 910 V)
FM1: Nominal dV command: *K1* =89 [dec]. (about 890 V)
(the FM-1 will be kept as a flight spare)

FM2: Maximum allowed dV command: *L1* = 91 [dec]. (about 910 V)
FM2: Nominal dV command: *L1* =89 [dec]. (about 890 V)

The 3rd unit is marked as QMR (QM Refurbished). This unit is planned to replace FM-1.
QMR: Maximum allowed dV command: *K1* = 91 [dec]. (about 910 V)
QMR: Nominal dV command: *K1* =90 [dec]. (about 900 V)

Commands requesting dV-values above 91 will be rejected by the DFEE software. This limit can, if necessary, be changed by patching of the DFEE software.

Note about HV commanding:

Changes of the high voltage settings will be broken up by the DFEE as a sequence of small changes. This process will take a maximum of 2 minutes per command. During the execution of such a sequence the DFEE will only accept a restricted set of commands (“High Voltage Off” will always be honoured). If the DFEE receives a command it is not able to process during the high voltage change it will respond with a Request Acknowledge Code = 6.

3.7.5.2.1.6 **Set HV Cathode (V_C) Command** **TC_ID K/L4**

TID = 0
FID = 34
Param#1 - HV-cathode (range 18..160) ***K/L2***

No default value is required since the high voltage unit is Off in the default state.

Please note that the voltages quoted below are for reference only, they can not be used to generate commands. The controlling parameters are the raw command values, only these have been used during the development of the instrument.

Nominal V_C-value: 112 [dec]. (about 1120 V)
The maximum allowed value for the V_C-command is 160 [dec]. (about 1600 V)

Requests for VC-values above 160 will be rejected by the DFEE software.

3.7.5.2.1.7 **HV Ready Command** **TC_ID K/L1**

TID = 0
FID = 4

This is the arming command for the switch-on of the HV-converter. The armed condition of the DFEE is signalled by the DFEE state parameter equal to 6 in K/L5022. The DFEE state returns to "Setup" when a HV-on command is received, or after a 128 s delay if no HV-On command is received.

3.7.5.2.1.8 **HV On Command** **TC_ID K/L2**

TID = 0
FID = 5

This command is only legal if the DFEE is in the "armed" state with DFEE-state = 6. If the command is accepted the High-Voltage converter will switched on at the minimum voltage setting (value = 18, corresponding to about 180 V) for both the dV and the V_C outputs..

3.7.5.2.1.9 **HV Off Command** **TC_ID K/L7**

TID = 0
FID = 6

3.7.5.2.1.10 **Set threshold levels for detector pressure** **TC_ID K/L53**

TID = 1
FID = 14
Param#1 - pressure level 1 ***K/L173***
legal range: 0 to 255
(corresponding to approximately 50 000 to 1200 000 Pascal,
the nominal value is 152 000 Pascal @ 20 EC)
Param#2 - pressure level 2 ***K/L174***
legal range: 0 to 255
(corresponding to approximately 50 000 to 1200 000 Pascal,
the nominal value is 152 000 Pascal @ 20 EC)

The threshold for autonomous switch off must be set just below 110 000 Pascal - this will be the pressure reading at nominal gas density if the gas temperature falls below -60 EC

Specific pressure calibration curves and threshold levels exists for each pressure sensor and each JEM-X unit:

FM1: Sensor 1 calibration: P (Pascal) = 45600 + *K5101* * 4460
Threshold setting: *K173* = 15
Sensor 2 calibration: P (Pascal) = 80000 + *K5102* * 4250
Threshold setting: *K174* = 7
FM-1 will be kept as a flight spare.

FM2: Sensor 1 calibration: P (Pascal) = 58700 + *L5101* * 4350
Threshold setting: *L173* = 12
Sensor 2 calibration: P (Pascal) = 56900 + *L5102* * 4350
Threshold setting: *L174* = 12

QMR: Sensor 1 calibration: P (Pascal) = 62400 + *K5101* * 4770
Threshold setting: *K173* = 10
Sensor 2 calibration: P (Pascal) = 57700 + *K5102* * 4770
Threshold setting: *K174* = 11
The QMR is planned to replace the FM-1 unit for flight.

3.7.5.2.1.11 **Set threshold levels for detector temperature** **TC_ID K/L60**

TID = 1
FID = 24
Param#1 - upper limit for temperature #1
legal range: 0 to 255
Param#2 - upper limit for temperature #2
legal range: 0 to 255

The detector temperature is not anymore expected to be a critical parameter.

3.7.5.2.1.12 **Set delay for reaction to Rad. Monitor count rates** **TC_ID K/L 54**

TID = 1
FID = 13
Param#1 - Number of required occurrencies of RMCR > High Limit ***K/L175***
legal range: 8 s to 80 s, default: 16 s
(corresponding parameter values: 1 to 10, default value: 2)

Param#2 - Number of required occurrencies of RMCR < Low Limit ***K/L176***
legal range: 8 s to 1920 s, default: 600 s
(corresponding parameter values: 1 to 240, default value: 75)

3.7.5.2.1.13 **Set no. of events/image in Restricted Img. Fmt** **TC_ID K/L 55**

TID = 4
FID = 47
Param#1 - Number of required photons per image ***K/L177***
The legal range is between 1000 and 10000. The default value is 2580 photons

The efficiency of the packing scheme used in the restricted imaging format will oscillate between a high and a low value dependent on the degree of filling of the last packet in the group of telemetry packets used to transmit each "image". Simulations indicate that 2580 events will fill precisely eight packets with only a small amount of unused space in the last packet. In general the efficiency will increase with more events in each image. The selected value is a compromise between packing efficiency and the degradation of the time resolution in the packed data.

3.7.5.2.1.14 **Load context from DPE to DFEE** **TC_ID K/L30**

TID = 0
FID = 7

Note: Restoration of the DFEE code corrections and parameter context will be done autonomously by the IASW after DFEE switch-on if the previous shutdown was autonomous according to the information in the Broadcast Packet - and if no ground commanding of JEM-X was done in between. See the description of the autonomous recovery possibilities in section 3.7.10.2.3, and note the functioning of the command "Save DFEE memory CRC's" below.

Also note that the setting of the CPU state is not covered by the "Load Context" command.

3.7.5.2.1.15 **Save DFEE memory CRC's** **TC_ID K/L31**

TID = 0
FID = 8

Note: This command must be executed manually prior to switching off the DFEE from the ground. The command is executed autonomously by the IASW if the Broadcast packet signals that instrument switch-off is imminent (ESAM, Eclipse Entry). If executed manually the command will only work properly if used as the last command prior to DFEE switch-off. The parameter "Autonomous Recovery Level" should be set to zero before attempting to save the DFEE CRC's.

Previously, this command was called "Save DFEE Context". However that name was misleading.since no transfer of any DFEE context takes place. All that happens is that the DFEE calculates CRC values for four memory areas, two containing the DFEE code and two containing the DFEE parameters. These CRC values are transferred to the DPE and saved for later reference after restoration of the DFEE memory following a DFEE switch-off/switch-on sequence..

3.7.5.2.1.16 **Set flags for „Automatic Recovery Enable”** **TC_ID K/L62**

TID = 1
FID = 12
Param #1 = 0000(hex) OFF (CPU state 8MHz/1 waitstate (DFEE default)) ***K/L182***
= 0001(hex) set CPU state 8 MHz/0 waitstate
= 0002(hex) set CPU state 16 MHz/1 waitstate
= 0003(hex) set CPU-state 16 MHz/0 waitstate (operational default)
= 030x(hex) set CPU state and recover context
= 060x(hex) set CPU state, recover context and HV
= 090x(hex) set CPU state, recover context, HV and Data Taking
Default value: 0303(hex) set CPU state 16MHz/0 waitstate and recover context.

This parameter controls the autonomous recovery of the DFEE state after radiation belts and eclipse.

3.7.5.2.1.17 **Set Operator overrides for Broadcast Pckt data** **TC_ID K/L32**

TID = 1 FID = 18
Param#1 16 bit flags „Disable Check"
Param#2 16 bit flags „Error Condition"

When a Disable Check bit is set to 1, the corresponding condition will not be read from BCPKT. instead its value will be determined by the corresponding bit Error Condition.

Bit #	***Parm#1***	BCPKT data overridden by Disable Check = 1	***Parm#2***	Meaning of Error Condition = 1
0	***K/L100***	OTF	***K/L111***	OTF=0 (Not On Target)
1	***K/L101***	AOCS Mode	***K/L112***	not Inertial Pointing Mode
2	***K/L102***	AOCS Submode	***K/L113***	(not used)
3	***K/L103***	ESAM	***K/L114***	ESAM=1
4	***K/L104***	Radiation Monitor Counter #1	***K/L115***	value exceeds a limit
5	***K/L105***	Radiation Monitor Counter #2	***K/L116***	--"--
6	***K/L106***	Radiation Monitor Counter #3	***K/L117***	--"--
7	***K/L107***	Radiation Belts Entry/Exit Times	***K/L118***	Radiation Belts condition true
8	***K/L108***	Eclipse Entry/Exit Times	***K/L119***	Eclipse condition true
9	***K/L109***	Data Rate Share	***K/L120***	Data Rate = 16 (otherwise Data Rate = 8)
10	***K/L110***	Imminent Instrument Switch Off	***K/L121***	Instrument Imminent Switch Off = 1
11 to 15		Spare		

3.7.5.2.1.18 **Set Operator overrides for mRTU data** **TC_ID K/L 33**

TID = 1 FID = 19
Param#1 16 bit flags „Disable Check"
Param#2 16 bit flags „Error Condition"

When a Disable Check bit is set to 1, the corresponding condition will not be read from the mRTU, instead its value will be determined by the corresponding bit Error Condition.

Bit #	***Parm #1***	mRTU data is overridden if Disable Check = 1	***Parm #2***	Meaning of Error Condition = 0/1	Autonomous reactions to Out-of-range conditions (See 3.7.10.2.3)
0	***K/L130***	Detector Pressure #1	***K/L142***	Value in range/out of range	HV off. Shutdown lvl 60
1	***K/L131***	Detector Pressure #2	***K/L143***	Valuein range/out of range	HV off Shutdown lvl 60
2	***K/L132***	Detector Temperature #1	***K/L144***	Value in range/out of range	HV off Shutdown lvl 60
3	***K/L133***	Detector Temperature #2	***K/L145***	Value in range/out of range	HV off Shutdown lvl 60
4	***K/L134***	+5V digital (voltage)	***K/L146***	Value in range/out of range	Shutdown level 70
5	***K/L135***	+5V digital (current)	***K/L147***	Value in range/out of range	Shutdown level 70
6	***K/L136***	+5V analog (voltage)	***K/L148***	Value in range/out of range	Shutdown level 70
7	***K/L137***	-5V analog (voltage)	***K/L149***	Value in range/out of range	Shutdown level 70
8	***K/L138***	+12V (voltage)	***K/L150***	Value in range/out of range	Shutdown level 70
9	***K/L139***	+12V (current)	***K/L151***	Value in range/out of range	Shutdown level 70
10	***K/L140***	-12V (voltage)	***K/L152***	Value in range/out of range	Shutdown level 70
11	***K/L141***	-12V (current)	***K/L153***	Value in range/out of range	Shutdown level 70
12-15		Not used		Not used	

See 3.7.5.2.9 for description of the "shutdown level" concept. An OEM will be generated when a value changes from the "in range" to the " out of range" condition and when a transition in the opposite direction is detected.

3.7.5.2.1.19 **Enable auto generation of Lost Synchro. Diagn. TM TC_ID K/L 34**

TID = 3 FID = 1
Param#1 = 0 - disabled (IASW default), = 1 - enabled. ***K/L160***

3.7.5.2.1.20 **Update the Pulseheight Conversion Table TC_ID K/L 24, K/L25, K/L26, K/L27**

TID = 4 FID = 44 **K/L 24**
Param #1 = 0
Param #2..#65 - 64 values loaded into the table ***K/L28....K/L91***

TID = 4 FID = 44 **K/L 25**
Param #1 = 64
Param #2..#65 - 64 values loaded into the table ***K/L28....K/L91***

TID = 4 FID = 44 **K/L 26**
Param #1 = 128
Param #2..#65 - 64 values loaded into the table ***K/L28....K/L91***

TID = 4 FID = 44 **K/L 27**
Param #1 = 192
Param #2..#65 - 64 values loaded into the table ***K/L28....K/L91***

The pulseheight conversion table is used to translate the raw output of the ADC (12 bits, 4096 ch.) into the 256 channel pulseheight scale used for the data transmission. The conversion is not linear because the primary region of interest is in the lower half of the energy range covered by JEM-X. The table is designed to make best use of the 8-channel scale used in the restricted imaging format. In this scale one channel will cover energies below 2 keV, one channel all energies above 35 keV and the remaining 6 channels covers the 2 to 35 keV band. The 8-channel scale is derived from the 256-channel scale by discarding the lower 5 bits of the 256-channel index.

To update a full table, which is 256 words long, four commands are needed. Each of the 256 values (except the initial 0) represents the upper value of the corresponding pulseheight channel. The numbers must appear in increasing order, the first value must be 0 and the last 4095. The table becomes effective only after expansion - see the next command.

The table is located with a starting address of AC00 [Hex] in the DFEE memory, and with a starting address of 17396 [Hex] in the DPE memory. The default table is given below.

0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93
96	100	104	108	112	116	120	124	128	132	136	140	144	148	152	156
160	164	168	172	176	180	184	188	192	196	200	204	208	212	216	220
224	228	232	236	240	244	248	252	256	260	264	268	272	276	280	284
288	292	296	300	304	308	312	316	320	324	328	332	336	340	344	348
352	356	360	364	368	372	376	380	384	388	392	396	400	404	408	412
416	421	426	431	436	441	446	451	456	461	466	471	476	481	486	491
496	504	512	520	528	536	544	552	560	568	576	584	592	600	608	616
624	632	640	648	656	664	672	680	688	696	704	712	720	728	736	744
752	765	778	791	804	817	830	843	856	869	882	895	908	921	934	947
960	973	986	999	1012	1025	1038	1051	1064	1077	1090	1103	1116	1129	1142	1155
1168	1186	1204	1222	1240	1258	1276	1294	1312	1330	1348	1366	1384	1402	1420	1438
1456	1474	1492	1510	1528	1546	1564	1582	1600	1618	1636	1654	1672	1690	1708	1726
1744	1808	1872	1936	2000	2064	2128	2192	2256	2320	2384	2448	2512	2576	2640	2704
2768	2832	2896	2960	3024	3088	3152	3216	3280	3344	3408	3472	3536	3600	3664	4095

When truncated to an 8 channel scale in "restricted imaging format" the channel boundaries will correspond approximately the following X-ray energies:

channel no:	0	1	2	3	4	5	6	7
upper limit (keV):	1.9	4.5	7	10	15	23	35	73

3.7.5.2.1.21 **Expand Pulseheight Conversion Table TC_ID K/L 35**

TID = 4
FID = 45

To be effective the pulseheight conversion table must be expanded to another table - 4096 bytes long in which each byte represents pulseheight channel number (0..255) assigned to an ADC channel

(0..4095).

This expansion is normally done autonomously during the initialization of the DPE and DFEE software. This command is therefore only needed if a new table have been uploaded. In addition to the expansion of the table in the DPE, this command will also initiate the transfer of the table to the DFEE and trigger the expansion of the table in the DFEE (as described in section 3.7.4.6.8).

The expanded table is located with a starting address of E000 [Hex] in the DFEE memory, and with a starting address of 17496 [Hex] in the DPE memory..

3.7.5.2.1.22 **Set the Grey Filter** **TC_ID K/L 37**

TID = 4
FID = 43
Param #1 Grey Filter to be used ***K/L161***

A parameter value in the range: 0..31 will lock the current Grey Filter to the this value. A parameter value of FFFF[Hex] implies that the DPE should control the Grey Filter autonomously (this is the default).

A filter number of N corresponds to a filter transmission value F, of: $F = (N + 1) / 32$

Note: This command is primarily intended for test purposes. After the test the automatic grey filter function must again be enabled (by sending the command with a parameter value of FFFF[Hex]).

The prerequisite for the use of this command is "IASW started" and DFEE S/W in Data-Taking. The command will be accepted by the IASW also when the DFEE is in other modes, but OEM error messages will result, since the DFEE is only prepared to accept Grey Filter commands when in Data Taking. The error messages can be disregarded - the IASW will in any case remember the request.

3.7.5.2.1.23 **Set parameters for automatic Grey Filter control** **TC_ID K/L 36**

TID = 4
FID = 46

Param #1	- Not used, must be 0	***K/L162***
Param #2	- Minus Level (IASW default 20%)	***K/L163***
Param #3	- Plus Level (IASW default 50%)	***K/L164***
Param #4	- High Level (IASW default 80%)	***K/L165***

The four parameters corresponds to four filling levels of the event buffer maintained by the IASW. To achieve a correct control function the values of the parameters must fulfill the condition

0 = Param#1 # Param#2 # Param#3 # Param#4 < 100 (%)

The Grey filter is normally reset to full transmission at the beginning of every observation. Should the filling level raise above the "Plus" level the Grey filter transmission will be decreased to reduce the rate of events processed by the instrument. If the filling level raises above the "High" level the Grey filter transmission will be reduced more rapidly. If, after a period of significant buffer filling the buffer filling sinks below the "Minus" level, then the Grey filter tranmission will again begin to increase. (See also the more detailed description in section 4.1.8.5).

The prerequisite for the use of this command is "IASW started". The DFEE S/W mode is irrelevant.

3.7.5.2.1.24 **Set period for autogener. of SW Diagn. reports** **TC_ID K/L 38**

TID = 1
FID = 15
Param #1 - Period of generation of SW Diagnostic TM Packets ***K/L166***

The period is expressed as a number of BCP1 periods (8 sec each). If set to 0 (default) - no automatic reports will be produced.

The prerequisite for the use of this command is "IASW started". The DFEE S/W mode is irrelevant.

3.7.5.2.1.25 **Set thresholds for Rad. Monitor Count Rates** **TC_ID K/L 39**

TID = 1
FID = 17

		pre-launch limits:
Param #1 - Higher value (rad.belts entry) of proton count rate	***K/L167***	10
Param #2 - Lower value (rad.belts exit) of proton count rate	***K/L168***	1
Param #3 - Higher value (rad.belts entry) of dose rate	***K/L169***	30
Param #4 - Lower value (rad.belts exit) of dose rate	***K/L170***	3
Param #5 - Higher value (rad.belts entry) of electron count rate	***K/L171***	80
Param #6 - Lower value (rad.belts exit) of electron count rate	***K/L172***	8

3.7.5.2.1.26 **Set CPU State** **TC_ID K/L 59**

TID = 0
FID = 9
Param #1 (16 bit word, legal range 0 to 3) ***K/L178***

Parameter value	CPU speed	Wait states
0	8 MHz	1
1	8 MHz	0
2	16 MHz	1
3	16 MHz	0

The default value is 0 - the most conservative value, the nominal value is 3.

3.7.5.2.1.27 Update the X-Position Linearization Table TC_ID K/L70, K/L71, K/L72, K/L73

TID = 4	FID = 51	**TC_ID K/L70**
Param #1	0 starting address inside the table	
Param #2..#65	- 64 values to be loaded into the table	***K/L200....K/L263***

TID = 4	FID = 51	**TC_ID K/L71**
Param #1	64 starting address inside the table	
Param #2..#65	- 64 values to be loaded into the table	***K/L200....K/L263***

TID = 4	FID = 51	**TC_ID K/L72**
Param #1	128 starting address inside the table	
Param #2..#65	- 64 values to be loaded into the table	***K/L200....K/L263***

TID = 4	FID = 51	**TC_ID K/L73**
Param #1	192 starting address inside the table	
Param #2..#65	- 64 values to be loaded into the table	***K/L200....K/L263***

The X-position linearization table is used to translate the intermediate X-positions calculated in the DFEE (10 bits, 1023 position bins) into the 256 bin scale used for data transmission. The software default table as results in a linear translation of the 1024 input channels into the 256 output channels.

This command was introduced to cope with a problem which is specific for the FM-1 unit. As it is now planned to replace the FM-1 with the QMR-unit the software defaults can be used as is.

```
Software default table for X- and Y-position translation:
  0,   5,   9,  13,  17,  21,  25,  29,  33,  37,  41,  45,  49,  53,  57,  61,
 65,  69,  73,  77,  81,  85,  89,  93,  97, 101, 105, 109, 113, 117, 121, 125,
129, 133, 137, 141, 145, 149, 153, 157, 161, 165, 169, 173, 177, 181, 185, 189,
193, 197, 201, 205, 209, 213, 217, 221, 225, 229, 233, 237, 241, 245, 249, 253,
257, 261, 265, 269, 273, 277, 281, 285, 289, 293, 297, 301, 305, 309, 313, 317,
321, 325, 329, 333, 337, 341, 345, 349, 353, 357, 361, 365, 369, 373, 377, 381,
385, 389, 393, 397, 401, 405, 409, 413, 417, 421, 425, 429, 433, 437, 441, 445,
449, 453, 457, 461, 465, 469, 473, 477, 481, 485, 489, 493, 497, 501, 505, 509,
513, 517, 521, 525, 529, 533, 537, 541, 545, 549, 553, 557, 561, 565, 569, 573,
577, 581, 585, 589, 593, 597, 601, 605, 609, 613, 617, 621, 625, 629, 633, 637,
641, 645, 649, 653, 657, 661, 665, 669, 673, 677, 681, 685, 689, 693, 697, 701,
705, 709, 713, 717, 721, 725, 729, 733, 737, 741, 745, 749, 753, 757, 761, 765,
769, 773, 777, 781, 785, 789, 793, 797, 801, 805, 809, 813, 817, 821, 825, 829,
833, 837, 841, 845, 849, 853, 857, 861, 865, 869, 873, 877, 881, 885, 889, 893,
897, 901, 905, 909, 913, 917, 921, 925, 929, 933, 937, 941, 945, 949, 953, 957,
961, 965, 969, 973, 977, 981, 985, 989, 993, 997,1001,1005,1009,1013,1017,1023
```

This command was introduced to correct for a manufacturing error related to JEM-X FM-1. The provisional correction table is given below:

```
Provisional X-linearization table for JEM-X FM-1
   0    7   10   14   17   19   23   27   30   32   37   44   50   55   61   64
  67   71   76   79   81   86   92   95   97  101  105  109  114  119  122  125
 129  132  138  143  147  150  154  159  164  169  174  177  180  184  189  192
 195  199  203  207  211  214  218  221  227  231  235  239  243  247  249  255
 259  263  269  273  277  280  284  288  292  295  300  304  306  312  317  320
 323  328  332  335  340  345  348  352  356  360  363  368  372  374  377  383
 390  395  400  404  406  410  414  416  419  424  429  433  437  441  444  447
 454  458  461  463  467  471  474  480  486  489  492  496  499  502  510  517
 519  523  526  529  532  538  543  545  550  555  558  561  566  572  574  577
 582  586  589  593  596  600  603  607  611  614  621  625  628  633  637  640
 642  645  651  655  659  664  669  671  673  678  684  689  694  698  701  706
 710  712  716  721  726  729  735  739  742  746  750  754  760  767  774  780
 785  789  794  797  800  805  808  811  813  815  818  820  823  825  828  831
 835  839  843  850  856  860  866  872  883  890  897  903  907  910  913  915
 916  919  921  923  925  927  928  930  933  937  940  945  948  953  957  964
 974  980  986  992  996  999 1005 1010 1013 1015 1016 1018 1019 1021 1022 1023
```

To update a full table, which is 256 words long, four commands are needed. Each of the 256 entries (except the initial 0) represents the upper value of the corresponding DFEE-position channel. The numbers must appear in increasing order, the first entry is not used, but must be 0 and the last must be equal 1023. The table becomes effective only after expansion - see the next command.

The table is located with a starting address of 16996 [Hex] in the DPE memory.

3.7.5.2.1.28 Expand X-Position Linearization Table TC_ID K/L 74

TID = 4
FID = 52

To be effective the position linearization table must be expanded to another table - with 1024 entries, in which each entry represents a bin number (0..255) to be used for the downlink.

This command was introduced to cope with a problem which is specific for the FM-1 unit. As it is now planned to replace the FM-1 with the QMR-unit the software defaults can be used as is.

This expansion is normally done autonomously during the initialization of the DPE software. This command is therefore only needed if a new table have been uploaded.

The expanded table is located with a starting address of 16B96 [Hex] in the DPE memory.

3.7.5.2.1.29 **Update the Y-Position Linearization Table TC_ID K/L80, K/L81, K/L82, K/L83**

TID = 4 **TC_ID K/L80**
FID = 53
Param #1 0 - starting address inside the table
Param #2..#65 - 64 values to be loaded into the table ***K/L300....K/L363***

TID = 4 **TC_ID K/L81**
FID = 53
Param #1 64 - starting address inside the table
Param #2..#65 - 64 values to be loaded into the table ***K/L300....K/L363***

TID = 4 **TC_ID K/L82**
FID = 53
Param #1 128 - starting address inside the table
Param #2..#65 - 64 values to be loaded into the table ***K/L300....K/L363***

TID = 4 **TC_ID K/L83**
FID = 53
Param #1 192 - starting address inside the table
Param #2..#65 - 64 values to be loaded into the table ***K/L300....K/L363***

This command was introduced to cope with a problem which is specific for the FM-1 unit. As it is now planned to replace the FM-1 with the QMR-unit the software defaults can be used as is.

The Y-position linearization table is used to translate the intermediate Y positions calculated in the DFEE (10 bits, 1023 position bins) into the 256 bin scale used for the data transmission. We expect this table to remain stable after the commissioning phase. The software default table results in a simple linear translation of the 1024 input channels into the 256 output channels (4 input channels per output channel). The software default table (identical for Y and X) is given in section 3.7.2.1.27.

To update a full table, which is 256 words long, four commands are needed. Each of the 256 entries (except the initial 0) represents the upper value of the corresponding DFEE-position channel. The numbers must appear in increasing order, the first entry is not used, but must be 0 and the last must be equal 1023. The table becomes effective only after expansion - see the next command.

The table is located with a starting address of 16A96 [Hex] in the DPE memory.

3.7.5.2.1.30 **Expand Y-Position Linearization Table TC_ID K/L84**

TID = 4
FID = 54

To be effective the position linearization table must be expanded to another table - with 1024 entries, in which each entry represents a bin number (0..255) to be used for the downlink.

This command was introduced to cope with a problem which is specific for the FM-1 unit. As it is now planned to replace the FM-1 with the QMR-unit the software defaults can be used as is.

This expansion is normally done autonomously during the initialization of the DPE software. This command is therefore only needed if a new table have been uploaded.

The expanded table is located with a starting address of 16F96 [Hex] in the DPE memory.

3.7.5.2.1.31 **Switch-off High-Voltage via mini-RTU** **TC_ID K/L 90**

TID = 1
FID = 251

This command allows to switch off the JEM-X high voltage via the mini-RTU. This command should only be used in case a normal HV-OFF command (TC_ID K/L7) or go to SAFE command (TC_ID K/L8) does not seem to work. This command activates a mini-RTU hardware line and does not depend on the digital low speed interface between the DPE and the DFEE. The command will be detected by the DFEE software and its execution will be indicated in the JEM-X housekeeping. (K/L5584). K/L5001 and K/L002 (the HV analog monitor channels) will show that the high voltage is off, and K/L5376, K/L5580 and K/L5581 (the "Requested HV settings") will also be reset.. The DFEE state will be reset to "Setup". An OEM with ID 189 will be issued by the DPE.

A command: "Goto Setup" should be issued after the HV switch-off to synchronize the DFEE and DPE states. An OEM with ID 254 will be issued by the DPE.

3.7.5.2.1.32 **Switch-off High-Voltage via RTU** **TC_ID K9810 / L9815**

This command is a hardware command directly from the RTU to the JEM-X High-Voltage unit. It should be invoked only in emergencies where normal commanding via the DPE is not possible.

The command only affects the HV-unit, and the DFEE and DPE software does not know about or react to it. The DFEE and DPE states ("Data Taking", "Setup", ...) will remain unaffected, and also the HK channels K/L5376, K/L580 and K/L5581 will continue to show the same "Requested HV settings" although the analog HV monitors (K/L5001 and K/L5002) will show that the high voltage is off.

A command: "Goto Safe" should be issued after the HV switch-off to synchronize the DFEE and DPE states.

3.7.5.2.1.33 **Set reduction-step for autonomous HV-recovery** **TC_ID K/L 64**

TID = 0
FID = 14

Param #1: Reduction for dV-voltage. Software default: 5 HV steps (about 50 V)
Param #2: Reduction for V_C-voltage. Software default: 5 HV steps (about 50 V)

The nominal values for these parameters is 3 steps (30 V) for the dV recovery and 0 steps (0 V) for the V_C recovery. These values must be uplinked as part of the DPE activation (see section 6.1.1)

3.7.5.2.2 TC(5,4) - Report Task Parameters

Header (3 words)				
00[Bin]	Chk-type	Ack=0000[Bin]	5	4
TID			FID	

TIDs, FIDs and format in most cases are the same as for TC(5,3). Only SW parameters can be queried, no HW Settings Report is provided with use of TC(5,4). Actual HW Settings are reported in the housekeeping packets. As a response to TC(5,4) a TM(5,4) packet is generated. Normally one TC(5,4) generates one TM(5,4), there are two exceptions:
- SW Diagnostic (TM(5,4)/TID=1/FID=16) can be produced automatically with a programmed period,
- HSL Lost Synchro. Diagnostic (TM(5,4)/TID=3/FID=1) can be produced automatically as a response on the event of losing synchronization.

3.7.5.2.2.1 **Report DFEE's SW Integer Parameters Table** **TC_ID K/L21**

Request: TID = 0
FID = 11

Answer: TID = 0
FID = 11
Param #1..#100 - Set of Integer Parameters (1 integer parameter = 1 word)

3.7.5.2.2.2 **Report DFEE's SW Float Parameters Table** **TC_ID K/L22**

Request: TID = 0
FID = 12

Answer: TID = 0
FID = 12
Param #1..#200 - Set of Float Parameters (1 float parameter = 2 words)

3.7.5.2.2.3 **Get diagnostic dump of HSL input buffer** **TC_ID K/L 42**

Request: TID = 3
FID = 1

Answer: TID = 3
FID = 1
Param#1..205 - see chapter "Lost HSL Synchro. Diagnostic Telemetry"

3.7.5.2.2.4 **Report IASW Version:** **TC_ID K/L 43**

Request: TID = 1
FID = 11

Answer: TID = 1
FID = 11
Param #1 - Major part of the Version Number (= 1)
Param #2 - Minor part of the Version Number (= 64)

(The flight version of the IASW is 1.64)

3.7.5.2.2.5 **Report threshold levels for detector pressure** **TC_ID K/L56**

Request: TID = 1
FID = 14

Answer: TID = 1
FID = 14
Param #1: Limit for pressure sensor #1
Param #2: Limit for pressure sensor #2

3.7.5.2.2.6 **Report delay in reaction to Rad. Monitor cnt rate** **TC_ID K/L 58**

TID = 1
FID = 13

3.7.5.2.2.7 **Report SW Diagnostic** **TC_ID K/L 57**

TID = 1
FID = 16

3.7.5.2.2.8 **Report params for auto Grey Filter select. proc.** **TC_ID K/L 45**

Request: TID = 4
FID = 46
Answer: TID = 4
FID = 46

Param #1	- Not used	(always 0)
Param #2	- Minus Level	(default: 20 (%))
Param #3	- Plus Level	(default: 50 (%))
Param #4	- High Level	(default: 80 (%))

To achieve a correct control function the values of the parameters must fulfill the condition
0 # Param#2 # Param#3 # Param#4 < 100

3.7.5.2.2.9 **Report period of autogeneration of SW Diagn. reports** **TC_ID K/L 46**

Request: TID = 1
FID = 15

Answer: TID = 1
FID = 15
Param #1 - Period of autogener. of the SW Diagn. reps (default = off (0))

3.7.5.2.2.10 **Report thresh. for Rad. Monitor Count Rates** **TC_ID K/L 47**

Request: TID = 1
FID = 17

Answer: TID = 1
FID = 17
Param #1 - Higher value (for rad.belts entering) of Radiation Monitor Count Rate #1
Param #2 - Lower value (for rad.belts exiting) of Radiation Monitor Count Rate #1
Param #3 - Higher value (for rad.belts entering) of Radiation Monitor Count Rate #2
Param #4 - Lower value (for rad.belts exiting) of Radiation Monitor Count Rate #2
Param #5 - Higher value (for rad.belts entering) of Radiation Monitor Count Rate #3
Param #6 - Lower value (for rad.belts exiting) of Radiation Monitor Count Rate #3

3.7.5.2.2.11 **Report thresh. for Detector Temperature** **TC_ID K/L 61**

Request: TID = 1
FID = 24

3.7.5.2.2.12 **Report reduction-values for HV-recovery** **TC_ID K/L 65**

Request: TID = 0
FID = 14

Answer: TID = 0
FID = 14
Param # 1: reduction-step for dV-recovery
Param # 2: reduction-step for V_C-recovery

3.7.5.2.3 TC(5,5) - Mode Transition

Header (3 words)				
00[Bin]	Chk-type	Ack=0000[Bin]	5	5
MODE			Param#	
Data Field (number of parameters depends on the MODE)				

TC(5,5) is used to switch between states - the major actions of JEM-X. The format of this command provides a set of parameters (see IPSD). MODE (8-bit) codes the target state. Param.#1 (8-bit) and Params.#2..#5 (16-bit) are present or not, depending on the target state.

3.7.5.2.3.1 **Target state = SAFE** **TC_ID K/L8**
STATE = 1

3.7.5.2.3.2 **Target state = MEMORY OPERATIONS** **TC_ID K/L10**
STATE = 2

3.7.5.2.3.3 **Target state = SETUP** **TC_ID K/L9**
STATE = 5

3.7.5.2.3.4 **Target state = DATA TAKING** **TC_ID K/L11**
STATE = 10
Param #1 = 0 (not used) ***K/L8***
Param #2 = Primary Format Code (see below) ***K/L9***
Param #3 = Secondary Format Code (see below) ***K/L10***
Param #4 = Legal range: 0 to (Param#5 - 1) inclusive
Grey Filter value at which we switch to Secondary Format ***K/L22*** (see below)
default value 10, corresponding to a filter transmission factor of 34%
Param #5 = Legal range: (Param#4 + 1) to 30 inclusive.
Grey Filter value at which we switch back to Primary Format ***K/L23*** (see below)
default value 25, corresponding to a filter transmission factor of 81%

The Grey Filter thresholds should satisfy: 0 <= Param#4 < Param#5 <= 30. The transition from secondary to primary format requires that the grey filter value exceeds parameter #5.

For coding of Primary and Secondary Imaging Formats use numerical codes:

Code of the Format	Format
1	Full Imaging (default for both primary and secondary formats)
2	Spectral-timing
3	Restricted Imaging
4	Timing
5	Spectrum
90	Test (see sections 3.7.4.2.1, 3.7.5.2.3.7 and 3.7.7.17)

Parameters #2, #3, #4 and #5 are optional. The data formats (Primary and Secondary) and Grey Filter threshold levels will remain unchanged relative to the last Data Taking situation if the parameters are omitted.
If a value of FFFF[Hex] is used for a parameter the default value for the parameter will be used.
If a value of FF00[Hex] is used the previously used value for that parameter will be used again.

See section 4.1.8.2 for recommended uses of the telemetry formats.

When format 90 is requested, the DFEE will be set in DATA TAKING and the DPE will let the event data from the high speed line pass through to the telemetry without modifications except that the event start marker word (F000 [Hex], see 3.7.4.5) will be removed. This means that the anode signal will be transmitted in a 16 bit word of which the 12 lower bits will be significant (4096 channels), and the X- and Y-position data will we transmitted as two 16 bit words of which the lower 10 bits will be significant (formal resolution 0.25 mm). (see sections 3.7.4.2, 3.7.5.2.3.7 and 3.7.7.17). Format 90 data may be used briefly during the instrument commissioning to verify/optimize the onboard translation tables for the pulseheight and position data.

3.7.5.2.3.5 **Target state = CALIBRATION** **TC_ID K/L12**

STATE = 20
Param #1 = 0 (not used) ***K/L8***
Param #2 = Number of events per calibration level ***K/L11***

Parameter #2 range: 10 to 1023, default: 10

Note that with the modification of the on-board calibration routine introduced through memory patches K/L1728 and K/L1729 only every second calibration event will be triggered through the normal mechanism, i.e. with the trigger resulting from a (calibration-) signal on the fast anode amplifier output. In between these events will come other events where the read-out logic is activated without the presense of a signal on the fast anode output. These new "pure noise" events have been found to provide the most reliable way to monitor the amplifier offsets. The correctness of these offsets are critical for the performance of the onboard event analysis and selection.

3.7.5.2.3.6 **Target state = DIAGNOSTIC** **TC_ID K/L13**

STATE = 40
Param #1 = 0 (not used) ***K/L8***
Param #2 = Number of events to be transmitted*) ***K/L12***

Parameter #2 legal range: -6900 to -10 and 10 to 6900; default: 1000

Recommended values for parameter #2:	Param.#2	TM time**)
Short exposure (all triggers transmitted):	94 events	20 s
Medium exposure (all triggers transmitted):	1521 events	5 min
Long exposure (all triggers transmitted):	5994 events	20 min
Short exposure (selected triggers transmitted):	-94 events*)	20 s
Medium exposure (selected triggers transmitted):	-1521 events*)	5 min
Long exposure (selected triggers transmitted):	-5994 events*)	20 min

*) The absolute value of parameter #2 is the desired number of events.
**) The TM time is the estimated duration of the data downlink, assuming nominal TM allocation.

If parameter #2 is positive (between 10 and 6900) all events will be transmitted. This will be the preferred mode during ground testing and during the initial activation of the detector after launch..
If parameter #2 is negative (between -6900 and -10) some of the on-board particle rejection algorithms will be enabled and a large fraction of the particle induced events will be rejected. The fraction of X-ray induced events in the data will then increase significantly. This is likely to be the preferred mode when in orbit.

The peculiar values recommended for the number of events are selected to minimize the chance of terminating the data collection when the DFEE output FIFO is more than half filled. If this happens the DPE will not correctly recognize the termination of the diagnostic mode done autonomously by the DFEE, and an On-event-message signalling "Unexpected DFEE state" (OEM 189) will result. The condition, if encountered, can be cleared using a "Goto Setup" command (see section 6.4.2).

3.7.5.2.3.7 **Target state = TEST DATA TAKING (test data state)** **TC_ID K/L50**

STATE = 11

The following three states were designed for diagnosing problems on the high speed line. The three states, indicated by 11, 21 and 41 in K/L5482, are for the DFEE equivalent to the states 10, 20 and 40 respectively. However, the DPE will let the data on the HSL pass through to the telemetry without any processing (including the event start marker words). These data states may be usefull if anomalies occur in the instruments after launch. These data states are represented in the HK data K/L5022 as 10, 20 and 40 and in K/L5482 as 11, 21, 41.

When state 11 is commanded, the DFEE will be set in DATA TAKING and the DPE will let the event data on the HSL pass through to the telemetry without modifications.
(see sections 3.7.4.2.1, 3.7.5.2.3.4 and 3.7.7.17)

Note that the DFEE state reported in the K/L5022 will be 10!

3.7.5.2.3.8 **Target state = TEST CALIBRATION (test data state)** **TC_ID K/L51**

STATE = 21
Param #1 = 0 (not used) ***K/L8***
Param #2 = Number of events per calibration level ***K/L11*** Default 10.

When state 21 is commanded, the DFEE will be set in CALIBRATION and the DPE will let the event data on the HSL pass through to the telemetry without modifications.

Note that the DFEE state reported in the K/L5022 will be 20!

Note also that when receiving test data the IASW is not checking the content of the data. Therefore the IASW will not detect the automatic termination of the Calibration state.
After the DFEE terminates the Calibration state and returns to the Setup state the IASW will, however, detect the mismatch between the DFEE state reported in the housekeeping (Setup) and the "expected" state (Calibration). This will cause an On-Event message (#189). Recover from this condition usíng the Contingency Procedure described in section 6.4.2 for OEM 189.

3.7.5.2.3.9 **Target state = TEST DIAGNOSTIC (test data state)** **TC_ID K/L52**

STATE= 41
Param #1 = 0 (not used) ***K/L8***
Param #2 = Number of events to be dumped ***K/L12*** Default: 1000

When state 41 is commanded, the DFEE will be set in DIAGNOSTIC and the DPE will let the event data on the HSL pass through to the telemetry without modifications.

Note that the DFEE state reported in the K/L5022 will be 40!

Note also that when receiving test data the IASW is not checking the content of the data. Therefore the IASW will not detect the automatic termination of the Diagnostic state.
After the DFEE terminates the Diagnostic state and returns to the Setup state the IASW will, however, detect the mismatch between the DFEE state reported in the housekeeping (Setup) and the "expected" state (Diagnostic). This will cause an On-Event message (#189). Recover from this condition usíng the Contingency Procedure described in section 6.4.2 for OEM 189.

3.7.5.2.4 TC(6,1) - Load Memory **TC_ID K/L17**

<table>
<tr><td colspan="5">Header (3 words)</td></tr>
<tr><td>00[Bin]</td><td>Chk-type</td><td>Ack=0000[Bin]</td><td>6</td><td>1</td></tr>
<tr><td colspan="5">MID (= 255) K/L27</td></tr>
<tr><td colspan="5">Start address K/L17 (32 bits)</td></tr>
</table>

Program accepts only commands with MID=255, which is interpreted as DFEE RAM identifier. Load Memory commands are stored in DPE in order of occurrence. This information is used in the process of automatic recovery of the DFEE configuration following a DFEE switch-off (eclipse passage). There is also a TC(5,3)-Load DFEE Context, which loads all stored memory patches to DFEE.
See IPSD for further details.

The subsequent commands must be uplinked once (only once!) following each activation of the DPE. The DPE will store the commands and re-issue them to the DFEE every time the DFEE is powered up, for instance following a temporary DFEE switch-off during an eclipse passage.

3.7.5.2.4.1 **Correct FIFO-flushing error** **TC_ID K/L1700**

MID	= 255
Start Address in DFEE memory	= 941A [Hex]
Parameter #1	= 80B0 [Hex]

This command corrects a coding error in the DFEE software related to the flushing of the DFEE output FIFO at the end of an observation.

3.7.5.2.4.2 **Eliminate call to Footprint routine 1** **TC_ID K/L1701**

MID	= 255
Start Address in DFEE memory	= B049[Hex]
Parameter #1	= FF00 [Hex]
Parameter #2	= FF00 [Hex]
Parameter #3	= 85B0 [Hex]
Parameter #4	= 0001 [Hex]

This commands eliminates a call to an event selection routine which turned out to have undesirable side effects.

3.7.5.2.4.3 **Eliminate call to Footprint routine 2** **TC_ID K/L1702**

MID	= 255
Start Address in DFEE memory	= B0A7 [Hex]
Parameter #1	= FF00 [Hex]
Parameter #2	= FF00 [Hex]

This commands eliminates a call to an event selection routine which turned out to have undesirable side effects.

3.7.5.2.4.4 **Eliminate call to Footprint routine 3** **TC_ID K/L1703**

MID	= 255
Start Address in DFEE memory	= B19D [Hex]
Parameter #1	= FF00 [Hex]
Parameter #2	= FF00 [Hex]
Parameter #3	= 85B0 [Hex]
Parameter #4	= 0001 [Hex]

This commands eliminates a call to an event selection routine which turned out to have undesirable side effects.

3.7.5.2.4.5 **Eliminate call to Footprint routine 4** **TC_ID K/L1704**

MID	= 255
Start Address in DFEE memory	= B218 [Hex]
Parameter #1	= FF00 [Hex]
Parameter #2	= FF00 [Hex]

This commands eliminates a call to an event selection routine which turned out to have undesirable side effects.

3.7.5.2.4.6 Insert call to energy correction patch — TC_ID K/L1705

MID = 255
Start Address in DFEE memory = B0D4 [Hex]
Parameter #1 = 7EF0 [Hex]
Parameter #2 = B621 [Hex]

3.7.5.2.4.7 Insert call to energy correction patch — TC_ID K/L1706

MID = 255
Start Address in DFEE memory = B251 [Hex]
Parameter #1 = 7EF0 [Hex]
Parameter #2 = B621 [Hex]

3.7.5.2.4.8 Energy correction patch — TC_ID K/L1707

MID = 255
Start Address in DFEE memory: B621 [Hex]
Parameter #1 = D8A0 [Hex]
Parameter #2 = D262 [Hex]
Parameter #3 = 8020 [Hex]
Parameter #4 = D116 [Hex]
Parameter #5 = E942 [Hex]
Parameter #6 = 8660 [Hex]
Parameter #7 = D664 [Hex]
Parameter #8 = C964 [Hex]
Parameter #9 = B860 [Hex]
Parameter #10 = D662 [Hex]
Parameter #11 = C964 [Hex]
Parameter #12 = A860 [Hex]
Parameter #13 = D660 [Hex]
Parameter #14 = C9A6 [Hex]
Parameter #15 = 8020 [Hex]
Parameter #16 = D115 [Hex]
Parameter #17 = E942 [Hex]
Parameter #18 = 8660 [Hex]
Parameter #19 = D66A [Hex]
Parameter #20 = C964 [Hex]
Parameter #21 = A860 [Hex]
Parameter #22 = D668 [Hex]
Parameter #23 = C9A6 [Hex]
Parameter #24 = 7FF0 [Hex]

3.7.5.2.4.9 Parameters for energy correction patch

FM-1: **TC_ID K1708**

MID = 255
Start Address in DFEE memory: D660 [Hex]
Parameter #1 = 7D2F [Hex]
Parameter #2 = 1A00 [Hex]
Parameter #3 = 40CD [Hex]
Parameter #4 = 4FF4 [Hex]
Parameter #5 = 577B [Hex]
Parameter #6 = ADEB [Hex]
Parameter #7 = 0000 [Hex]
Parameter #8 = 0000 [Hex]
Parameter #9 = 7D0E [Hex]
Parameter #10 = 5600 [Hex]
Parameter #11 = 5CCC [Hex]
Parameter #12 = 89F2 [Hex]

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content will be detailed in the database update (version 3.3) to be issued after the exchange of the instrument units.

FM-2: **TC_ID L1708**
MID = 255
Start Address in DFEE memory: D660 [Hex]

Parameter #1	= 7D2F [Hex]
Parameter #2	= 1A00 [Hex]
Parameter #3	= 40CD [Hex]
Parameter #4	= 4FF4 [Hex]
Parameter #5	= 577B [Hex]
Parameter #6	= ADEB [Hex]
Parameter #7	= 0000 [Hex]
Parameter #8	= 0000 [Hex]
Parameter #9	= 7D0E [Hex]
Parameter #10	= 5600 [Hex]
Parameter #11	= 5CCC [Hex]
Parameter #12	= 89F2 [Hex]

3.7.5.2.4.10 **Set software gain for fast anode** **TC_ID K/L1709**

Modify the software gain factor for the fast anode signal.
The content of this memory load command is detailed in the database.

The following load memory commands serves to update the DFEE software parameters for the DFEE event processing. Specific parameter sets will be needed for every JEM-X model.

3.7.5.2.4.11 **QMR: TC_ID K1710**
FM-2: TC_ID L1710

Modify the low-range/high-range cross-over energy for the fast/slow-ratio rejection criterion.
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit.

3.7.5.2.4.12 **QMR: TC_ID K1711**
FM-2: TC_ID L1711

Modify the upper limits for the fast/slow-ratio rejection criterion - in the low range.
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.5).

3.7.5.2.4.13 **QMR: TC_ID K1712**
FM-2: TC_ID L1712

Modify the lower limits for the fast/slow-ratio rejection criterion - in the low range.
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.6).

3.7.5.2.4.14 **QMR: TC_ID K1713**
FM-2: TC_ID L1713

Modify the upper limits for the fast/slow-ratio rejection criterion - in the high range.
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.7).

3.7.5.2.4.15 **QMR: TC_ID K1714**
FM-2: TC_ID L1714

Modify the lower limits for the fast/slow-ratio rejection criterion - in the high range.
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.8).

3.7.5.2.4.16 **QMR: TC_ID K1715**
FM-2: TC_ID L1715

Modify the upper limits for the veto signal selection
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.13).

3.7.5.2.4.17 **QMR: TC_ID K1716**
FM-2: TC_ID L1716

Modify the lower limits for the veto signal selection
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.14).

3.7.5.2.4.18 **QMR: TC_ID K1717**
FM-2: TC_ID L1717

Modify the upper limits for the cathode signal selection
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.9).

3.7.5.2.4.19 **QMR: TC_ID K1718**
FM-2: TC_ID L1718

Modify the lower limits for the cathode signal selection
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.10).

3.7.5.2.4.20 **QMR: TC_ID K1719**
FM-2: TC_ID L1719

Modify the upper limits for the backplane signal selection
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.11).

3.7.5.2.4.21 **QMR: TC_ID K1720**
FM-2: TC_ID L1720

Modify the lower limits for the backplane signal selection
The content of this memory load command is detailed in the database.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.2.12).

3.7.5.2.4.22 **Set software HV switch-off for flight conditions TC_ID K/L1721**

MID	= 255
Start Address in DFEE memory	= A08A [Hex]
Parameter #1	= C000 [Hex]

This command should only be used after launch!

The JEM-X detector system is protected by a software check against excessive count rate conditions. During ground testing the trigger threshold for this check is set at 16384 counts per 8 seconds. This limit is not high enough during flight where we expect about 2000 triggers/s alone due to cosmic ray particles. In flight we will initially set the switch-off limit to 49152 counts per 8 s.

3.7.5.2.4.23 **Modify the amplifier offsets TC_ID K/L1722**

The contents of these memory load commands are detailed in the database.

Note that after the modification of the FM-2 electronics in February 2002 the content of the L-patch has changed regarding the offsets for the "anode slow" and "anode fast" signals. (see section 3.7.6.1.1)
Note that after the planned replacement of the QMR unit with the QMR-unit in March 2002 a K-patch will be required (FM-1 did not require patching of the offsets). The content of the new K-patch has been detailed in the database version 3.1 delivered with the QMR unit. (see section 3.7.6.1.1).

3.7.5.2.4.24 **Update the X-positions for the calibration events TC_ID K/L1723**

The contents of these memory load commands are detailed in the database separately for the FM-2 and QMR units.

Note that after the planned replacement of the FM-1 unit with the QMR-unit in March 2002 the content of this patch must be changed. The new content has been detailed in the database version 3.1 delivered with the QMR unit (see section 3.7.6.1.3).

3.7.5.2.4.25 **Set new safety limit for FM-1 dV-HV command. TC_ID K1724**

MID	= 255
Start Address in DFEE memory	= A07C [Hex]
Parameter #1	= 104

Contingency patch after short circuit in anode segment 4 of the FM-1 unit.
It is now planned to exchange the FM-1 with the QMR-unit. After this exchange the patch should not be used
Moreover, the short circuit in the FM-1 unit has now disappeared again, so even if the FM-1 remains on the satellite this patch should only be used in consultation with the JEM-X PI.

3.7.5.2.4.26 **Increase event rate for electronic calibration - part 1 TC_ID K/L1725**

The content of this memory load command is detailed in the database version 3.1.

3.7.5.2.4.27 **Increase event rate for electronic calibration - part 2** **TC_ID K/L1726**

The content of this memory load command is detailed in the database version 3.1.

3.7.5.2.4.28 **Modify HV-monitor read-out sequence** **TC_ID K/L1727**

The content of this memory load command is detailed in the database version 3.1.

3.7.5.2.4.29 **Include noise test in electronic calibration - part 1** **TC_ID K/L1728**

The content of this memory load command is detailed in the database version 3.1.

This patch and the following one modifies the on-board calibration routine. Only every second calibration event will now be triggered through the normal mechanism, i.e. with the trigger resulting from a (calibration-) signal on the fast anode amplifier output. In between these events will come other events where the read-out logic is activated without the presense of a signal on the fast anode output. These new "pure noise" events have been found to provide the most reliable way to monitor the amplifier offsets. The correctness of these offsets are critical for the performance of the onboard event analysis and selection.

3.7.5.2.4.30 **Include noise test in electronic calibration - part 2** **TC_ID K/L1729**

The content of this memory load command is detailed in the database version 3.1.

3.7.5.2.5 TC(6,2) - Dump Memory

3.7.5.2.5.1 Dump DPE Memory **TC_ID K/L9050**

<table>
<tr><td colspan="5">Header (3 words)</td></tr>
<tr><td>00[Bin]</td><td>Chk-type</td><td>Ack=0000[Bin]</td><td>6</td><td>2</td></tr>
<tr><td colspan="4">FIX 000 [Hex]</td><td>M4BIT_PHYSIC_ADD K/L9007</td></tr>
<tr><td colspan="5">M16BIT_PHYSIC_ADD K/L9002</td></tr>
<tr><td colspan="5">Length of memory dump K/L9005</td></tr>
</table>

See IPSD for further details.

3.7.5.2.5.2 Dump DFEE Memory **TC_ID K/L18**

<table>
<tr><td colspan="5">Header (3 words)</td></tr>
<tr><td>00[Bin]</td><td>Chk-type</td><td>Ack=0000[Bin]</td><td>6</td><td>2</td></tr>
<tr><td colspan="5">MID (= 255) K/L27</td></tr>
<tr><td colspan="5">Start address K/L17 (32 bits)</td></tr>
<tr><td colspan="5">Length of memory section K/L18</td></tr>
</table>

The program accepts only commands with MID=255, which is interpreted as DFEE RAM identifier. Length of the dump is not limited to the TM packet size, one dump can cover the whole range of addresses - 8000..FFFF(Hex). DPE itself will decompose the long dump into a series of TM(6,2) packets.

See IPSD for further details.

3.7.5.2.6 TC(6,3) - Calculate Memory CRC **TC_ID K/L23**

Header (3 words)				
00[Bin]	Chk-type	Ack=0000[Bin]	6	3
MID (= 255) ***K/L27***				
Start address ***K/L17*** (32 bits)				
CRC address range ***K/L19***				

Program accepts only commands with MID=255, which is interpreted as DFEE RAM identifier.

See IPSD for further details.

3.7.5.2.7 TC(13,1) - Test command

This is a No Operation Command. Its only action is incrementing of the counter of telecommands received.

3.7.5.2.8 TC(15,1) - Broadcast Packet

The Broadcast Packet (BCPKT) is analyzed as soon as it is received by DPE. Some specific content of the BCPKT can cause a so called "shutdown" - stopping of data taking. Automatic recovery of data taking is possible, but only if the flag "Automatic Recovery Enabled" is set.

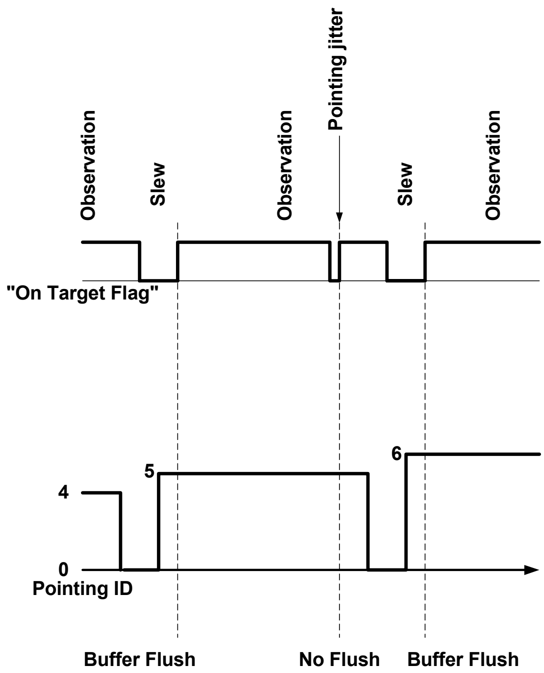
The reaction to the On Target Flag is performed independently of the value of "Automatic Recovery Enabled" flag. See chapters: 3.7.5.2.9 and 3.7.5.2.10 for further details.

3.7.5.2.8.1 **Data Rate Share**.

This value is used in the algorithm for calculating of the Grey Filter, used to moderate the JEM-X data rate.

3.7.5.2.8.2 **OTF-On Target Flag**.
The OTF is used in combination with the Pointing ID to determine the start of a new observation. We will recognize the acquicsition of a new target (distinct from any temporary flickering of the On Target Flag during a pointing) by the following logic: Whenever the (validated) On Target Flag makes a transition from zero to one the current value of the Pointing ID parameter in the Broadcast Packet will be compared with the Pointing ID value stored on the previous occasion of the On Target Flag zero-to-one transition. If the stored value and the current value of the Pointing ID is the same, no action will be taken by the IASW. If the values are different, then the DPE and the DFEE data buffers will be flushed and the new value of the Pointing ID will be stored for future reference.

This logic is illustrated below:



3.7.5.2.8.3 **AOCS Mode**.
When equal to IPM (Inertial Pointing Mode) - enables interpretation of OTF (as described above). For all other values the content of the OTF is ignored.

3.7.5.2.8.4 **AOCS Sub Mode**. Ignored.

3.7.5.2.8.5 **Radiation Monitor Count Rate (#1,#2,#3)**.
If any of the three counters exceeds the TBD threshold (adjustable individually for each of them through a Load Task Parameter TC(5,3)(TID=1, FID=17)), it is interpreted as the entrance into the radiation belts. Exit from radiation belts is assumed when all counters are below thresholds. Thresholds defining exit from radiation belts will be lower than those defining entering into radiation belts (hysteresis). Interpretation of these data is affected by DRMC flag.
Entrance into the area of high radiation will result in stopping data taking in soft mode, switching off HV, and setting DFEE to Safe state.

3.7.5.2.8.6 **DRMC-Disregard Rad. Monit. Count Rates**.
Radiation Monitor Count Rates are considered valid only when DRMC=0 (Disregard Radiation Monitor Count Rates). Otherwise (DRMC=1) Radiation Monitor Count Rates are assumed low.

3.7.5.2.8.7 **ESAM-Emergency Safe Acquisition Mode**.
Reaction on this signal as in case of high radiation.

3.7.5.2.8.8 **Instrument Imminent Switch-Off**.

Data taking is stopped in soft mode, HV is turned off. Next DPE stores context of DFEE, to be able to recover data taking. DFEE is left in Safe state, waiting for turning off the low voltage supply.

3.7.5.2.8.9 **Ground Station Hand-Over Flag**.
Ignored.

3.7.5.2.8.10 **Pointing ID**.
Used in the On Target Flag logic as described above.

3.7.5.2.8.11 **Radiation Belts Crossing**
(Start Time, Radiation Belts Crossing Exit Time and Eclipse Entry Time).
All valid time-type fields (not equal to zero) from BCPKT will be stored separately. The purpose is to have good data for comparison with the current OBT in case of interrupted connection Earth - S/C. Time-type data are recalculated at the very beginning from BCPKT format to 48-bit format. The program uses internally only 48-bit format coding for On Board Time.

Entrance into the radiation belt will result in stopping data taking in soft mode, switching off HV, and setting DFEE to SAFE.

At exit from the radiation belt the DFEE state prior to the entry may be be restored autonomously - this assumes that the “Autonomous Recovery Flag has been set on - the default value for this flag is off.

When entering into eclipse region, data taking is stopped in soft mode and the HV is turned off. Next, the DPE stores the context of DFEE, to be able to recover data taking after the eclipse. The DFEE is left in SAFE state, waiting for the turn-off of the low voltage.

Recovery after eclipse exit takes place under ground control.

3.7.5.2.9 Shutdown and Recovery scheme

Under normal conditions all instrument state changes are initiated from the ground, and the operator is responsable for the proper sequence of commands. Some situations exists when the DPE autonomously stops the activity and later must be able to resume the previously interrupted mode. The so called Shutdown Level is a key concept in the alghoritms for our shutdown/recovery scheme. Under nominal conditions (whether in data taking or not) the Shutdown Level is zero. A nonzero value for the Shutdown Level indicates that the exterior conditions does not allow continuation of the state commanded from ground. Generally a higher value for the Shutdown Level indicate a more significant departure from the nominal case - see the table below. The software keeps two variables: “Actual Shutdown Level”, which represents the current depth of shutdown, and “Wanted Shutdown Level”, which is a function of the external information - coming from the Broadcast TM and from the mRTU analog readouts. The job for the Task STATE is to keep the Actual Shutdown Level equal to the Wanted one. Both levels are reported in the IASW HK TM.

Note that every state changing command send from the ground will reset both shutdown levels to zero because "the ground" has now taken over the responsability for what the instrument is doing.

Wanted Shutdown Level	External condition leading to a given shutdown level
0 H	Normal operation
30H	Radiation belts
40H	Eclipse
50H	Low Voltage Off in Eclipse
60H	Detector anomalies (see table in 3.7.5.2.1.18) or ESAM = 1 or Imminent Instrument Switch-Off = 1. (automatic recovery will not be attempted)
70H	DFEE anomalies (see table in 3.7.5.2.1.18) or unexpected Low Voltage Off. (automatic recovery will not be attempted)
80H	Loss of LSL-communication with the DFEE, (no automatic recovery)

List of Shutdown Levels.

Transition between levels	Shutdown action
0H to 30H (entering radiation belts)	1) Save current DFEE state in the DPE 2) Store HV settings and HV monitor values in the DPE 3) DFEE go to Setup 4) DFEE goto Safe (HV off)
30H to 40H (entering eclipse)	Save CRC of DFEE memory in DPE (the DFEE can now be switched off)
40H to 50H (DFEE low voltage switch-off during eclipse)	No action
Any level to 60H (Detector anomalies or S/C anomalies signalled in Broadcast packet)	DFEE goto Safe (HV off)
Any level to 70H (DFEE anomalies or Low Voltage unexpectedly off)	Signal "Delayed Soft Stop" to IASW task SC_-OUT
Any level to 80H (Loss of communication of DPE-DFEE low speed line)	Switch off DFEE HV via relay#0 line Signal "Delayed Soft Stop" to IASW task SC_-OUT

DPE autonomous actions when Shutdown levels increase

Transition between levels	Recovery action
40H to 30H (exit from eclipse)	Load the context to the DFEE
30H to 10H (exit from radiation belts)	*The four steps below are conditional on the "automatic recovery enable flag" being set.* 1) HV Ready 2) HV on 3) Set Cathode HV (V_C) 4) Set Anode HV (dV)
10H to 0H	*The following step is conditional on the "automatic recovery enable flag" being set.* Go to Data Taking

DPE autonomous actions when Shutdown levels decrease

The above tables lists actions of the DPE, when the Wanted Shutdown Level is not equal to the Actual one.

During an automatic recovery the DPE will have to wait for the DFEE to complete certain actions. For instance, when requesting: Set Cathde HV or the Set Anode HV, the DFEE may be busy completing the previous command. The DPE will then keep trying until the DFEE accepts the command. It may take a few minutes until the DFEE will be ready to start data taking.

When the Actual Shutdown Level is not zero, some of the operator commands, which normally are legal, may become illegal and will be rejected.

3.7.5.2.10 Eclipse and Rad. Belt Entry/Exit Times

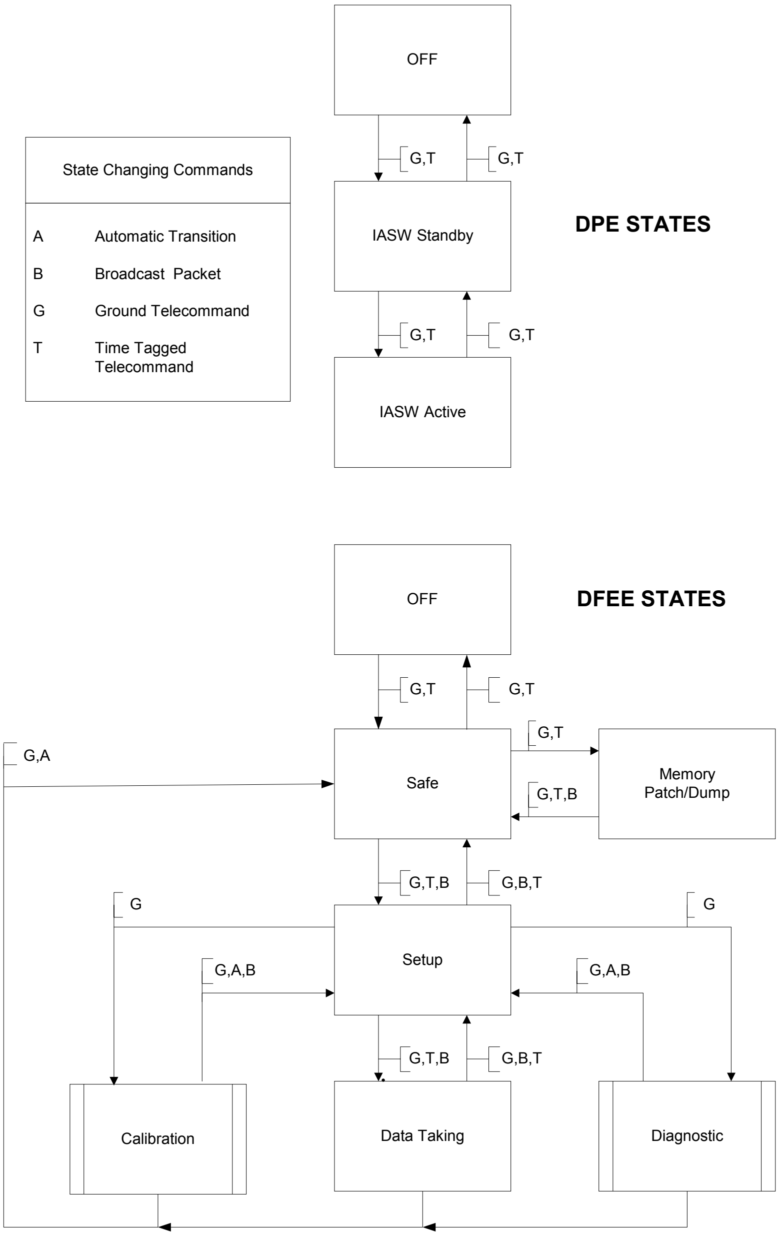
The Entry and Exit times are normally provided in the Broadcast Packets TC(15,1). (All-Zero's in the time-data fields in the Broadcast Packet will be interpreted as "no data").
The DPE stores valid time data from the Broadcast Packets, and uses these stored times for deciding its actions. The old stored time data are invalidated after 100 hours.
It is repeatedly checked whether the current time T lies inside the range T1 - T2 (Entry - Exit). This is not as trivial as one might think, because of possibility of having incomplete data. Consider the following cases:

- Both T1 and T2 are given, T1 < T2 - this is the trivial case.
- Both T1 and T2 are given, but T2 < T1 - it is assumed that T2 marks the end of one potential danger period while T1 starts a new one. In this case T is in a danger period if T<T2 or T>T1.
- Only T1 is given - then it is assumed that T2 will be given soon and we react as if T<T2.
- Only T2 is given - again, probably T1 will be given soon and we react as if T>T1.
- Both T1 and T2 are not given - a safe situation is assumed.

There is one more complication - OBT wraps arround in about 194 days, so this will happen several times during the mission. The operator "<" used for comparing of OBT-s takes this into account. When the two compared OBT-s differ more than half full range (about 97 days), then the result of comparision is reversed - it is assumed, that the smaller one has wrapped by one more times than the larger.

3.7.5.3 The JEM-X Operational States

The operational states for the JEM-X instrument and their interrelations are illustrated in the following flowchart.



The distinctions between the DPE and the DFEE states are illustrated in the two following tables.

JEM-X State Tables

DPE States

Name	DPE Power	CSSW	IASW	DFEE power
OFF	OFF	-	-	OFF
IASW STAND-BY	ON	Active	Inactive	OFF
IASW ACTIVE	ON	Active	Active	OFF-/ON

DFEE States

Name	DFEE state #	DFEE power	DFEE S/W	High Voltage	Event Interrupt	Calibration Generator
OFF	-	OFF	-	-	-	-
SAFE	1	ON	Active	OFF	OFF	OFF
MEMORY (DUMP/PATCH)	2	ON	Active	OFF	OFF	OFF
SETUP	5	ON	Active	ON/OFF	OFF	OFF
SETUP (HV arm)	6	ON	Active	OFF	OFF	OFF
DATA TAKING	10	ON	Active	ON	ON	OFF
DATA TAKING (TEST)	11	ON	Active	ON	ON	OFF
CALIBRATION	20	ON	Active	ON/OFF	ON	ON
CALIBRATION (TEST)	21	ON	Active	ON/OFF	ON	OFF
DIAGNOSTIC	40	ON	Active	ON	ON	OFF
DIAGNOSTIC (TEST)	41	ON	Active	ON	ON	OFF

The JEM-X DFEE State-Changing Commands

Name	Function	Prerequisites	TC-type	TC-sub type	Ground or Autono-mous	Params	Comments
Low Voltage On	OFF to SAFE	DPE: IASW_go DFEE temp. in limits	5	5	G+A	No	After Eclipse
State_ Setup	SAFE to SETUP	Outside radiation belts Rad. Monitor below limit	5	5	G+A	No	After Eclipse or Radiation Belt Passage
State_ Data_ Taking	SETUP to DATA TAKING	Outside radiation belts Rad. Monitor below limit	5	5	G+A	No	After Eclipse or Radiation Belt Passage
State_ Calibrate	SETUP to CALIBRATE	Outside radiation belts Rad. Monitor below limit	5	5	G	# of events/ level	
State_ Diagnostic	SETUP to DIAGNOSTIC	Outside radiation belts Rad. Montor below limit	5	5	G	# of events desired	
State_ Setup	DIAGNOSTIC / DATA TAKING / CALIBRATE to SETUP	None	5	5	G+A	No	Eclipse or Rad. Belt Entry Switch-off Im-minent
State_ Memory	SAFE to MEMORY	None	5	5	G	No	
State_ Safe	SETUP to SAFE	None	5	5	G+A	No	Eclipse or Rad. Belt Entry Switch-off Im-minent
Low Voltage Off	SAFE to OFF	None	5	5	G	No	

3.7.5.4 Legal JEM-X Commands versus instrument state

State	State Characteristics					Legal Commands (see notes below)													
Original State \	CSSW Run	IASW Run	DFEE Pwr	DFEE State	HV	DFEE state changing commands (final state)								DFEE reconfiguration commands				DPE reconf.	
						Off	Safe	Memory	Setup	Datatk.	Calibr.	Diagn.	Test	CPU	H/W commands HV/discr/anode	S/W param	Memory load/dump	S/W param.	Memory load/dump
IASW Act.	run	run	off	n/a	off	n/a	**X**											X	X
DFEE Safe	run	run	on	safe	off	**X**	n/a	**X**										**X**	**X**
DFEE Mem	run	run	on	mem	off	(X)	**X**	n/a									**X**	**X**	**X**
Setup	run	run	on	setup	off	(X)	**X**		n/a		**X**			**X**	**X**	**X**		**X**	**X**
					on	(X)	**X**		n/a	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**	**X**
Datatake	run	run	on	data take	on	(X)	**X**		**X**	n/a									
Calibration	run	run	on	calib	off	(X)	**X**		**X**		n/a								
					on	(X)	**X**		**X**		n/a								
Diagnostic	run	run	on	diag	on	(X)	**X**		**X**			n/a							
Test	run	run	on	test	off	(X)	**X**		**X**				n/a						
					on	(X)	**X**		**X**				n/a						

Legal commands are indicated with an **X**. Legal, but not recommended commands are indicated with an (X).

3.7.5.5 JEM-X telemetry versus instrument state

State	State Characteristics					Possible telemetry formats & data														
	CSSW Run	IASW Run	DFEE Pwr	DFEE State	HV	HK				Full Image	Restr. Image	Cnt Rate	Spect Time	Spect.	Calib	Diagn	Mem dump	S/W diag	HSL Syn	Test
						mRTU	DFFE*)													
							HVHK	CNT	CAL											
IASW Stdby	run	stdby	off	n/a	off															
IASW Act.	run	run	off	n/a	off	X														
DFEE Safe	run	run	on	safe	off	X	X													
DFEE Mem	run	run	on	mem	off	X	X										M			
Setup	run	run	on	setup	off	X	X											SW		
					on	X	X	X										SW	HSL	
Datatake	run	run	on	data take	on	X	X	X	X	FI	RI--	--RI	ST	S				SW	HSL	
Calibration	run	run	on	calib	off	X	X	2X							C			SW	HSL	
					on	X	X	2X							C			SW	HSL	
Diagnostic	run	run	on	diag	on	X	X	X	X							D		SW	HSL	
Test	run	run	on	test	off	X	X											SW	HSL	T
					on	X	X	X	(X)									SW	HSL	T

*) The HK data from the DFEE contain (among other things) the HV monitor (HVHK), the hardware trigger rate (CNT) and the calibration data from the radioactive sources (CAL

3.7.6 TC parameter description

3.7.6.1 List of DFEE integer software parameters
Start address in DFEE memory: D500 (hex)

3.7.6.1.1 Integer software parameters **Amplifier offsets**

Param #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
0	separator	0	0	0	0	
1	separator	0	0	0	0	
2	anode slow	01DB	01DB	019C	019C	
3	anode fast	01DD	01DD	019A	019A	
4	veto	019C	019C	019B	019B	
5	separator	0	0	0	0	
6	backplane 0	019C	019C	019B	019B	
7	backplane 1	019D	019D	019E	019C	
8	backplane 2	019B	019B	019C	019B	
9	backplane 3	019C	019C	019C	019B	
10	backplane 4	019A	019A	019B	019B	
11	backplane 5	019D	019D	019D	019C	
12	backplane 6	019B	019B	019D	019B	
13	backplane 7	019B	019B	019C	019A	
14	backplane 8	019A	019A	019C	019C	
15	backplane 9	019D	019D	019C	019D	
16	backplane 10	019A	019A	019C	019A	
17	backplane 11	019C	019C	019D	019C	
18	backplane 12	019B	019B	019C	019C	
19	backplane 13	019B	019B	019C	019B	
20	backplane 14	019A	019A	019B	019B	
21	backplane 15	019C	019C	019C	019D	
22	backplane 16	019B	019B	019D	019C	
23	backplane 17	019A	019A	019B	019B	
24	backplane 18	019C	019C	019D	019A	
25	backplane 19	019C	019C	019C	019B	
26	separator	0	0	0	0	
27	separator	0	0	0	0	
28	cathode 0	019B	019B	019D	019A	

29	cathode 1	0199	0199	019B	019B	
30	cathode 2	019B	019B	019B	019C	
31	cathode 3	019B	019B	019C	019C	
32	cathode 4	019A	019A	019A	0199	
33	cathode 5	019B	019B	019C	019B	
34	cathode 6	019B	019B	019A	019A	
35	cathode 7	019C	019C	019B	019A	
36	cathode 8	019B	019B	019C	019A	
37	cathode 9	019C	019C	019B	019B	
38	cathode 10	019B	019B	019C	019B	
39	separator	0	0	0	0	

3.7.6.1.2 integer software parameters **Cathode-Anode Coupling Constants**

Param #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
40		4	4	4	4	
41		4	4	4	4	
42		4	4	4	4	
43		3	3	3	3	
44		3	3	3	3	
45		3	3	3	3	
46		2	2	2	2	
47		2	2	2	2	
48		1	1	1	1	
49		1	1	1	1	
50		1	1	1	1	
51		0	0	0	0	
52		4	4	4	4	
53		4	4	4	4	
54		3	3	3	3	
55		3	3	3	3	
56		2	2	2	2	
57		2	2	2	2	
58		2	2	2	2	

59		1	1	1	1	
60		1	1	1	1	
61		1	1	1	1	
62		4	4	4	4	
63		0	0	0	0	

3.7.6.1.3 integer software parameters **Calibration Source Positions**

Param #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
64	Lower Y limit lower sources	0306	0306	0306	0306	
65	Upper Y limit lower sources	0326	0326	0326	0326	
66	Lower Y limit Upper sources	0396	0396	0396	0396	
67	Upper Y limit Upper sources	03B6	03B6	03B6	03B6	
68	Not used	0	0	0	0	
69	Not used	0	0	0	0	
70	Not used	0	0	0	0	
71	Not used	0	0	0	0	
72	Low X (Src 1)	0088	0088	0090	0090	
73	HighX (Src 1)	00A4	00A4	00A8	00A8	
74	Low X (Src 2)	018A	018A	0191	0190	
75	HighX (Src 2)	01A6	01A6	01A9	01A5	
76	Low X (Src 3)	024A	024A	0257	0252	
77	HighX (Src 3)	0266	0266	026F	0268	
78	Low X (Src 4)	0351	0351	0357	0358	
79	HighX (Src 4)	0371	0371	036F	036E	

3.7.6.1.4 integer software parameters **Misc parameters**

Param #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
80	Max. anode signal	0E00	0E00	0E00	0E00	
81	Min. anode signal	0	0	0	0	
82	Not used	0	0	0	0	

3.7.6.1.5 integer software parameters **Zero Block**

Param #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
83	Not used	0	0	0	0	
84	Not used	0	0	0	0	
85	Not used	0	0	0	0	
86	Not used	0	0	0	0	
87	Not used	0	0	0	0	
88	Not used	0	0	0	0	
89	Not used	0	0	0	0	
90	Not used	0	0	0	0	
91	Not used	0	0	0	0	
92	Not used	0	0	0	0	
93	Not used	0	0	0	0	
94	Not used	0	0	0	0	
95	Not used	0	0	0	0	
96	Not used	0	0	0	0	
97	Not used	0	0	0	0	
98	Not used	0	0	0	0	
99	Not used	0	0	0	0	

3.7.6.2 DFEE integer parameters accessible through memory load commands

3.7.6.2.1 Anode-Cathode Left Matrix

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
D564		2	2	2	2	
D565		4	4	4	4	
D566		4	4	4	4	
D567		4	4	4	4	
D568		4	4	4	4	
D569		2	2	2	2	
D56A		4	4	4	4	
D56B		2	2	2	2	
D56C		0	0	0	0	
D56D		2	2	2	2	

D56E		4	4	4	4	
D56F		4	4	4	4	
D570		6	6	6	6	
D571		4	4	4	4	
D572		0	0	0	0	
D573		4	4	4	4	
D574		0	0	0	0	
D575		0	0	0	0	
D576		4	4	4	4	
D577		4	4	4	4	
D578		2	2	2	2	
D579		4	4	4	4	
D57A		2	2	2	2	
D57B		0	0	0	0	
D57C		2	2	2	2	
D57D		4	4	4	4	
D57E		4	4	4	4	
D57F		4	4	4	4	
D580		4	4	4	4	
D581		2	2	2	2	
D582		4	4	4	4	
D583		2	2	2	2	
D584		0	0	0	0	
D585		0	0	0	0	
D586		0	0	0	0	
D587		0	0	0	0	

3.7.6.2.2 Anode-Cathode Right Matrix

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
D588		2	2	2	2	
D589		4	4	4	4	
D58A		4	4	4	4	
D58B		4	4	4	4	
D58C		4	4	4	4	

D58D		2	2	2	2	
D58E		0	0	0	0	
D58F		2	2	2	2	
D590		4	4	4	4	
D591		2	2	2	2	
D592		4	4	4	4	
D593		4	4	4	4	
D594		0	0	0	0	
D595		0	0	0	0	
D596		4	4	4	4	
D597		0	0	0	0	
D598		4	4	4	4	
D599		6	6	6	6	
D59A		4	4	4	4	
D59B		4	4	4	4	
D59C		2	2	2	2	
D59D		0	0	0	0	
D59E		2	2	2	2	
D59F		4	4	4	4	
D5A0		2	2	2	2	
D5A1		4	4	4	4	
D5A2		4	4	4	4	
D5A3		4	4	4	4	
D5A4		4	4	4	4	
D5A5		2	2	2	2	
D5A6		0	0	0	0	
D5A7		2	2	2	2	
D5A8		4	4	4	4	
D5A9		0	0	0	0	
D5AA		0	0	0	0	
D5AB		0	0	0	0	
D5AC		0	0	0	0	
D5AD		0	0	0	0	

D5AE		0	0	0	0	
D5AF		0	0	0	0	

3.7.6.2.3 Backplane Parameters (strip positions, delta strips)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
D5B0		7	7	7	7	
D5B1		E	E	E	E	
D5B2		15	15	15	15	
D5B3		1B	1B	1B	1B	
D5B4		21	21	21	21	
D5B5		27	27	27	27	
D5B6		2D	2D	2D	2D	
D5B7		33	33	33	33	
D5B8		39	39	39	39	
D5B9		3F	3F	3F	3F	
D5BA		45	45	45	45	
D5BB		4B	4B	4B	4B	
D5BC		51	51	51	51	
D5BD		57	57	57	57	
D5BE		5D	5D	5D	5D	
D5BF		63	63	63	63	
D5C0		69	69	69	69	
D5C1		70	70	70	70	
D5C2		77	77	77	77	
D5C3		7F	7F	7F	7F	
D5C4		0	0	0	0	
D5C5		0	0	0	0	
D5C6		0	0	0	0	
D5C7		0	0	0	0	
D5C8		7	7	7	7	
D5C9		7	7	7	7	
D5CA		7	7	7	7	
D5CB		6	6	6	6	

D5CC		6	6	6	6	
D5CD		6	6	6	6	
D5CE		6	6	6	6	
D5CF		6	6	6	6	
D5D0		6	6	6	6	
D5D1		6	6	6	6	
D5D2		6	6	6	6	
D5D3		6	6	6	6	
D5D4		6	6	6	6	
D5D5		6	6	6	6	
D5D6		6	6	6	6	
D5D7		6	6	6	6	
D5D8		6	6	6	6	
D5D9		7	7	7	7	
D5DA		7	7	7	7	
D5DB		8	8	8	8	
D5DC		7	7	7	7	
D5DD		7	7	7	7	
D5DE		0	0	0	0	
D5DF		0	0	0	0	

3.7.6.2.4 Cathode Parameters (Strip positions, delta strips)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
D5E0		1D	1D	1D	1D	
D5E1		35	35	35	35	
D5E2		4B	4B	4B	4B	
D5E3		60	60	60	60	
D5E4		75	75	75	75	
D5E5		8A	8A	8A	8A	
D5E6		9F	9F	9F	9F	
D5E7		B4	B4	B4	B4	
D5E8		CA	CA	CA	CA	
D5E9		E2	E2	E2	E2	

D5EA		FF	FF	FF	FF	
D5EB		0	0	0	0	
D5EC		0	0	0	0	
D5ED		0	0	0	0	
D5EE		0	0	0	0	
D5EF		0	0	0	0	
D5F0		1D	1D	1D	1D	
D5F1		18	18	18	18	
D5F2		16	16	16	16	
D5F3		15	15	15	15	
D5F4		15	15	15	15	
D5F5		15	15	15	15	
D5F6		15	15	15	15	
D5F7		15	15	15	15	
D5F8		16	16	16	16	
D5F9		18	18	18	18	
D5FA		1D	1D	1D	1D	
D5FB		1D	1D	1D	1D	
D5FC		1D	1D	1D	1D	
D5FD		0	0	0	0	
D5FE		0	0	0	0	
D5FF		0	0	0	0	

3.7.6.2.5 Fit parameters for fast-slow ratio, upper limit in low pulse height range. (1)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DA00		03E8	04B0	04B0	04B0	
DA01		0384	03E8	03E8	03E8	
DA02		0321	038F	03A3	03BA	
DA03		030D	0354	0363	0367	
DA04		02ED	032F	034F	0339	
DA05		02DD	0317	0324	031D	
DA06		02CD	030B	0313	0308	
DA07		02C4	02FE	030D	0303	

DA08		02B0	02FC	0302	02EE	
DA09		02B2	02F0	02F6	02E7	
DA0A		02A5	02EE	02ED	02DC	
DA0B		02A0	02EE	02E3	02CE	
DA0C		0292	02EE	02DB	02C4	
DA0D		0282	02EE	02CF	02BA	
DA0E		0294	02EE	02EF	02D7	
DA0F		0293	02EE	02E0	02C9	
DA10		028F	02EE	02DF	02C7	
DA11		0000	02EE	02DE	02CD	
DA12		0000	02EE	02DF	02CF	
DA13		0000	02EE	02E2	02CF	
DA14		0000	02EE	02E6	02D7	

3.7.6.2.6 Fit parameters for fast-slow ratio, lower limit in low pulse height range.(2)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DA18		00C8	00C8	00C8	00C8	
DA19		0190	012C	012C	012C	
DA1A		0239	01A6	01A8	01D2	
DA1B		025D	0206	01F7	0228	
DA1C		0276	0244	021F	024E	
DA1D		027F	025E	0263	025F	
DA1E		0280	0265	0269	026C	
DA1F		0281	0272	0269	026C	
DA20		027D	0274	0272	0276	
DA21		0277	0279	0277	0273	
DA22		0273	0278	027A	0273	
DA23		026A	0279	027C	0274	
DA24		0264	0277	027E	026D	
DA25		025A	026F	027B	0265	
DA26		024C	0269	024F	0247	
DA27		025D	0262	0285	0274	
DA28		0268	0253	028B	0274	

DA29		0000	0266	028C	0270	
DA2A		0000	0267	028F	0273	
DA2B		0000	0267	028F	027C	
DA2C		0000	026A	028F	027E	

3.7.6.2.7 Fit parameters for fast-slow ratio, upper limit in high pulse height range.(3)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DA30		0290	02EE	02EE	02D7	
DA31		0290	02EE	02EE	02D7	
DA32		0290	02EE	02EE	02D7	
DA33		0290	02EE	02EE	02D7	
DA34		0290	02EE	02EE	02D7	
DA35		0290	02EE	02EE	02D7	
DA36		02AF	02EE	02F2	02E1	
DA37		02BA	02EE	02FC	02E9	
DA38		02C0	02EE	0300	02EE	
DA39		02C8	02EE	0301	02F1	
DA3A		02CD	02F0	0307	02FB	
DA3B		02D3	02F5	0308	02FC	
DA3C		02D7	02FD	030A	0304	
DA3D		02DD	0301	0310	030C	
DA3E		02DF	030C	0314	0311	
DA3F		02E4	0310	031A	0319	
DA40		02E8	0319	031C	031C	
DA41		02EA	0321	0322	032B	
DA42		02EE	0334	0334	0334	

3.7.6.2.8 Fit parameters for fast-slow ratio, lower limit in high pulse height range. (4)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DA48		0267	026A	028F	027E	
DA49		0267	026A	028F	027E	
DA4A		0267	026A	028F	027E	
DA4B		0267	026A	028F	027E	
DA4C		0267	026A	028F	027E	
DA4D		0275	026A	028F	027E	
DA4E		028A	027B	0293	0290	
DA4F		0295	028C	029B	029A	
DA50		029F	0298	02A2	02A2	
DA51		02A4	02A4	02AB	02AA	
DA52		02AB	02A4	02AB	02A9	
DA53		02B1	02AA	02B0	02B0	
DA54		02B4	02AB	02B2	02AE	
DA55		02B7	02AF	02AF	02AB	
DA56		02BB	02AB	02AD	02AC	
DA57		02BC	02AC	02AA	02A4	
DA58		02BD	02A6	02AB	02A6	
DA59		02BE	02A0	02A3	0295	
DA5A		02C1	028A	028A	028A	

3.7.6.2.9 Fit parameters for the upper limits for the cathode/anode ratio. (5)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DA60		0403	0408	0426	03E8	
DA61		02B6	02D4	02ED	02CB	
DA62		0251	0264	025F	0263	
DA63		0253	0267	025B	025F	
DA64		02C4	02E6	02F0	02EB	
DA65		038A	03AE	03C5	03BA	
DA66		02BC	02D9	02EA	02E5	
DA67		0251	0267	0265	0270	

DA68		0258	0266	0263	0272	
DA69		02CC	02E6	02EE	0302	
DA6A		0384	03B2	03A0	03CC	
DA6B		02C2	02DE	02E6	02F6	
DA6C		024F	0262	0266	026D	
DA6D		0247	0264	0257	0268	
DA6E		02B5	02CD	02D1	02E3	
DA6F		0372	038E	03BA	03CC	
DA70		02AF	02C0	02C6	02D8	
DA71		0240	025B	024F	0259	
DA72		023E	0252	024F	0253	
DA73		02B0	02CD	02D7	02DC	
DA74		0365	0387	038E	0394	
DA75		02B9	02CF	02D6	02D3	
DA76		0243	0258	0251	0252	
DA77		024A	0268	0257	0253	
DA78		02BD	02E5	02DB	02E2	
DA79		0374	0396	0394	039B	
DA7A		02B9	02D9	02DF	02E4	
DA7B		024A	0262	025F	0266	
DA7C		024F	0268	0253	026B	
DA7D		02C5	02E3	02D3	02F8	
DA7E		0377	039D	039A	03C8	
DA7F		02D3	02E7	02D2	02FD	
DA80		0259	0269	024F	026A	
DA81		0257	0260	024B	026A	
DA82		02CF	02EB	02D3	02ED	
DA83		0391	03A8	0375	03AF	
DA84		02D6	02DE	02C6	02EF	
DA85		024F	025C	0245	025F	
DA86		0258	0263	0243	0263	
DA87		02BC	02CB	02B6	02D8	
DA88		038A	03A6	0378	03C2	

DA89		0301	0316	02C1	02EE	
DA8A		0296	02B6	0246	026B	
DA8B		0292	0293	0248	026B	
DA8C		02E1	02FC	02CD	0303	
DA8D		038A	03B4	0380	03D9	
DA8E		02E5	02F5	02DA	030D	
DA8F		029E	028F	0256	027C	
DA90		0287	0297	0258	0281	
DA91		02BB	02D5	02D0	02FD	
DA92		03A3	03BF	03B0	03E2	
DA93		02DF	030A	02EF	0306	
DA94		0263	0288	0259	0270	
DA95		0254	026B	025B	0271	
DA96		02AE	02C3	0333	02CB	
DA97		042C	0420	0426	03E8	

3.7.6.2.10 Fit parameters for the lower limits for the cathode/anode ratio..(6)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DAA0		0218	0246	0233	01F4	
DAA1		022D	023A	0223	01FB	
DAA2		01F6	0204	0212	01F6	
DAA3		01ED	0200	0211	01F3	
DAA4		022D	0247	024D	0224	
DAA5		02F8	02F8	0322	02E9	
DAA6		0241	024D	0253	0239	
DAA7		020D	0215	0221	0203	
DAA8		01FB	020D	021C	01FF	
DAA9		023E	0248	0258	0238	
DAAA		02E5	02F9	031B	02F2	
DAAB		0232	0240	023C	0231	
DAAC		01F1	0202	0205	01FF	
DAAD		01FE	0201	0214	0202	
DAAE		022D	0238	0242	022D	

DAAF		02CC	02D4	02C7	02B4	
DAB0		0219	022E	023B	0219	
DAB1		01E5	01ED	020D	01E9	
DAB2		01DE	01F2	020B	01F0	
DAB3		0219	0230	0243	0221	
DAB4		02D7	02DE	030F	02C9	
DAB5		0225	023C	0247	021B	
DAB6		01E4	01FC	020F	01E7	
DAB7		01F0	01FF	0215	01EC	
DAB8		022B	0242	024B	0213	
DAB9		02E6	02FB	0315	02CA	
DABA		022F	023B	0257	0227	
DABB		01EC	01F7	0217	01ED	
DABC		01EE	0203	020F	01F6	
DABD		0230	0245	024F	0230	
DABE		02DC	02F5	0325	02E9	
DABF		021C	0241	023E	022E	
DAC0		01EA	0201	0207	0200	
DAC1		01F7	01FC	020C	01F5	
DAC2		023A	023D	023E	0231	
DAC3		02FD	02E8	02FD	02DF	
DAC4		023B	0236	023A	0222	
DAC5		01FB	01F7	0203	01F0	
DAC6		01F1	01F9	0203	01F1	
DAC7		022B	022D	0231	021F	
DAC8		02D3	02D8	02DD	02B1	
DAC9		0269	0279	0233	0222	
DACA		0236	023D	0206	01FC	
DACB		021B	0227	0207	0200	
DACC		0257	0259	0237	022C	
DACD		02F8	02F7	0301	02FA	
DACE		025B	0267	024F	0245	
DACF		021D	023B	0211	020D	

DAD0		021B	0232	0219	020C	
DAD1		0240	0250	0249	0240	
DAD2		02E6	02E0	030C	02F6	
DAD3		023E	0248	0241	0237	
DAD4		0205	020B	0212	01FA	
DAD5		01F7	01FD	020F	01FD	
DAD6		0224	0228	0223	01FB	
DAD7		01F9	0240	0233	01F4	

3.7.6.2.11 Fit parameters for the upper limits for the backplane/anode ratio.(7)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DAE0		03E8	04B0	04B0	04B0	
DAE1		03CB	0473	0467	0470	
DAE2		045D	04B0	048E	04B2	
DAE3		03A6	03F2	0422	0423	
DAE4		0446	0487	048E	047B	
DAE5		0395	03DB	0404	03FC	
DAE6		0450	04A8	04A3	0485	
DAE7		03A3	03E3	03FF	040D	
DAE8		03FF	0462	0455	0476	
DAE9		0359	03CE	03CC	0414	
DAEA		03C8	0453	042A	0497	
DAEB		0354	03A7	03C8	03F3	
DAEC		03DE	045E	045D	043F	
DAED		034C	0388	03E9	03D6	
DAEE		03D7	0469	047C	0463	
DAEF		0367	03DA	03F9	03D9	
DAF0		040F	0496	0478	044A	
DAF1		0376	03EA	03F6	03E2	
DAF2		041A	04A7	0471	0474	
DAF3		0345	0379	03E9	03DE	
DAF4		03C1	046E	0473	044A	
DAF5		033B	0398	03E1	03D5	

DAF6		03EB	044D	0467	0459	
DAF7		0362	03C0	03BD	03C8	
DAF8		0412	0452	0413	042E	
DAF9		0357	0387	039C	03C0	
DAFA		040C	0461	0413	043E	
DAFB		0361	03BF	03B0	03C4	
DAFC		041D	0487	0426	0435	
DAFD		0389	03F5	03C4	03D1	
DAFE		041E	048B	043B	045D	
DAFF		038C	03C6	03E3	03F3	
DB00		041F	049D	046B	045D	
DB01		0385	03C8	03FD	03CE	
DB02		041D	0491	0470	0412	
DB03		035B	03C3	03D9	03C5	
DB04		03E7	045C	0443	0467	
DB05		036F	03CA	03D8	0409	
DB06		03E6	045A	043D	0472	
DB07		03BE	042B	03F0	042E	
DB08		034A	0604	03F6	03E1	

3.7.6.2.12 Fit parameters for the lower limits for the backplane/anode ratio.(8)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DB10		0320	01F4	01F4	01F4	
DB11		02A8	021E	0273	027C	
DB12		02C4	0235	029A	02BE	
DB13		0276	0215	022E	022F	
DB14		02C8	0271	029A	0287	
DB15		0273	022F	0210	0208	
DB16		02E7	0293	02AF	0291	
DB17		0283	0269	020B	0219	
DB18		02E2	02B7	0261	0282	
DB19		0285	0227	01D8	0220	
DB1A		02AB	0253	0236	02A3	

DB1B		0233	01F7	01D4	01FF	
DB1C		0292	0253	0269	024B	
DB1D		0249	0240	01F5	01E2	
DB1E		02C8	027E	0288	026F	
DB1F		024E	0202	0205	01E5	
DB20		02A4	0257	0284	0256	
DB21		0249	01F9	0202	01EE	
DB22		029B	023D	027D	0280	
DB23		0235	0239	01F5	01EA	
DB24		0274	0226	027F	0256	
DB25		0220	01D9	01ED	01E1	
DB26		0288	020A	0273	0265	
DB27		023D	01D4	01C9	01D4	
DB28		029A	026B	021F	023A	
DB29		0243	0234	01A8	01CC	
DB2A		0293	024B	021F	024A	
DB2B		0250	0207	01BC	01D0	
DB2C		02A8	0247	0232	0241	
DB2D		0259	01EF	01D0	01DD	
DB2E		02C6	0282	0247	0269	
DB2F		026C	0263	01EF	01FF	
DB30		02C6	0294	0278	0269	
DB31		0280	0264	0209	01DA	
DB32		02BA	0279	027C	021E	
DB33		025A	0214	01E5	01D1	
DB34		02AC	0264	024F	0273	
DB35		0251	020A	01E4	0215	
DB36		02A4	0279	0249	027E	
DB37		026F	020D	01FC	023A	
DB38		02F7	0430	0202	01ED	

3.7.6.2.13 Fit parameters for veto/anode ratio, upper limits.(9)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DB40		04B0	04B0	04B0	04B0	
DB41		04B0	04B0	04B0	04B0	
DB42		044F	0494	0503	05A8	
DB43		0383	03CD	040C	045E	
DB44		0295	02B7	0304	0320	
DB45		007B	0099	0058	00CF	
DB46		00AC	00DB	00C0	00E8	
DB47		00C3	00EE	00EE	0125	
DB48		00C1	00DF	00DD	0111	
DB49		009B	00B8	009A	00D2	
DB4A		000B	004F	0000	0063	
DB4B		009A	00C3	00C5	00DC	
DB4C		00C2	00F5	0107	011C	
DB4D		00BE	00FA	00EC	0118	
DB4E		00B0	00DC	00C2	010C	
DB4F		0078	009F	0086	00E5	
DB50		00EF	012D	0113	0192	
DB51		0117	0157	013B	0178	
DB52		010A	014E	012D	0161	
DB53		00DE	0111	00F1	0137	
DB54		005B	009E	004E	00C3	
DB55		008F	00C9	00AD	0107	
DB56		00BB	00E9	00D2	0117	
DB57		00B3	00E9	00CC	00FF	
DB58		0095	00BD	00A4	00EA	
DB59		003C	0075	0035	00BC	
DB5A		0080	00AF	008C	00B1	
DB5B		0099	00D6	00B1	00F1	
DB5C		0094	00D3	00A6	00D8	
DB5D		0078	009D	0086	00AC	
DB5E		0042	006F	002C	00B3	

DB5F		0091	00CB	009C	00D5	
DB60		00AC	00E8	00C1	00FA	
DB61		00B5	00F0	00C4	010B	
DB62		0096	00DC	00A3	00E3	
DB63		0058	008F	0047	00C8	
DB64		00DC	0118	00E5	0135	
DB65		0101	013A	0120	0158	
DB66		0110	014E	012B	0176	
DB67		00FF	013C	0105	0174	
DB68		0097	00C2	00A1	0130	
DB69		0081	00B8	00B8	0104	
DB6A		0099	00D7	00E3	0123	
DB6B		00A6	00DF	00DB	011D	
DB6C		0077	00AD	00A5	00E3	
DB6D		0008	0033	FFFF	007D	
DB6E		006C	008F	0093	00C4	
DB6F		0097	00DB	00CE	00FE	
DB70		00A7	00D8	00DF	0118	
DB71		0096	00D4	00BB	00EB	
DB72		005A	008F	004B	00D3	
DB73		026B	02AF	029E	0340	
DB74		034B	03CE	03D0	046E	
DB75		042D	0475	04A5	0550	
DB76		04B0	04B0	04B0	04B0	
DB77		04B0	04B0	04B0	04B0	

3.7.6.2.14 Fit parameters for veto/anode ratio, lower limits.(10)

Memory location	Function	S/W default	FM1 values	FM2 values	QMR values	
DB80		03E8	03E8	03E8	03E8	
DB81		03E8	03E8	03E8	03E8	
DB82		0341	037F	03B2	02AB	
DB83		02A9	0335	02F7	025A	

DB84		0140	010F	012B	00F1	
DB85		FF7B	FF70	FF89	FF40	
DB86		0022	0004	0032	FFFB	
DB87		006F	0056	0076	0029	
DB88		0052	004D	0065	0021	
DB89		FFE8	FFE2	FFFA	FFC8	
DB8A		FF82	FF48	FF73	FF31	
DB8B		0004	FFE2	FFEF	FFD4	
DB8C		005E	003E	004B	0026	
DB8D		0076	0044	0079	0037	
DB8E		000A	FFEC	0027	FFD2	
DB8F		FF8D	FF75	FF8D	FF3F	
DB90		006F	0043	0083	FFE9	
DB91		00A9	0086	00CB	007E	
DB92		00A0	0077	00BB	0073	
DB93		0044	0028	0059	0006	
DB94		FFC5	FFA0	FFD4	FF80	
DB95		002F	0005	0030	FFD9	
DB96		0051	0035	0064	0013	
DB97		0052	0029	005E	0021	
DB98		0016	FFF8	0020	FFD9	
DB99		FFC5	FF95	FFC6	FF64	
DB9A		000B	FFEE	0010	FFE8	
DB9B		0037	000C	0041	FFF8	
DB9C		002E	FFFE	003A	0000	
DB9D		FFFF	FFE7	000A	FFDF	
DB9E		FFAA	FF82	FFBF	FF59	
DB9F		0002	FFDA	001F	FFD7	
DBA0		0048	001D	0059	0013	
DBA1		004C	0021	005C	000C	
DBA2		0020	FFE1	0022	FFE4	
DBA3		FFBD	FF9F	FFCF	FF6C	
DBA4		0037	0011	0051	FFFB	

DBA5		00A2	0083	00AB	006B	
DBA6		00A8	0086	00BE	006B	
DBA7		0055	0034	007D	0001	
DBA8		FF72	FF58	FF5E	FF03	
DBA9		FFE7	FFC1	0020	FFCD	
DBAA		003E	000F	0073	0024	
DBAB		003E	0010	006D	001C	
DBAC		FFF8	FFCC	000B	FFC6	
DBAD		FF70	FF4C	FF74	FF13	
DBAE		FFEE	FFDA	FFFA	FFCB	
DBAF		0038	000F	0060	0029	
DBB0		0042	0023	0071	002C	
DBB1		0028	FFFB	0034	FFF5	
DBB2		FF6B	FF60	FF91	FF33	
DBB3		00F1	00D2	0108	00C1	
DBB4		0278	0240	024C	0253	
DBB5		0361	037A	0384	0309	
DBB6		03E8	03E8	03E8	03E8	
DBB7		03E8	03E8	03E8	03E8	

3.7.6.3 List of DFEE float software parameters
Start address in DFEE memory: D600 (hex)

3.7.6.3.1 Amplifier gain values, organized to facilitate rapid processing.

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
0	separator	0000 0000	0000 0000	0000 0000	0000 0000	
1	separator	0000 0000	0000 0000	0000 0000	0000 0000	
2	anode slow	4000 0001	4000 0001	4000 0001	4000 0001	
3	anode fast	7C28 F500	4000 0001	4000 0001	4000 0001	
4	veto	4000 0001	4000 0001	4000 0001	4000 0001	
5	separator	0000 0000	0000 0000	0000 0000	0000 0000	
6	backplane 0	4000 0001	4000 0001	4000 0001	4000 0001	
7	backplane 1	4000 0001	4000 0001	4000 0001	4000 0001	
8	backplane 2	4000 0001	4000 0001	4000 0001	4000 0001	

9	backplane 3	4000 0001	4000 0001	4000 0001	4000 0001	
10	backplane 4	4000 0001	4000 0001	4000 0001	4000 0001	
11	backplane 5	4000 0001	4000 0001	4000 0001	4000 0001	
12	backplane 6	4000 0001	4000 0001	4000 0001	4000 0001	
13	backplane 7	4000 0001	4000 0001	4000 0001	4000 0001	
14	backplane 8	4000 0001	4000 0001	4000 0001	4000 0001	
15	backplane 9	4000 0001	4000 0001	4000 0001	4000 0001	
16	backplane 10	4000 0001	4000 0001	4000 0001	4000 0001	
17	backplane 11	4000 0001	4000 0001	4000 0001	4000 0001	
18	backplane 12	4000 0001	4000 0001	4000 0001	4000 0001	
19	backplane 13	4000 0001	4000 0001	4000 0001	4000 0001	
20	backplane 14	4000 0001	4000 0001	4000 0001	4000 0001	
21	backplane 15	4000 0001	4000 0001	4000 0001	4000 0001	
22	backplane 16	4000 0001	4000 0001	4000 0001	4000 0001	
23	backplane 17	4000 0001	4000 0001	4000 0001	4000 0001	
24	backplane 18	4000 0001	4000 0001	4000 0001	4000 0001	
25	backplane 19	4000 0001	4000 0001	4000 0001	4000 0001	
26	separator	0000 0000	0000 0000	0000 0000	0000 0000	
27	separator	0000 0000	0000 0000	0000 0000	0000 0000	
28	cathode 0	4000 0001	4000 0001	4000 0001	4000 0001	
29	cathode 1	4000 0001	4000 0001	4000 0001	4000 0001	
30	cathode 2	4000 0001	4000 0001	4000 0001	4000 0001	
31	cathode 3	4000 0001	4000 0001	4000 0001	4000 0001	
32	cathode 4	4000 0001	4000 0001	4000 0001	4000 0001	
33	cathode 5	4000 0001	4000 0001	4000 0001	4000 0001	
34	cathode 6	4000 0001	4000 0001	4000 0001	4000 0001	
35	cathode 7	4000 0001	4000 0001	4000 0001	4000 0001	
36	cathode 8	4000 0001	4000 0001	4000 0001	4000 0001	
37	cathode 9	4000 0001	4000 0001	4000 0001	4000 0001	
38	cathode 10	4000 0001	4000 0001	4000 0001	4000 0001	
39	separator	0000 0000	0000 0000	0000 0000	0000 0000	

3.7.6.3.2 Anode-Cathode Correlation Factors

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
40		0000 0000	0000 0000	0000 0000	0000 0000	
41		47AE 14FB	47AE 14FB	47AE 14FB	47AE 14FB	
42		47AC 14FC	47AC 14FC	47AC 14FC	47AC 14FC	
43		5604 18FC	5604 18FC	5604 18FC	5604 18FC	
44		4189 37FA	4189 37FA	4189 37FA	4189 37FA	
45		72B0 20FC	72B0 20FC	72B0 20FC	72B0 20FC	
46		4189 37FD	4189 37FD	4189 37FD	4189 37FD	
47		4189 37FC	4189 37FC	4189 37FC	4189 37FC	
48		4189 37FC	4189 37FC	4189 37FC	4189 37FC	
49		4189 37FD	4189 37FD	4189 37FD	4189 37FD	
50		74BC 6AFC	74BC 6AFC	74BC 6AFC	74BC 6AFC	
51		49BA 5EFA	49BA 5EFA	49BA 5EFA	49BA 5EFA	
52		47AE 14FC	47AE 14FC	47AE 14FC	47AE 14FC	
53		449B A5FD	449B A5FD	449B A5FD	449B A5FD	
54		4189 37FD	4189 37FD	4189 37FD	4189 37FD	
55		4189 37FC	4189 37FC	4189 37FC	4189 37FC	

3.7.6.3.3 Miscellaneous Correction Factors

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	
56	Anode Strength	7AE1 47FB	7AE1 47FB	7AE1 47FB	7AE1 47FB	
57	Backplane 1.95 mm/strip	7CCC CC03	7CCC CC03	7CCC CC03	7CCC CC03	
58	Cathode 1.062 mm/strip	43F7 CE03	43F7 CE03	43F7 CE03	43F7 CE03	
59	Cath.-Back multiplier	4000 0001	4000 0001	4000 0001	4000 0001	
60	fast/slow ratio	4000 0000	4000 0000	4000 0000	4000 0000	

3.7.6.3.4 Cathode Backplane Coupling Factors

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
61		5999 9900				
62		587E 7C00				
63		552B D300				

64		4FA4 3F00				
65		47E6 C400				
66		7BE4 25FF				
67		638E 4BFF				
68		46CB 53FF				
69		4B37 C9FE				
70		0000 0000				

3.7.6.3.5 Various numerical constants

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
71	const. 1.0	4000 0001	4000 0001	4000 0001	4000 0001	
72	const. 50.0	6400 0006	6400 0006	6400 0006	6400 0006	
73	const. 200.0	7D00 000B	7D00 000B	7D00 000B	7D00 000B	

3.7.6.3.6 Read-out impedances

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
74	Read-out imped. 1.03	41EB 8501	41EB 8501	41EB 8501	41EB 8501	
75	Read-out imped. 1.05	4333 3301	4333 3301	4333 3301	4333 3301	

3.7.6.3.7 Parameters for nonlinear read-out

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
76		70A3 D7FC				
77		6666 66FB				
78		5999 9901				
79		7999 9900				

3.7.6.3.8 Parameters for energy correction

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
80		4CCC CC01				
81		9999 9A00				
82		6666 6600				

3.7.6.3.9 Parameters for backplane correction

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
83		4D6C 9AF7				
84		68F5 C2FF				
85		970A 3EFF				

3.7.6.3.10 Conversion parameters

Param. #	Function	S/W default	FM1 values	FM2 values	QMR values	PREF
86		6400 0005				
87		0000 0000				

3.7.6.3.11 The floating software parameters 88 - 99 are not used

All the above parameters are “Engineering” parameters which may need to be adjusted during the verification phase.

All hardware parameters and many individual software parameters are directly adjustable using TC(5,3) commands. Multiple adjustments af larger sets of parameters can be handled by the DFEE memory upload commands. The DFEE memory is only accessible through commands via the DPE.

3.7.7 TM Packet Structure and Content

3.7.7.1 TM allocation management

The JEM-X software will seek to optimize the usage of the available telemetry. The DPE IASW will interrogate the Broadcast Packet for the current TM allocation. Nominally, the TM allocation is 18 packets per polling cycle in total for the two JEM-X instruments early in the mission (at solar maximum conditions) and 16 packets per cycle later in the mission (at solar min). Each JEM-X instrument will transmit one HK-packet per polling cycle as long as the corresponding DPE is powered on, but otherwise the two instruments may be set up with different packet rates as long as the total allocation is respected.

The packet length is 440 bytes. The packet header occupies 6 bytes and the terminating CRC occupies 2 bytes. This leaves 432 bytes or 216 words per packet for the data field.

Prior to a new observation each JEM-X unit will be given a telemetry allocation and also instructed about which telemetry formats to use. The typical situation will be that both units are requested to use the “Full Imaging Format” as the primary format. Then, as the secondary format, which will be used if the count rate exceeds what can be handled in the full format, one unit may be set up to use “Restricted Imaging”, the other “Spectral Timing”. Should the count rate exceed also the capacity of the secondary format, then the grey filtering process will be activated.

Grey Filtering

If the input data rate exceeds the rate at which data can be transmitted the DPE software will autonomously select an alternative format or, if the telemetry capacity problem persists for the alternative format, activate the “grey filtering” event rejection process in the DFEE, whereby a certain fraction of the DFEE input triggers are rejected. The grey filter process can operate with 32 different transmission fractions. The 32 filters are numbered from 0 to 31, and the filter transmission fraction, F, is calculated as: $F = (N + 1) / 32$, where N is the filter number.

3.7.7.2 Format for time stamping of the telemetry packets.

Time information is given at the beginning of each packet. A 40 bit format is used beginning in bit 8 of the first word. The least significant bit (of the third word) is counting in units of 1/65536 s. In this way the least significant bit of the second word will be counting in units of 1 s, making the format compatible in this respect with a standard, two-word, data field header.

The precision of the timing of the individual X-ray events in JEM-X is 1/8192 s. Therefore the least significant 3 bits of the 40 bit time should be considered as spare bits and are not to be used in the data analysis.

<table>
<tr><td colspan="6">Packet Header</td></tr>
<tr><td colspan="2">Version no.
[3]</td><td>type
[1]</td><td>flag
[1]</td><td colspan="2">APID [11]</td></tr>
<tr><td>sequ.fl.[2]</td><td colspan="5">sequence count [14]</td></tr>
<tr><td colspan="6">packet length [16]</td></tr>
<tr><td colspan="6">Data Field Header</td></tr>
<tr><td colspan="2">packet type [4]</td><td colspan="2">subtype[4]</td><td colspan="2">Note: NONSTANDARD time [8] (unit 65536 s)</td></tr>
<tr><td colspan="6">time [16] (unit 1 s)</td></tr>
<tr><td colspan="5">time [13] (unit 1/8192 s)</td><td>spare [3]</td></tr>
<tr><td colspan="6">Data Field</td></tr>
<tr><td colspan="6">data 212*[16]</td></tr>
<tr><td colspan="6">CRC</td></tr>
</table>

JEM-X Science-TM packet header layout with nonstandard Data Field Header.

3.7.7.3 Full Imaging Format

APID: 110 0100 1000 [Bin], =1608 (JEM-X unit 1)
110 1100 1000 [Bin], =1736 (JEM-X unit 2)

In the Full Imaging Format each event is described in two (or three) words:

X position bits 0-7	Y position bits 8-15	Processed pulseheight bits 0-7	Delta time relative to prev. event[3]. (The value 255 indicates that an extra word follows). bits 8-15	Delta time extension (Only present if 8 bits are insufficient)
8 bits	8 bits	8 bits	8 bits (time unit 1/8192 s)	(16 bits) **Note 1**

Full Imaging Format

#	Content	Word	Bit pos	Length bits	Comment
1	Type Subtype = 0000 1000 [Bin]	0	0	8	
2	OBT of 1.st event	0	8	40	format: see 3.7.7.2
3	No. of events in packet	3	0	16	Variable event format !
4	Grey filter # for first event in packet.	4	0	16	**Note 2**
5	Event data (- 105 events)	5-215	0	3676	
6	CRC	216	0	16	Provided by CSSW

Note 1. *If two events are separated by more than 8 s then the delta-time cannot be described in 16 bits. In this case the timing information for the remaining events in this packet will be lost. The delta time extension will contain FFFF[Hex].This situation should only occur when the data stream from the DFEE for one reason or another stops for a period. If no events have been received for a full Housekeeping-cycle the unfilled packet will be transmitted. This will be the situation when the data transmission from the DFEE to the DPE has terminated completely.*
Note 2. *If a change of Grey filter occurs in the middle of a packet the position of the change will be indicated by inserting a marker event (a grey filter change report) with the X and Y positions equal to zero (this cannot happen for a real event) and with the new grey filter number in the second word. These marker events are included in the event count indicated in the packet header.*
Note 3. *Delta time is relative to previous "true" event. Grey filter marker events are ignored in the calculation of delta times.* ***The delta-time of the first event in each packet is relative to the last event of the previous packet. This allows verification of the stability of the instrument time to OBT correlation.***

3.7.7.4 Restricted Imaging Format

APID: 110 0101 1000 [Bin] =1624 (JEM-X unit 1)
110 1101 1000 [Bin] =1752 (JEM-X unit 2)

The restricted imaging format may be used when the count rate exceeds the value which can be transmitted using the full imaging format. In this format the timing information for the individual events is discarded. As compensation, count rate packets will be generated whenever the restricted imaging format is in use. The countrate packet is described in section 3.7.7.5.

When the restricted imaging format is in use, about 2580 events are collected in a buffer in the DPE. The actual number of events to combine into one image is commandable. The events in the buffer are sorted according to their position in the image, using as a key the integer value: 256X+Y. (Both X and Y are scaled to the range 1 to 255).

The image data are then transmitted in nominally 8 TM-packets. For the first event in each packet the full X/Y position is given, and for the following events only the distance between event positions in the 65536 position array. The delta-positions are encoded in 5 bits. In cases where the 5 bits do not suffice, an additional 8 bit word is added. (Note that the value 31 in the 5 bit delta position is not a delta-value but a flag indicating that an ekstra 8 bit word follows). If even the 8 bit extension does not suffice to bridge the gap to the next event position a second, 16-bit extension word will be used.

For each event a 3 bit pulseheight value is also given. The 3 bit value is derived from the 8 bit pulseheight value used in the full imaging and spectral timing formats. See 3.7.5.2.1.20.

Event format in Restricted Imaging

Delta position (Δ)	Compressed pulseheight	Delta pos. extension (Δ') Only present if 5 bits does not suffice. (Δ is set to 31)	2. Delta position extension Only present if 8 bits does not suffice. (Δ' is set to 255)
5 bits	3 bits	(8 bits)	(16 bits)

A timeout function for the collection of the 2580 events (TBC) needed for one image will be initiated whenever data collection for a new image is started. If, after 32 seconds, less than the required number of events has been collected, the available image data will anyway be transmitted. This function assures that we do not wait indefinitely transmitting the last part of the data if the event data stream from the detector or from the DFEE is interrupted. Under normal circumstances the restricted imaging will only be invoked when the countrate exceeds the capacity of the full imaging format, - 100 counts/s.

Restricted Imaging Format

#	Content	Word	Bit pos	Length bits	Comment
1	Type Subtype=0001 1000 [Bin]	0	0	8	
2	OBT of first event in image	0	8	40	OBT format: see 3.7.7.2
3	No. of events in packet	3	0	16	
4	Grey filter, first event in image.	4	0	8	**Note 1**
5	Grey filter, last event in image	4	8	8	**Note 1**
6	Length of time interval covered by image	5 - 6	0	32	word 5: time unit 1 s. word 6: bits 0-13: time unit 1/8192 s bits 14-16: unused
7	XY pos for first event in packet.	7	0	16	8 bits X pos +8 bits Y pos.
8	XY pos for last event in packet.	8	0	16	8 bits X pos +8 bits Y pos
9	Sequence # of packet in image (8000[hex] added for last packet)	9	0	16	First packet in sequence has number 0.
10	Event data (-320 events)	10-215	0	3296	
11	CRC	216	0	16	Provided by CSSW

Note 1. *There is no way to indicate in this Restricted Imaging Format which events in the image have been recorded with a specific greyfilter value. However, in the corresponding countrate packet the time-evolution of the grey filter values can be followed.*

3.7.7.5 Count Rate Format

APID: 110 0111 1000 [Bin] = 1656 (JEM-X unit 1)
110 1111 1000 [Bin] = 1784 (JEM-X unit 2)

The countrate format cannot be used by itself. It will be automatically invoked when the restricted imaging format is used. The countrate packets will appear in between the packets of the restricted imaging format.Each time bin in the count rate packet is 125 ms wide.

In order to assure that the time bins in a count rate packet always align with other data (spectra transmitted in spectral format and time bins in other count rate packet blocks) the time bins will always begin when the DFEE time counter has zeroes in the lower 10 bits. This happens every 125 ms. The DFEE time counter is reset via a logic based on the BCP2 pulse, and therefore there will be a fixed relation between the OBT and all time bin start times.

Countrate Format

#	Content	Word	Bit pos	Length bits	Comment
1	Type Subtype = 0011 1000 [Bin]	0	0	8	
2	OBT of first time bin	0	8	40	format: see 3.7.7.2
3	8 grey filter specifiers (see be-low)	3	0	128	
4	# of time bins in this packet	11	0	16	.
5	Count rate in first time bin	12	0	16	
6	Delta-count rates (see text)	13-215	0	3248	
7	CRC	216	0	16	Provided by CSSW

The delta-countrates in the packet are coded into 8 bits (-127 to +126 with negative numbers in two-complement notation). If 8 bits does not suffice for a particular time bin, then a marker of +127 is placed in the first 8 bit followed by the full 16 bit countrate (not the difference!). The 16 bit value is placed in the buffer without any gap, even if it is not word aligned.

Format for greyfilter specifiers

Bit pos	Length (bits)	Content
0	5	Greyfilter number
5	11	Time bin number in packet where greyfilter takes effect The time bin number will allways be zero for the first specifier. The subsequent specifiers are only valid if time bin number is nonzero

3.7.7.6 Spectral Timing Format

APID: 110 0101 0000 [Bin] = 1616 (JEM-X unit 1)
110 1101 0000 [Bin] = 1744 (JEM-X unit 2)

In this format the imaging data for each event are discarded. The format is only suited for observations where one, strong source dominates the scene. The time difference between events are encoded in 8 bits. If that happens to be insufficient a value of 255 is given in the 8 bits and a full 16 bit word is added to encode the time difference. The pulseheight information is encoded in 8 bits.

Event format in Spectral/Timing

Processed pulseheight	Delta time (0 to 254)	Delta time extension. (If the delta time is larger than 254)
8 bits	8 bits (time unit 1/8192 s)	(16 bits)

Spectral/Timing Format

#	Content	Word	Bit pos	Length bits	Comment
1	Type Subtype = 0001 0000[Bin]	0	0	8	
2	OBT of first event	0	8	40	format: see 3.7.7.2
3	No. of events in packet	3	0	16	No. of events is variable due to variable event format
4	Grey filter # for first event	4	0	16	**Note 1**
5	Event data (- 210 events)	5-215	0	3376	
6	CRC	216	0	16	Provided by CSSW

Note 1. *If a change of Grey filter occurs in the middle of a packet the position of the change will be indicated by inserting a marker event with an pulseheight value of zero and the new grey filter number will be inserted in place of the Delta time. Such marker events will be included in the event count indicated in the packet header.*

The delta-time of the first event in each packet is relative to the last event of the previous packet. This allows verification of the stability of the instrument time to OBT correlation.

3.7.7.7 Timing Format

APID: 110 0110 0000 [Bin] = 1632 (JEM-X unit 1)
110 1110 0000 [Bin] = 1760 (JEM-X unit 2)

In this format only the timing data for each event is retained. The format is only suited for observations where one, strong source dominates the scene. The time difference between events are encoded in 6 bits. If that happens to be insufficient a value of 63 is given in the 6 bits and a full 16 bit word is added to encode the time difference. It is inconvenient to mix the 6-bit and the 16 bit data items. We have therefore chosen to place the 16-bit delta-time extensions at the end of the packet data field - they will be placed in reverse order, so the first extension is placed in word 215, the next in word 214 and so on.

Note that up to 20 bits of each packet will be left unused. A count rate data item will not be inserted if there is less than 22 bits free in the packet as there would then be insufficient space to store a possible delta-time extension.

Event format in Timing

Delta time (Time unit =1/8192 s)	Delta time extension. (Only present if 6 bits does not suffice) These will be placed in reverse order at the rear of the packet. In this way we avoid to break the sequence of 6 bit values used for normal delta times.
6 bits	(16 bits)

Timing Format

#	Content	Word	Bit pos	Length bits	Comment
1	Type Subtype = 0010 0000 [Bin]	0	0	8	
2	OBT of first event	0	8	40	format: see 3.7.7.2
3	No. of events in packet	3	0	16	No. of events is variable due to the variable event format
4	Grey filter # for first event in packet.	4	0	16	**Note 1**
5	Event data (- 550 events)	5-215	0	3376	
6	CRC	216	0	16	Provided by CSSW

Note 1. *Changes in the grey filter cannot be guaranteed to happen only at packet boundaries. But if a change occurs in the middle of a packet the position of the change will be indicated by inserting a marker event with a Delta time equal 63 and a Delta time extension word equal to FFE0[Hex] plus the number of the new grey filter. This would correspond to a Delta time of more than 8 seconds which is extremely unlikely to occur since this format will only be used at event rates well in excess of 100 counts/s. Such marker events will be included in the event count indicated in the packet header.*

The delta-time of the first event in each packet is relative to the last event of the previous packet. This allows verification of the stability of the instrument time to OBT correlation.

3.7.7.8 Spectrum Format

APID: 110 0110 1000 [Bin] = 1640 (JEM-X unit 1)
110 1110 1000 [Bin] = 1768 (JEM-X unit 2)

Note that the use of this format assumes that 8 packets per polling cycle is allocated to the unit!

In this format only the pulseheight information is transmitted. The format is only suited for observations where one, strong source dominates the scene. Spectra with 64 pulseheight channels are transmitted at a rate of 8 spectra per second. The 6-bit channel numbers are derived from the 8 bit pulseheight value used in the Full Imaging format by masking away the lower two bits. The 125 ms integration time intervals are aligned with the time bins used in the Count Rate format (see 3.7.7.5).

The content of each of the 64 spectral channels are allocated 4 bits in this format. Should a channel contain more than 14 counts the 4-bit value will be set to 15, and the full count value (truncated to 8 bits if necessary) will be placed in the next free 8 bit overflow field of this spectrum block.

Spectrum Format

#	Content	Word	Bit pos	Length bits	Comment
1	Type Subtype = 0010 1000 [Bin]	0	0	8	
1	OBT of 1st event in first spectrum	0	8	40	format: see 3.7.7.2
2	# of spectra in packet	3	0	16	May be less than 10 for last packet.
3	Unused	4	0	16	
4	Spectrum Block #1	5	0	336	
5	Spectrum Block #2	26	0	336	
6	Spectrum Block #3	47	0	336	
7	Spectrum Block #4	68	0	336	
8	Spectrum Block #5	89	0	336	
9	Spectrum Block #6	110	0	336	
10	Spectrum Block #7	131	0	336	
11	Spectrum Block #8	152	0	336	
12	Spectrum Block #9	173	0	336	
13	Spectrum Block #10.	194	0	336	
14	Unused	215	0	16	
15	CRC	216	0	16	Provided by CSSW

Format for each spectrum block

#	Content	Word	Bitpos	Length bits	Comment
1	Grey filter for first event in spectrum	0	0	16	
2	64 channel pulseheight spectrum (4 bits/ch)	1 - 16	0	256	
3	8 overflow fields (8 bits each)	17 - 20	0	64	

3.7.7.9 Calibration Format

APID: 110 0100 0001 [Bin] = 1601 (JEM-X unit 1)
110 1100 0001 [Bin] = 1729 (JEM-X unit 2)

In this format all the 34 ADC read-outs from the JEM-X detector analog chains are transmitted as raw values. Marker events are used in this format to signal new values for the calibration amplitude and for the “Events per step” parameter. These marker events are included in the calibration data packets. "Filler" event may be needed in the last calibration data packet. The marker and filler events are described in section 3.7.4.5.2.

Event Format for Calibration

#	Content	Word	Bit pos	Length	Comment
1	delta OBT rel. to first event in packet	0	0	16	precision: 1/8192 s
2	Slow Anode signal	1	0	16	A value of 0xFFFF (hex) signals a Marker- or Filler-event.
3	Fast Anode signal	2	0	16	Marker events have 3 here Filler events have 1 here
4	Veto signal	3	0	16	Marker events contain the new calibration amplitude here. Filler events: 0 here
5	20 x Backplane signals	3700 3	0	320	Marker events contain the number of events /step in place of the first Backplane data word. Remaining wrds: 0. Filler events: all 0
6	11 x Cathode signals	24-34	0	176	Marker and filler events : all 0

TM-Format for Calibration

#	Content	Word	Bit pos	Length	Comment
1	Type Subtype = 0000 0001 [Bin]	0	0	8	
2	OBT of 1.st event	0	8	40	format: see 3.7.7.2
3	Calibrator amplitude	3	0	16	
4	Events per amplitude step	4	0	16	
5	Anode switch status	5	0	16	in bits 12-15
6	Data for 6 events	6-215	0	3360	
7	CRC	216	0	16	Provided by CSSW

Due to a known and understood hardware peculiarity in the trigger pulses used for the electronic calibration the hardware trigger counter will count every calibration pulse twice.

3.7.7.10 Diagnostic Dump Format

APID: 110 0100 0010 [Bin] = 1602 (JEM-X unit 1)
110 1100 0010 [Bin] = 1730 (JEM-X unit 2)

In this format all the 34 ADC read-outs from the detector analog chains are given as raw values. In addition the result of the DFEE analysis: i.e.the rejection cause or the final "Full Imaging Format" data.

Event Format for Diagnostics

#	Content	Word	Bit pos	Length bits	Comment
1	HK cycle counter	0	0	16	prec: 8 s
2	DFEE timer value	1	0	16	prec: 1/8192 s
3	Processed anode pulseheight	2	0	16	
4	Calculated back plane position	3	0	16	
5	Calculated cathode position	4	0	16	
6	Fast anode signal (raw)	5	0	16	
7	Slow anode signal (raw)	6	0	16	
8	Fast anode signal (raw)	7	0	16	
9	Veto signal	8	10	16	
10	Backplane signals (20)	9	0	320	
11	Cathode signals (11)	29	0	176	
12	Processing status word	40	0	16	0 if accepted, 1 to 13 if rejected, (see text below)
13	0-3: Calibration event FFFF[Hex]: Not calib. event,	41	0	16	Marks events from one of the four calibration sources

The low byte of the “Processing Status” is zero for an accepted event and can take on the following following values according to the rejection cause for rejected events:

1: High "slow-anode" signal
2: High "fast-anode" signal
3: "fast anode"/"slow anode" low
4: "fast anode"/"slow anode" high
5: Too many hits in cathode plane (this test will be disabled through code correction patch)
6: "Cathode"/"slow anode" low
7: "Cathode"/"slow anode" high
8: "Veto"/"slow anode" low
9: "Veto"/"slow anode" high
10: "Backplane"/"slow anode" low
11: "Backplane"/"slow anode" high
12: Cathode position out of range
13: Backplane position out of range

The high byte of this word is not used.

TM-Format for Diagnostic

#	Content	Word	Bit pos	Length bits	Comment
1	Type/Subtype = 0000 0010 [Bin]	0	0	8	
2	OBT of 1.st event	0	8	40	format: see 3.7.7.2
3	Number of events in block	3	0	16	
4	Spare	4	0	16	
5	Anode Switch Status	5	0	16	in bits 12-15
6	Event data (5 events)	5-214	0	3360	
7	CRC	216	0	16	Provided by CSSW

3.7.7.11 DPE Memory Dump Format

APID: 110 0000 0000 [Bin] = 1536 (JEM-X unit 1)
110 1000 0000 [Bin] = 1664 (JEM-X unit 2)

The detailed format as determined by the CSSW is given in Appendix I.

Bit 0					Bit 47		Bit 48					var.
PACKET HEADER (48 bits)							**PACKET DATA FIELD** (variable (max 426) octets)					
PACKET ID				PACKET SEQUENCE CONTROL		PACKET LENGTH	DATA FIELD HEADER					
Version number	Type	Data field header flag	Application process ID	Segmen-tation Flag	Sequence Count		Pckt type	Pck tsub type	spare	time	Memory dump data	Packet error ctrl.
length 3 bits	length 1 bits	length 1 bits	length 11 bits	length 2 bits	length 14 bits	length 16 bits	len. 4 bits	len. 4 bits	len. 8 bits	len. 16 bits	length max 3360 bits	length 16 bits
value 4	value 0	value 1	value 1542 or 1670	value 3	value variable	value variable (max 425)	val. 6	val. 2	val. 0	val. var.	value variabl.	val var

Memory Dump Telemetry Packet Structure

3.7.7.12 DFEE Memory Dump Format

APID: 110 0000 0110 [Bin] = 1542 (JEM-X unit 1)
110 1000 0110 [Bin] = 1670 (JEM-X unit 2)

The detailed format is the same as the one given above, memory dumps from the DFEE will be routed via a designated area in the DPE memory. As far as the structure of the format goes, the packets will therefore appear as DPE memory dump packets.

3.7.7.13 Housekeeping Telemetry

The housekeeping TM packet contains three parts: the IASW HK part, the On-Event Messages part and the CSSW HK part. This chapter describes the IASW part of the HK packet, it consists of five blocks of information:

- Variables desribing the state of IASW,
- DPE housekeeping - readouts from analog input lines,
- Latest DFEE housekeeping,
- Latest BCPKT block,
- Continuation of IASW state variables + diagnostics.

Start (byte. bit#)	Size bits	SDB TM_ PREP	Content
			State of IASW
0	16	K5359	EVENT SIZE (0, 5, 36 or 42) (or 6, 37, 43 in test state)
2	8	K5381	ACTUAL SHUTDOWN LEVEL
3	8	K5382	WANTED SHUTDOWN LEVEL
4	8	K5362	PRIMARY FORMAT
5	8	K5363	SECONDARY FORMAT
6	16	K5303	ACTIVE FORMAT (=1 - primary, =2 - secondary)
8	8	K5402	COMMANDED GREY FILTER
9	8	K5364	REPORTED GREY FILTER (received from HSL)
10	16	K5365	HSL BUFFER SIZE (number of words actually in the buffer)
12	16	K5366	HSL BUFFER INDEX (position of taking data from the buffer)
14	16	K5367	TIME SINCE READOUT (time in units of 8 secs. from the last HSL readout)
16	16	K5368	EVENTS TRANSFERRED (number of events received in last BCP1 period)
18	8	K5458	Auto Recovery Level (See section 3.7.5.2.1.16)
19	8	K5582	CPU mode recovered (See section 3.7.5.2.1.16)
20	16	K5371	EVENTS IN BUFFER (number of events stored in the DPE's buffer)
22	32	K5301	TOTAL EVENTS (total number of events read)
26	16	K5372	MEMORY PATCHES (number of DFEE mem. patches stored in DPE)
28	48	K5305	PARAMETERS OBT (time of last modification of DFEE's parameters)
34	16	K5349	JEM-X IASW Status (=1: IASW startet / =0: IASW not started)
			mRTU Housekeeping Note: Legal analog readouts range is 0 .. 255. The value 256 is inserted if an error occurs during the reading of an analog channel.
36	16	K5101	ANA8 - Detector pressure#1
38	16	K5102	ANA9 - Detector pressure#2
40	16	K5103	ANA10 - Detector temperature, TH8
42	16	K5104	ANA11 - Detector temperature, TH9
44	16	K5105	ANA0 - Voltage +5V Digital supply
46	16	K5106	ANA1 - Current +5V Digital supply
48	16	K5107	ANA2 - Voltage +5V Analog supply
50	16	K5108	ANA3 - Voltage -5V Analog supply
52	16	K5109	ANA4 - Voltage +12V
54	16	K5110	ANA5 - Current +12V
56	16	K5111	ANA6 - Voltage -12V

58	16	K5112	ANA7 - Current -12V
60	16	K5113	Connector J01 temperature, TH0
62	16	K5114	CPU board temperature, TH1
64	16	K5115	LVPS cooling bridge temperature, TH2
66	16	K5116	DDHK board temperature, TH3
68	16	K5117	Motherboard at ANOD connector temperature, TH4
70	16	K5118	Motherboard at ANA2 board temperature, TH5
72	16	K5373	ANA12 - FIFO Flag
74	16	K5379	ANA13 - HV Power Supply Temperature, TH6
76	16	K5380	ANA14 - HV Power Supply Temperature, TH7
78	16		ANA15 - Spare
80	16		Spare#2 = 7777 [Hex]
DFEE Housekeeping Note: The following is an exact copy of the HK block received from DFEE.			
82	16	K5374	HK Cycle Counter
84	16	K5022	DFEE State. This parameter will not always correspond to the commanded state. F.i. when the HV-Arm command is given this parameter will be 6 , (not 5, as corresponding to the Set-Up state)
86	8	K5007	Low Level Discriminator
87	4	FIX	
87,4	1	K5006	Anode configuration, Anode 4 =On/Off
87,5	1	K5005	Anode configuration, Anode 3 =On/Off
87,6	1	K5004	Anode configuration, Anode 2 =On/Off
87,7	1	K5003	Anode configuration, Anode 1 =On/Off
88	16	K5001	Delta HV monitoring, (dV) (May differ from requested value during HV start-up and following HV hardware switch off)
90	16	K5002	Cathode HV monitoring, (V_C) (May differ from requested value during HV start-up and following HV hardware switch off)
92	4	K5580	Requested Cathode HV setting, (V_C), high order 4 bits
92,4	4	K5376	Requested delta HV setting, (dV), high order 4 bits
93	4		Requested delta HV setting, (dV), low order 4 bits
93,4	4	K5581	Requested Cathode HV setting, (V_C), low order 4 bits
94	16	K5119	Number of software processed event triggers
96	16	K5377	Number of accepted events
98	16	K5121	Number of events rejected by grey filter
100	16	K5136	Number of events rejected due to lack of buffer space
102	16	K5135	Number of events rejected due to FIFO full
104	16	K5123	Number of events rejected by anode signal amplitude checks
106	16	K5125	Not used
108	16	K5128	Number of events rejected by risetime check (crude)
110	16	K5127	Number of events rejected by risetime check (fine)
112	16	K5130	Number of events rejected by veto signal (fine)
114	16	K5100	Events **accepted** as coming **from** one of the four **radioactive sources**
116	16	K5134	Number of events rejected by too high signal in back plane peak
118	16	K5132	Number of events rejected by too low signal in back plane peak
120	16	K5133	Number of events rejected by too high signal in cathode plane peak
122	16	K5131	Number of events rejected by too low signal in cathode plane peak
124	16	K5200	Calibration spectrum partition number. See note at end of table.

126	32 x 16	K5201 - K5238	32 words of calibration spectrum. See note at end of table.
190	8	K5584	HV-off caused by a hardware signal processed via the DFEE CPU-board. Set to 1 of the HV-unit is switched off via the mRTU or due to high count rate condition in the JEM-X detector (both H/W ratemeter and S/W check). Reset to 0 next time the HV-unit is commanded from the ground. This flag does not report a switch-off via the RTU relay command directly to the High-Voltage converter unit. (see section 6.1.7)
191	8	K5583	CPU Mhz/waitstate indicator: 0 Y 8/1; 1 Y 8/0; 2 Y 16/1; 3 Y 16/0;
192	16	K5449	Hardware event trigger counter **(The primary channel for monitoring of the detector performance. This counter is enabled whenever the DFEE is powered up)** Due to a known and understood hardware peculiarity in the pulses used for the electronic calibration this counter will count every calibration pulse twice. Signals from the detector will be counted correctly.
194	16		Spare#3 = AAAA [Hex]
BCPKT Packet			
196	32	K5307	"Radiation belts entry" time
200	32	K5308	"Radiation belts exit" time
204	32	K5306	"Entry into eclipse" time
208	32	K5319	"Exit from eclipse" time
212	16	K5322	flag in bit 0: "Disregard Radiation Monitor Data" (if equal to 1) bits 1 to 15 are all set to 0
214	16		Spare (set to 0)
216	16		Spare (set to 0)
218	16		Spare (set to 0)
220	16		Spare (set to 0)
222	16	K5330	Pointing ID (Orbit number)
224	16	K5331	Pointing ID (Number within orbit)
226	32	K5323	Pointing duration (s)
230	8	K5324	TM share for SPI instrument (packets / polling cycle)
231	8	K5325	TM share for IBIS instrument
232	8	K5326	TM share for JEM-X1 instrument
233	8	K5327	TM share for JEM-X2 instrument
234	8	K5328	TM share for OMC instrument
235	8	K5314 K5329	flag in bit 8: "Instrument imminent switch off" (if equal to 1) flag in bit 9: "Ground station hand-over" (if equal to 1) bits 10 to 15 are all set to 0
236 - 247	96		Spare words (6) All set to 0
248	16	K5315	Radiation monitor count rate #1 (protons)
250	16	K5316	Radiation monitor count rate #2 (dose)
252	16	K5317	Radiation monitor count rate #3 (electrons)

254	16	K5311 K5312	flag in bit 0: "On-target flag" (if equal to 1) bits 1 to 11 are all set to 0 Attitude control mode indicator value in bits 12 to 15: 0000: AOCS inactive 0001: AOCS standby 0010: Initial sun acquisition 0011: Sun-sensor acquisition 0100: Star-tracker acquisition 0101: Inertial pointing 0110: Thruster control
256	16	 K5320 K5321	bits 0 and 1 are set to 0 flag in bit 2: "Emergency Safe Acquisition Mode" (if equal to 1) bits 3 to 10: are all set to 0 Point/Slew Instrument Pointing System sub-modes in bits 11 to 15: 00110: Sun-steering law (nominal pointing) 00111: Closed loop slew 01111: Open loop slew
258	16		bits 0 to 15 all set to 0
260	16		bits 0 to 15 all set to 0
262	16		bits 0 to 15 all set to 0
264	16		Spare#4 = FFFF[Hex]
State of IASW (continuation)			
266	16	 K5369 K5370 K5585 K5586 K5456 K5457	16 bit flags: bit#0 - not used bit#1 - not used bit#2 - not used bit#3 - not used bit#4 - not used bit#5 - not used bit#6 - "HSL Synchronization lost" (=1) bit#7 - "HSL request from DPE" bit#8 - " Master Error Flag" bit#9 - not used bit#10 - flag "Automatic Selection of Grey Filter", bit#11 - flag "Buffer Locked", bit#12 - semaphore for Big Buffer, bit#13 - not used bit#14 - not used bit#15 - not used
268	16	K5481	Counter of OEMs rejected because of filtering,
270	16	K5482	DFEE Reference State kept in IASW (May differ from actual DFEE state, f.i. after "HV Arm" command. or when operating the DPE in the test data states: 11, 21 and 41)
272	16		16 bit flags "Disable Check" for BCPKT
274	16		16 bit flags "Error Condition" for BCPKT
276	16		16 bit flags "Disable Check" for mRTU
278	16		16 bit flags "Error Condition" for mRTU
280	8	K5541	Counter of activity of Task MAIN
281	8	K5542	Counter of activity of Task TC
282	8	K5543	Counter of activity of Task HSL
283	8	K5544	Counter of activity of Task SC_OUT
284	8	K5545	Counter of activity of Task HK
285	8	K5546	not used, constant 0
286	8	K5547	Counter of activity of Task REQ_OUT
287	8	K5548	Counter of activity of Task STATE
CSSW Housekeeping TM			

290	144		9 spare words (all 0)
308	8	K9018	Number of occupied CSSW ICB Sub-Buffer positions
309	8	K9053	Number of occupied IASW ICB Sub-Buffer positions
310	8	K9019	Number of occupied ICB Science TM Sub-Buffer positions
311	8	K9020	Number of occupied ICB On-Request TM Sub-Buffer positions
312	8	K9021	Number of occupied ICB On-Event Message Sub-Buffer positions
313	8		Unused (all 0)
314	8	K9022	Minimum Percentage CPU Margin in previous TM cycle
315	8	K9023	Maximum Percentage CPU Margin in previous TM cycle
316	16	K9024	BCP4 Frozen Time (Most Significant Word)
318	16	K9025	BCP4 Frozen Time (Mid Significant Word)
320	16	K9026	BCP4 Frozen Time (Leasst Significant Word)
322	8	K9027	DC 5V Secondary Voltage
323	8	K9028	DC RAM 5V Secondary Voltage
324	8	K9029	DC 15V Relay Secondary Voltage
325	8	K9030	DC 15V Secondary Voltage
326	8	K9031	DC -15V Secondary Voltage
327	8	K9032	DPE Hot Point Temperature
328	16	 K9033 K9034 K9035	bits 0 to 11 all set to 0 "Periodic BIT results" indicator in bits 12 to 15: bit 12: Analog Channels (0: test failed, 1: test passed) bit 13: Unused bit 14: MMU Registers (0: test failed, 1: test passed) bit 15: CPU Registers (0: test failed, 1: test passed)
330	16	K9036	µP Configuration Register
332	16	K9037	PCC Control Register
334	16	K9038	RBI Status Word
336	16	K9039	RBI Configuration Register
338	16	K9040 K9041	bits 0 to 3: Number of On-event messages in the TM bits 4 to 15: Number of On-event messages which the DPE SW has attempted to generate since initialization. (wrap around counter)
340	80	K9101 -K9106	On-event message #1 (see 3.7.7.14)
350	80	K9107 -K9112	On-event message #2
360	80	K9113 -K9118	On-event message #3
370	80	K9119 -K9124	On-event message #4
380	80	K9125 -K9130	On-event message #5
390	80	K9131 -K9136	On-event message #6
400	80	K9137 -K9142	On-event message #7
410	80	K9143 -K9148	On-event message #8
420	8		Unused (all 0)

421	8	K9043	Accepted On-ground TCP counter
422	8	K9044	Accepted On-board TCP counter
423	8	K9045	Rejected TCP counter
424	8	K9046	Last TCP rejection reason: 0: Illegal APID 1: Wrong CRC 2: Invalid fixed (constant) field 3: ICB TC sub-buffer full 4: Not used 5: Wrong length
425	8	K9047	8 least significant bits of the APID in the last TCP
426	16	 K9048 K9049	bits 0 AND 1: not used (both 0) flag in bit 2: Source of last TCP (0: ground, 1: on-board) bits 3 to 15: Source sequence count of the last TCP

Note on the calibration data in the housekeeping block

The DFEE software identifies events localized under the four calibration sources (section 1.3.2.1.6). Four spectra with 256 channels are collected, one for each calibration source. The integration time is 32 polling cycles (256 s). A double buffer system is used so data are collected in four spectra while the data in the other four spectra are transmitted. Each HK-packet contains a "partition number" (between 0 and 31) and 8 channels from each of the four spectra. The channel positions in the restored spectra are defined by the partition number (8×partition number = start channel for the block of 8 channels). See section 3.7.4.2.1.1 for a more detailed description of the timing aspects of the calibration spectra.

Note that the data are only collected into the calibration spectra when the DFEE is in Data Taking or Diagnostic State. Note also that the rate of events collected from the calibration sources will be affected by the current transmission level of the "Grey Filter" mechanism, see section 4.1.8.5.

3.7.7.14 On Event Messages Telemetry

Each On Event Message occupies 5 words in the Housekeeping TM Packet:

Start (word. bit)	Size (bits)	Content
0 . 0	32	Time
2 . 0	6	Field#1
2 . 6	2	Class (0-Event, 1-Exception, 2-Major anomaly, 3-Failed TC Report)
2 . 8	8	Identifier
3 . 0	16	Field#2
4 . 0	16	Field#3

The identifier specifies a group of messages. For detailed specification whithin the group Field#1 is used.

The two fields - Identifier and Field#1 together forms the Message Cathegory. The cathegory is used in connection with the on-board prevention of the generation of cascades of identical or similar OEMs. For each of the possible cathegories the time of last issue is stored. Whenever a new request for generation of a OEM of a given cathegory is coming (from the IASW - the CSSW OEM's are not monitored!) the time is checked and too frequent generation is blocked. OEM of a given cathegory can be issued again only 10 seconds after the previous one.

Field#1 and field#2 follows the definition given in the INTEGRAL Packet Structure Definition document (INT-RP-AI-0030, Issue 6, 28-09-1999):

Field#2 - TC data header:
bits 0..7 - spare = 0,
bits 8..15 - 8 APID LSB
Field#3 - TC packet header - contains TCP Source Sequence Counter in bits 2..15

Field#1 bit 0-5	Class bit 6-7	Ident. Bit 8-15	Description
Group - Telecommand rejected			
1	Failed TC Report	128	Wrong field TYPE or SUBTYPE
2	Failed TC Report	129	Wrong field TID or FID
3	Failed TC Report	130	Wrong field MID
4	Failed TC Report	131	Wrong field ADDRESS
5	Failed TC Report	132	Wrong field LENGTH or wrong length of TC itself
6	Failed TC Report	133	Some other errors in the text of TC
7	Failed TC Report	134	DPE is busy - TC input queue is full
8	Failed TC Report	135	HW Command illegal because of shutdown in progress
9	Failed TC Report	136	State change illegal because of shutdown in progress
10	Failed TC Report	137	Execution started but failed
Group - Problems with HSL			
1	Major anomaly	151	Overflow
7	Exception	157	DFEE exception "HSL busy"
8	Major anomaly	158	CRC error
9	Major anomaly	159	Timeout
11	Event	154	Lost synchronization

Group - Problems with LSL			
1	Major anomaly	161	Overrun Field#2 - indicator word of the command Field#3 - indicator word of the answer
2	Event	162	Framing error Field#2 - indicator word of the command Field#3 - indicator word of the answer
3	Event	163	Parity error Field#2 - indicator word of the command Field#3 - indicator word of the answer
6	Exception	166	DFEE exception "LSL disabled"
7	Exception	167	DFEE exception "LSL busy"
9	Event	169	Timeout Field#2 - indicator word of the command Field#3 - indicator word of the answer
Group - Problems with Analog Acquisition			
5	Major anomaly	175	Error
7	Major anomaly	177	Busy
9	Major anomaly	179	Timeout
Group - Problems with communication with DFEE			
0	Major anomaly	180	Unexpected answer from DFEE Field#2 - indicator word of the command Field#3 - indicator word of the answer
1 .. 6	Event	181- -186	Request Acknowledge with the code 1..6 Field#2 - indicator word of the command Field#3 - indicator word of the answer
7	Major anomaly	187	Request Acknowledge with some other code Field#2 - indicator word of the command Field#3 - Request Acknowledge code
8	Event	188	CRC error Field#2 - indicator word of the command Field#3 - indicator word of the answer
9	Event	189	Unexpected DFEE state reported in HK Field#2 - expected state, Field#3 - reported state.
10	Event	190	Discontinuity in DFEE HK Cycle Counter (possibly DFEE reset) Field#2 - previous CC, Field#3 - current CC.
11	Event	191	Operation "Load DFEE context" unsuccessfull - check for CRC-s failed. Field#2 - specification of failed CRC's in bits 12 to 15: bit#15 = 1: failed CRC of Integer Parameter Table bit#14 = 1: failed CRC of Float Parameter Table bit#13 = 1: failed CRC of code area 9000 to 9FFF bit#12 = 1: failed CRC of code area B000 to CFFF
12	Major anomaly	192	Failure of pulse relay operation "HV Off"
Group - Problems with BCP1			
1	Major anomaly	201	BCP1 shorter than 7.5 sec
2	Major anomaly	202	No BCP1 after 8.5 sec
Group - Unexpected behaviour of IASW Field#2 contains id# of the task issuing the OEM			
1	Exception	211	Unexpected exception
2	Major anomaly	212	Problems with buffer software

3	Major anomaly	213	Problems with TC queue software
4	Major anomaly	214	Problems storing patches for the DFEE RAM in the DPE
Group - Unexpected behaviour of CSSW Field#2 contains id# of the task issuing the OEM			
1	Exception	221	Unexpected exception
2	Major anomaly	222	No RTC events
Group - Events when autonomous action of IASW			
1	Event	231	Shutdown initiated Field#2 - Actual level Field#3 - Target level
2	Event	232	Shutdown failed Field#2 - Actual level Field#3 - Target level
3		233	Recovery initiated Field#2 - Actual level Field#3 - Target level
4	Event	234	Recovery failed Field#2 - Actual level Field#3 - Target level
5	Event	235	New pointing - restart of data state Field#2,#3 - New Pointing ID
Group - Problems with Telemetry Field#2 contains APID of TM Packet which is source of problems			
1	Event	241	Count Rate TM Packet lost
Group - "Error-off " condition			
0	Event	254	Error off: Field #2 identifies subsystem for which the error contion has disappeared. 150 - HSL 160 - LSL 170 analog-to-digital conversion 188 CRC on LSL 189 DFEE Stae now as expected 200 BCP1 period correct

3.7.7.15 Software Diagnostic Telemetry APIDs: 1541 (JEM-X1) and 1669 (JEM-X2)

SW Diagnostic is generated on request in form of TM(5,4)/TID=1/FID=16. It can as well be produced periodically in the same form.
This TM packet contains set of counters of events, which are interesting for diagnostic ot the software. Each issue of this report clears the counters, so each report shows counts made between reports.

Start (word#)	Events counted
Group - TC	
0	Constant 1111 [Hex]
1	Received TC
2	Corrupted TC
3	Rejected TC
4	Timeout when reading TC
5	Timeout of BCP1
6	BCP1 too short
7	No RTC
Group - ADC	
8	Constant 2222 [Hex]
9	ADC readout
10	ADC error
11	ADC busy
12	ADC timeout
Group - LSL	
13	Constant 3333 [Hex]
14	Command sent
15	LSL error
16	CRC eror
17	LSL timeout
18	Aborted communication request
Group - HSL	
19	Constant 4444 [Hex]
20	HSL readout
21	CRC error
22	HSL timeout
23	HSL overflow
24	Lost synchronization
25	Constant 5555 [Hex]

3.7.7.16 HSL Synchronization Loss Diagnostic TM

This diagnostic TM is generated on request in form of TM(5,4)/TID=3/FID=1. It can also be produced automatically whenever the HSL synchronization is lost as indicated by the On Event Message #154. The automatic mode can be set/reset with use of TC(5,3)/TID=3/FID=1. By default this automatic mode is off.
The content of the diagnostic TM packet shows a fragment of HSL input buffer, where the loss of synchronization was detected.

Word #	Content
0	Event size+1 (6, 37, or 43). +1 is because in HSL buffer each event record is preceeded by the Event Marker = F000.
1	Number of words in the HSL input buffer. Usually it is a little more than 4096.
2	Buffer index, pointing the place, where synchronization was lost. Buffer is indexed starting with 0.
3	Offset of the dump. This shows the place in the HSL buffer where the dump start.
4..203	Dump of the fragment of HSL input buffer - up to 200 words.

This diagnostic TM is produced from data stored in a dedicated buffer, in which the HSL buffer is latched, when the synchronization loss is detected. Initially this buffer is empty, so this message should not be requested before an On Event Message has been received reporting about loss of HSL synchronization.

3.7.7.17 Test Format. APIDs: 1607 (JEM-X1) and 1735 (JEM-X2)

This data format may be used to diagnose problems with the data on the high speed line. The HSL data are passed on to the telemetry packets without any interpretation by the IASW. For this reason the OBT in the TM packet header is the OBT at the moment where the IASW create the TM packet, not the time of the first event contained in the packet.

Events will not be split across TM packet boundaries, events which cannot be fit into what remains of a packet will be placed at the beginning of the next packet. The event data are not compressed.

The test mode can be requested in two different ways:
1) By setting the format code to 90 when requesting the Data Taking state (see 3.7.5.2.3.4).
2) By selecting one of the test data states (see 3.7.5.2.3.7, ..8, ..9)

When using method 1 the DPE will read the event stream from the high speed line and will place the raw event data in the TM-packet without processing (5 16-bit words/event, 42 events/packet). This may be usefull for verifying/optimizing the tables used to translate the pulseheight and position data when operating in the normal full imaging format. This makes the full 12 bit resolution of the ADC and 10 bit resolution of the on-bard position calculation available on-ground.

When using method 2 the event synchronization is not checked on the high speed line. This allows to check the raw data on the high speed line. In this case the event length in the TM packets will be 6, 37 or 43 words/event (35, 5 or 4 events/packet), because the Event Start Marker (F000) is not removed in the TM stream.

The user must be prepared to accept some peculiarities when using the test data formats:
a) There is no way to distinguish which of the four event data formats is used in the test mode by looking at the TM data headers - this information is accessible only inside the data itself - and from the K/L5359 parameter in the HK-packet.

b) When using test data transmission in the Calibration or the Diagnostic states the IASW cannot reset the "Expected DFEE State" to "Setup" when the Calibration or Diagnostic terminates in the DFEE, because the DPE is not doing any checking the data.

This format is designed to be used primarily during development or in case of an in-flight contingency.

3.7.8 TM parameter description

Refer to the SDB.

3.7.9 CPU and memory budget

DPE CPU MA31750A

Usage: 65 % of 80 kword ROM
20 % of 2 Mword RAM

DFEE CPU MA31750A

Usage: 95 % of 8 kword ROM
75 % of 32 kword RAM

3.7.10 JEM-X Autonomous Functions

3.7.10.1 Hardware Autonomous Functions

3.7.10.1.1 DFEE Undervoltage Protection

This feature has been removed.

The undervoltage protection for the DFEE power converters has been disabled. The undervoltage protection is taken care of by the LCL circuit supplying the power to the DFEE.

3.7.10.1.2 JEM-X High Voltage Switch-Off by Internal Ratemeter

A hard wired ratemeter will switch off the high voltage to the JEM-X detector if the trigger counts exceeds 65535 over an 8 second period.

The ratemeter sensitivity is adjustable through the setting of the discriminator providing the input for the ratemeter (and the event trigger signal for instrument). This ratemeter will function even if the DFEE is in the SETUP state, since it is the raw trigger signals which are counted, not the processed triggers.

The disappearence of the high voltage will be detected by the DFEE software, which will report the HV-status to the DPE at the next transfer of the DFEE housekeeping data. The DPE IASW will then set the DFEE to the SAFE state. The state transition can be detected on the ground by inspecting the JEM-X housekeeping data (“DFEE State” parameter K/L5022). The cause for the state change (high count rate) is reported in K/L5584.

Autonomous recovery will not be invoked following a internal ratemeter induced switch off.

The hardware switch-off mechanism can be controlled in a number of ways. One is to disable one or more anode amplifiers. This mechanism has been employed in an attempt to cure a noise problem in the FM1. Another control possibility is to increase the threshold of the low level discriminator. Finally the mechanism can be fully disabled. This requires to uplink a software patch to the DFEE computer.

3.7.10.1.3 Reset of the DFEE processor by hardware Watchdog function.

A hardware watchdog circuit is implemented on the DFEE CPU board. The CPU will be reset if the running software have not transmitted an "aliveness" signal for 650 milliseconds. The aliveness signal will be generated every time the program executes its idle loop. This loop will executed at least once for every event being processed. The event processing time will be less than 500 microseconds. Aliveness signals are transmitted at short intervals also when the DFEE is in its Safe or Memory states.

The hardware watchdog circuit cannot be inhibited.

3.7.10.2 Software Autonomous Functions

3.7.10.2.1 JEM-X High Voltage Switch-Off by Software Ratemeter

A software ratemeter will switch off the high voltage to the JEM-X detector if the processed trigger counts exceeds a predefined limit (default value 25000) over an 8 second period. **Note that this ratemeter is only active when the DFEE is in the Normal Data Taking or Diagnostic states.**

The ratemeter sensitivity is adjustable through the choice of the limiting count and the setting of the discriminator providing the input for the instrument event trigger. The Grey Filter value does not affect the software ratemeter sensitivity.

The DFEE software will autonomously switch off the HV-unit if the maximum count is exceeded. The action is reported in the HK-parameter K/L5584.

Autonomous recovery will not be invoked following a software ratemeter induced switch off.

The software switch-off mechanism can be inhibited by patching the DFEE software.

3.7.10.2.2 Autonomous Transition to DFEE SAFE state (shut-down) according to Broadcast Packet

The DPE IASW will set the DFEE to the SAFE state when the Broadcast Packet indicates this to be necessary, such as at Radiation Belt Entry, Eclipse Entry, Radiation Monitor count rates out of range or Satellite Emergencies (ESAM, Instrument Switch-off Imminent).

A copy of the parameter values used by the DFEE is always kept in the DPE memory, to assure a full recovery of the current DFEE state following a power switch-off.

3.7.10.2.3 Autonomous Recovery from a shut-down.

If the autonomous recovery functionality is enabled the DPE IASW will restore the working state of the DFEE to the previously existing state when the condition causing the shut-down has disappeared (see sections 3.7.5.2.1.17 and -.18). During this recovery any updates to the DFEE software which are available in the DPE will be implemented before activating operational activities such as setting the high voltage and the transfer to the Normal Data Taking state.

The concept of the JEM-X context saving is the following: The baseline DFEE software, including a nominal set of parameters is kept in the DFEE PROMs. The DFEE default parameters will be copied to the DPE autonomously once after every DFEE switch-on, namely the first time a "Goto SETUP"-command is sent from the DPE to the DFEE. The first time this "Goto SETUP" command is sent from the DPE to the DFEE <u>after switch-on of the DPE</u>, the values of the default parameters will be stored as a reference in the DPE memory.

Any changes to the parameters, and any modifications to the basic code will come via commands from the ground. The IASW will update its copy of the parameter file according to the parameter commands and it will keep a complete record of all code correction commands. The DPE will re-issue the full list of corrections and command updates whenever the DFEE is switched on. Also the Anode configuration and the Low Level Discriminator setting will be restored autonomously.

When a parameter command is received the corresponding parameter in the DPE-copy of the parameter status will be updated. There is no limit to the number of such updates over the mission. The situation is different for memory load commands. If memory load commands are used to modify a parameter set, and later another memory load command is used to restore the parameter set to its original value then these two memory uploads will remain in the DPE list of memory uploads until the DPE memory is erased by power cycling the unit. A maximum of 150 memory load command sequences can be stored in the DPE.

An error message (OEM) will be issued if the CRC's obtained from the DFEE after completion of the restoration of the DFEE memory does not match with the values stored in the DPE following the previous "Save DFEE memory CRC's". In this case the autonomous recovery process will stop at after sending this OEM.

3.7.10.2.4 Change of format for the Science Telemetry

The JEM-X science telemetry will be allowed to switch between two different telemetry formats according to the Grey Filter level.

3.7.10.2.5 Grey Filter adjustment

The event rate which can be transmitted through the JEM-X telemetry allocation is very limited, and we will frequently encounter situations where more events are recorded than can be tranmitted. We will then try to adjust an unbiased filtering mechanism (the Grey Filter) so as to achieve a stable situation with the Large Data Buffer in the DPE about half full.

3.7.10.2.6 Autonomous termination of DFEE CALIBRATION state.

The CALIBRATION state of the DFEE is self terminating, after a defined number of events the DFEE will revert to the SETUP state.

3.7.10.2.7 Autonomous termination of DFEE DIAGNOSTIC state.

The DIAGNOSTIC state of the DFEE is self terminating, after a defined number of events the DFEE will revert to the SETUP state.

3.7.10.2.8 Autonomous flushing of the DFEE and DPE data buffers when starting a new observation, see section 3.7.5.2.8.2 and section 4.3.6 of the User Manual.

3.7.10.2.9 Autonomous switch off of the high voltage if the detector gas pressure is too low. The DPE software monitors the pressure in the detector and if is too low, then the high voltage will be switched off (and subsequent HV-ON commands will be rejected).

<u>3.7.10.3 Autonomous reactions to the Broadcast packet.</u>
These reactions are described in section 3.7.5.2.8.2 and in the User Manual chapter 4.3.

3.8 GSE Interfaces

3.8.1 Mechanical GSE

N/A

3.8.2 Electrical GSE

3.8.2.1 Hardware

The Electrical Ground Support Equipment is designed to be flexible in the way it will be configured for the following stages of JEM-X instrument development and checkout. Three major test configurations are planned:

- for instrument development and calibration - Level A,
- for DPE software development and stand-alone checkout - Level B,
- to support integration and final testing - Level C.

3.8.2.2 LEVEL A - Instrument development and manufacturing.

The EGSE at this level is mainly devoted to support the instrument development (hardware and DFEE software) phase. For development the instrument is connected to the EGSE instead of to the DPE and spacecraft PDU and/or RTU units, as shown in Figure 21.

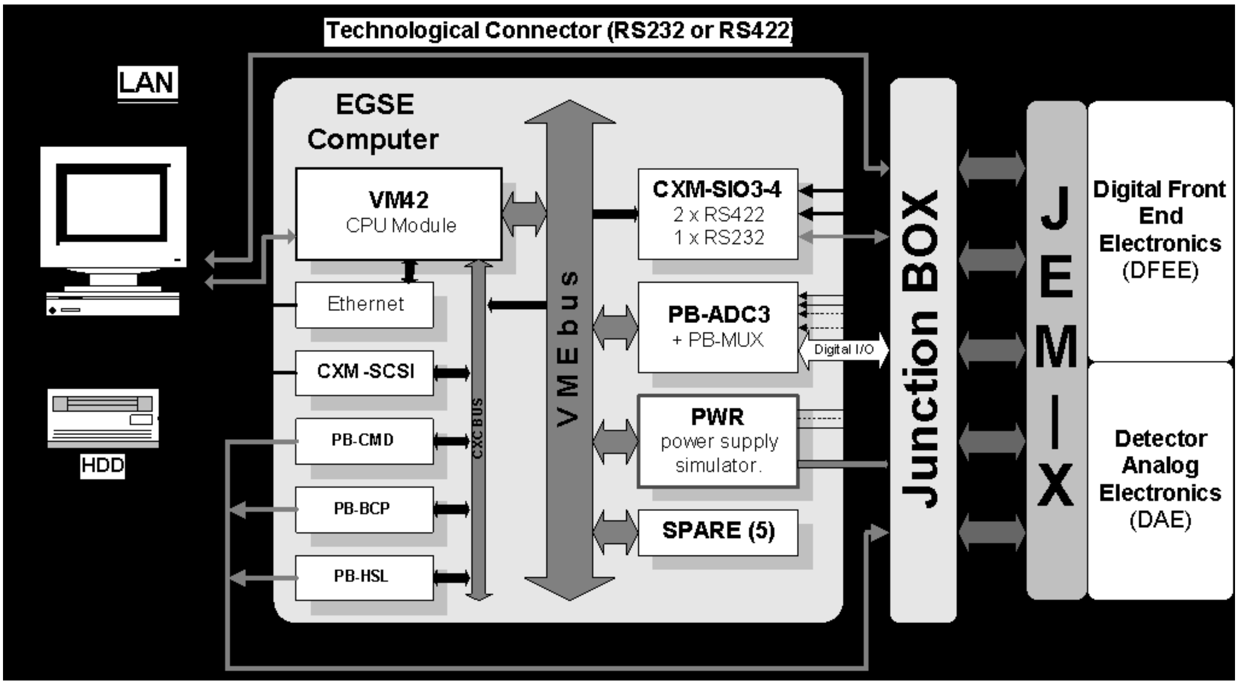


Figure 25 Level A EGSE architecture block diagram

Depending of each phase of testing the standard computer platform (VME) can be configured with various additional boards such as:

1. CXM-SIO3-4 board (Serial Line Interface Simulator)

The serial interface simulator support bi-directional synchronous/asynchronous data transmissions using balanced digital voltage interface (RS-422). Two kind of links are simulated:

-low-speed link, to provide a rate up to 64 Kbit/sec.
-technological links (two serial ports: RS-422 and RS-232)

2. PB-HSL board (High-Speed Link simulator)

The uni-directional synchronous serial interface simulator receives data from the instrument at a rate of up to 5 Mbit/sec transmission rate using balanced digital voltage interface (RS-422).

3. PB-ADC3 and PB-MUX boards (Analogue & Thermistor HK channels)These boards are providing Housekeeping data acquisition and monitoring functions. Both, the DPU and the RTU acquisition lines are simulated.
- 16 analogue inputs (res. 12 bit),
- 16 Thermistor YSI 44908 channels.

4. PB-CMD board (Discrete command lines)

The TC pulse generation controller and associated electrical interface for generation of High Power Telecommand On/Off pulses. The four separate lines are simulated. To facilitate verification of instrument interfaces it is possible to set an amplitude and pulse period to its maximum, normal and minimum values.
Specifications:
Number of lines: 4
Pulse Amplitude: 12 - 16 [V]
Pulse Width: 10 - 20 [ms]
Imax 300 [mA]

5. PB-BCP (DPE Timing Lines simulator).

The timing line simulator consists of four lines as this ones issued from DPE. Timing interface provides:
INST_CLK 4.19 MHz clock
BCP1 8 Hz timing pulses
BCP2 1 Hz timing pulses
CLK8N 1/8 Hz timing pulses

6. PWR module (Power supply simulator).

This module is responsible for the provision of all power to the instrument or heater as would be provided by flight PDU. For his purpose PWR module consists of a programmable controlled DC/DC converter with current limiting and over-voltage protection. The PWR module is equipped with a built-in self test procedure.
Features of the PWR module:
Output power : 40 W (max.).
Output voltage: 24 - 32 V (nom. 28V)
Load current: 1.2 A (max.)
Output current and voltage monitoring (resolution 8bit)
Spare hardware slots are available to allow extra instrument interfaces and system modules to be incorporated without design impact. Each interface simulator includes its own servicing task to allow for flexible configuration and fast software upgrade.

3.8.2.3 LEVEL B - Instrument integration, calibration and testing.

This level is required to verify the complete instrument parameters fields, including the worst test conditions and final calibrations.
Additionally, the EGSE in this configuration will be used for DPE software development and debugging.

It is also planned to use the INTEGRAL simulator, SIS, at this level. Figure 22 shows the EGSE architecture

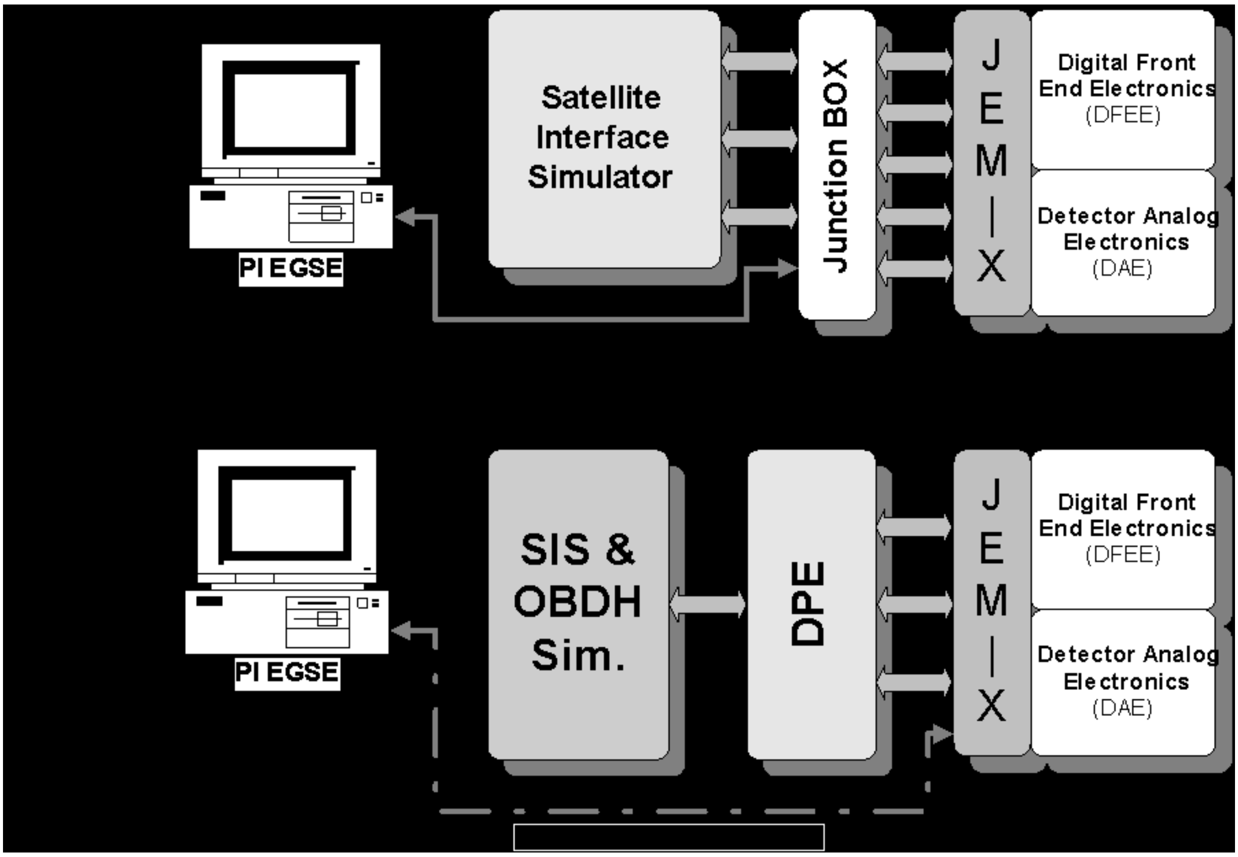


Figure 26 Level B JEM-X EGSE configurations

.

Two stages of testing configuration are planned:
a) - JEM-X will be connected to DPE simulator
b) - JEM-X will be connected to DPE

Final tests before delivery will be performed in configuration "B".

3.8.2.4 LEVEL C - S/C integration.

At the integration test level the EGSE will be mainly aimed to verify the compatibility of subsystems and capability of the instrument to perform the pre-programmed operations.
It is expected that the EGSE will be able to support:

- preparing and sending commands to instrument (via MAIN EGSE subsystem),
- receiving and storing down link telemetry data (via MAIN EGSE using LAN connection),
- monitoring of the on board HK parameters contained in telemetry data, e.g. acquisition, comparison against references and reporting.
- monitoring and on line presentation of the DFEE HK parameters (via technological connector)

It is planned that up to the final stage of integration tests both instruments will be connected to EGSE using the technical connections e.g. galvanic isolated RS-422/RS-232 serial link.
The EGSE will be designed in such a way that any failure in any test configuration will never propagate to the item under test.

3.8.2.5 Software.

The EGSE software has been written in high order programming language. The "C" and "C++" object oriented language has been used. However, some part of software, like drivers, handlers, act. was written in assembler language.The programs used in various EGSE configurations consists of two main parts:

1. "OS/9 part" running on powerful VME-bus computer PEP-VM42 (Motorola 68040 CPU + 68360).
2. "Windows part" running on PENTIUM CPU based PC.

The "OS/9 Part" perform all necessary real time processing relevant to the I/O boards (interface simulators). An application software is built by a number of concurrent tasks in charge of performing the following functions:

1. I/O VME modules set-up - perform the set-up of the I/O simulators modules according to the command sent by operator's test sequence.
2. Real-time processing - perform all necessary real time processing relevant to I/O modules data acquisition (HK channels scanning), data time-stamping, interface health monitoring, correlation of acquired data to dedicated responses (alarm events triggering), data block collection and formatting.
3. Host Computer(s) interfacing - perform the interface with the Host Computer(s) via serial direct connection and/ or LAN interface according to TCP/IP protocol logical link. Communication process in order to acquire set-up commands, transmits to the host data, simulator status and error messages.

Figure 23 shows the software logical structure of this part and its relations with hardware .

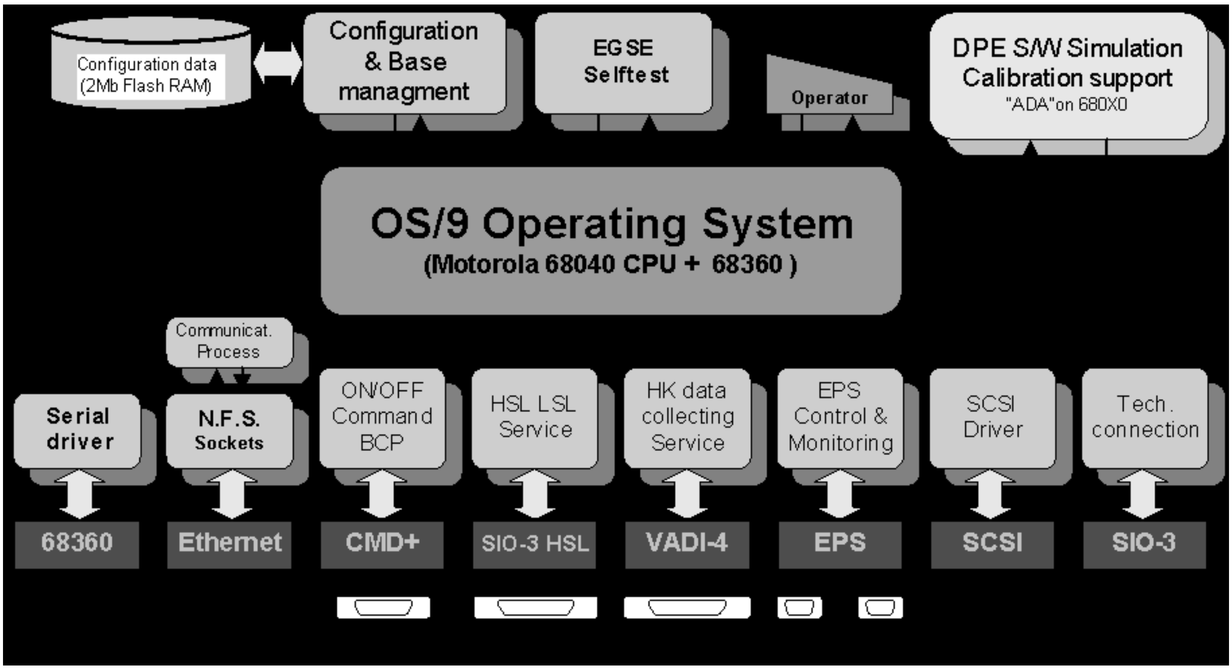


Figure 27 EGSE software structure (OS/9 part)

The "Windows part" is based on a common Basic Software Platform (DOS / Windows / Windows NT) and provides the following main task:

1. Graphical User Interface All operation performed by user (operator) can be done like in the other regular "Windows" applications. All test results are displayed with techniques optimised for human perception (e.g., tables, colour graphic pictures, histograms, diagrams, bar graph, act.)
2. Tests preparation end execution. The specialised script language has been written. The built-in interpreter allows the operator to run prepared test sequence.
3. Data Monitoring and Displaying. A dedicated HK Channels Database set-up facility allowing the operator to easily describe the data channel sets that will be monitored. When test results exceeds predefined values an event alarm is displayed. (numerical and graphical presentation)

4. Data archiving (calibration and test data), The data received from tested instrument can be stored at run-time.
5. Test results presentation and report generation. It will be possible to produce all test related documents on the system, directly accessing or including data and graphics produced during the test process. (Instrument Data and EGSE Event log Database).
6. Data Base Management,
7. Instrument Development Support, (technical connection)
8. "OS/9 platform" Communication,
9. EGSE self-test and diagnostic, The basic checkout kernel for each testing level will carry out subsystem or module main test (answer: GOOD or FILED). Only in case of detection of errors (or operator request) detailed testing or calibration procedures (and/or child processes) will be performed.

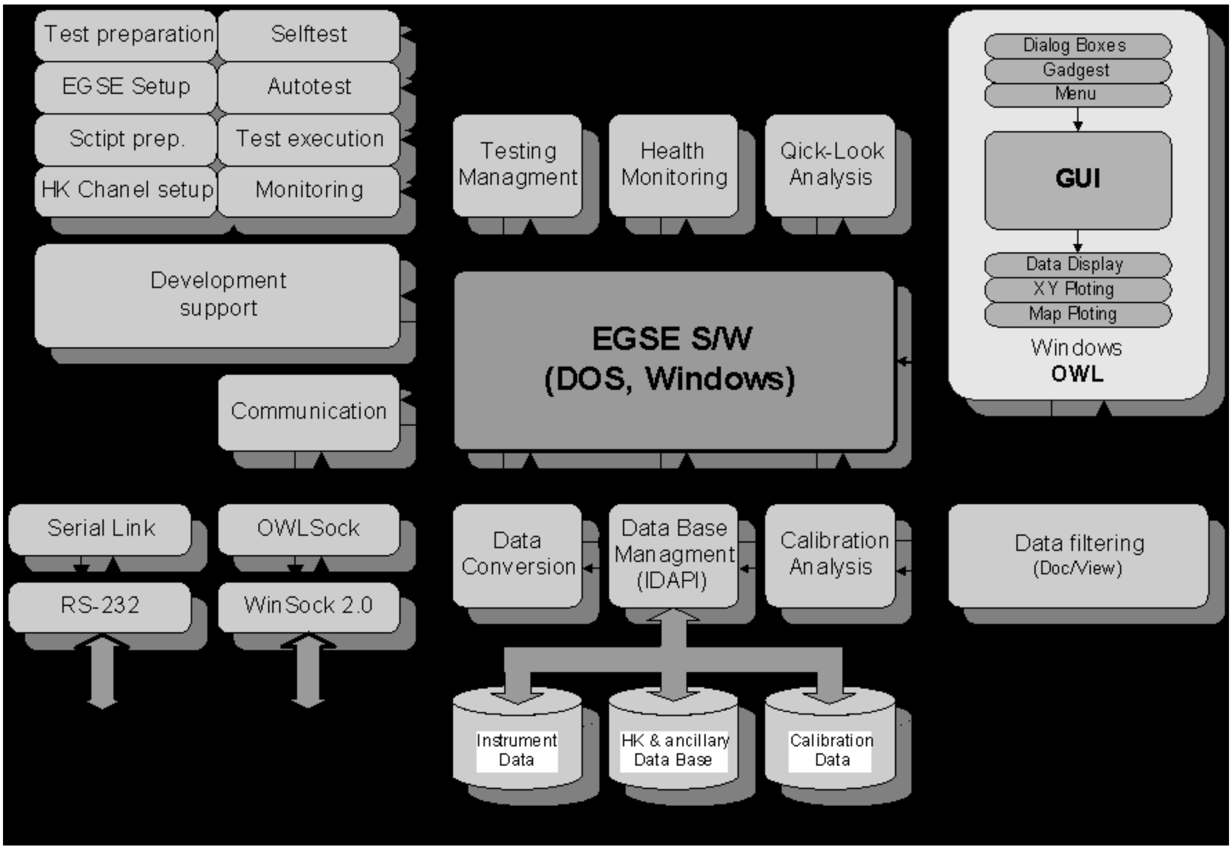


Figure 28 EGSE software structure (IBM/PC - "Windows" part)

The software will be structured such that it could be adapted to several testing levels. Functions which needs flexible adaptation during the test will be changeable without S/W recompilation. The general view of this part of EGSE software structure is shown on Figure 24

3.9 ISSW - Instrument specific software

The ISSW is the software to handle the instrument specific parts of the scientific data. The software is installed at ISDC, following ISDC requirements and its development and maintenance are in accordance with PSS-05-0. An internal set of software standards and formats for writing and delivering code has been published by the INTEGRAL Science Data Centre (**ISDC**):

- `Coding and Testing Standards' version 2.4, Sept. 26th, 2001.

All ISDC documents are available from the ISDC wedsite at:
http://isdc.unige.ch/index.cgi.?Documents+documents

All current documents relating to the JEM-X ISSW can be found at:
http://www.dsri.dk/~oxborrow/sdast/sdast_forum.html

The software is described briefly in the following section. More detailed descriptions of the software and the ISDC environment can be found in the following documents:

- User Requirements Document (ISDC-URD) 2.0 Dec. 20 1996
- Software Requirements Document (ISDC-SRD) 2.0 June 22 1998
- ISDC Top Level Add (ISDC-ADD) Version 1.4, November 25, 2001
- JEM-X ISSW Architectural Design Document (ADD) 6.3, November 26, 2001 (version 7.0 expected in March 2002).

The JEM-X ISSW ADD also incorporates the Detailed Design for this software and is therefore the authoritative guide for those writing, developing and maintaining the software. ISDC will also publish Users Manuals for the data processing software, one for each instrument. Observers should refer to these Users Manuals, available directly from the ISDC website, to learn how to install and use the software.

In addition to support software libraries developed by ISDC for the use of all instrument teams, (DAL, PIL, RIL, Common, DAL3HK, DAL3CAT, etc.), the JEM-X ISSW will also use an ISDC-supplied library, **DAL3JEMX**, for performing I/O on JEM-X-specific data structures. All of the science, calibration and instrument model data are stored in these files.

Currently DAL3JEMX provides functions to
- read all scientific events in a Science Window, or during a particular time interval
- read packet header information during a particular time interval
- read grey filter values and instrument mode from the status history table

Details of all ISDC support software libraries can be found in the related documents on the ISDC web site, there is one user manual per library. The complete system made by installing all the libraries is known as the ISDC Reference Platform, currently version 3.0, though a new version is expected to be released several months before the launch.

The ISDC support libraries and ISSW for all instruments, run primarily on Sun Ultrasparc workstations running Sun Solaris 2.8. Users who wish to install the entire ISDC/ISSW package on their own systems would need the Sun Forte 6.1 f90/C/C++ compilers. Linux version 2.2 is also supported. For a full description of system requirements for installing the ISDC/ISSW package, see the ISDC homepage (links ÷ "Software" ÷ "Reference Platform").

3.9.1 Instrument health monitoring

Operations Status Monitoring software **(OSM)** was developed at ISDC to perform automatic health monitoring for all the INTEGRAL instruments.The OSM software examines the housekeeping (HK) data stream and alerts the operator in case of detected error conditions. Parameter limits against which to check incoming housekeeping data are provided by the Instrument Team, along with the list of parameters to be displayed and monitored by MOC operators. Calibration spectra from the FRSS calibration sources are also displayed for health monitoring.

OSM capabilities include, but may not be limited to:
- conversion of HK parameters to physical units
- examination of HK parameters for out-of-limits conditions.
- visual display of HK parameters with interactive control of the displays

- alerts to human operators if the alert flag is set.
- examination of execution status of telecommands
- production of Good Time Intervals (GTIs) based on HK parameter monitoring for use by the ISSW Science Data Analysis software.

3.9.2 Quick Look Analysis

The QLA software runs as part of the Near Real Time (NRT) pipeline at ISDC, it automatically processes all of the immediately available JEM-X data to see that the scientific goals of the observation are met, and to check that the proposed objects for the observation are actually in the field of view. It will also allow observers to detect new astronomical objects in the field of view. The QLA software will utilise much of the Standard Analysis API (see below), sometimes using simpler, faster algorithms for lengthy processes such as image reconstruction. This is to ensure that QLA will be able to run fast enough to process data in real time as it is received from MOC over a dedicated line. QLA will also use a set of QLA-specific tools developed by ISDC for use with data from all instruments. For full details of the ISDC QLA system see `Quick Look Analysis Architectural Design Document' 2.1 April 4, 2001.
.

3.9.3 Standard analysis software

The Standard Analysis (SA) software will run on all of the consolidated JEM-X data and produce a set of standard data products to be delivered to observers with the raw data. SA is performed as part of the ISDC Consolidated Data Pipeline and processes the complete data received by ISDC up to 2 weeks after the original observation. Hence there are somewhat looser time constraints on the processing.

3.9.4 Science Data Analysis Software

The Science Data Analysis Software Team (**SDAST)** is responsible for supplying the executable source code for the QLA, SA and Offline (interactive) data analysis of JEM-X science data. In most cases the same software will be used for both SA and QLA. All science telemetry is first unpacked into fits (Flexible Image Transfer System) format files by the PreProcessing and DataPreparation executables of the ISDC Science Window Pipeline and Revolution File Pipeline. Hence all ISSW science processing is performed on data stored in fits format. The processing application scripts of the ISSW that come after PreProcessing are split up by ISDC processing level:

PRP Performs further preprocessing of the raw data which cannot be done by ISDC Preprocessing: creating Full On-Board Times from the Local On-Board Times received in telemetry. Creation of an instrument mode/grey filter status history table. Calculating the PHA/energy relationship (gain) of the detector from the four FRSS calibration source spectra which illuminate well-defined spots on the detector - one for each anode section. Also returns detector energy resolution and source strengths for instrument health monitoring and monitors raw science data for good behaviour.

COR Performs corrections on the raw event data according to instrument calibration and instrument model data: changes in detector gain over time; variations in gain across the detector area; position corrections and event ‘goodness’ evaluation. Other corrections may have to be implemented during the commissioning phase, if chronic or consistent problems appear in the data.

GTI Creates/evaluates Good Time Intervals from houesekeeping data - this application is based on generic ISDC tools to be used on all instrument HK data.

DEAD Application calculates the average dead time for every 8 second polling cycle.

CAT_I A collection of generic ISDC tools to search the catalogues for expected X-ray sources and to propose identifications for observed sources.

BKG Selects and scales suitable background models with time, spatial and spectral variation, so that background can be taken into account during the image reconstruction. Models are selected from a catalogue ordered by various orbital parameters. The background database is populated by the outputs from the BIN_T, BIN_S and j_bkg_interactive applications

BIN_T, BIN_S Re-bin data from the higher level data-taking modes where event data includes energy, position and time, to lower level data structures: lightcurves and spectra with reduced information content. Background models of lightcurves and spectra are also created for the background catalogue from empty fields.

BIN_I, IMA Generates coarse sky images with larger energy bins and quick background determination done automatically. The output from this stage is used as input for the last one which produces refined sky images in finer energy bins, using an iterative method that takes the coarse results as input. This later application also includes more sophisticated background determination and iterative removal of sources. A list of probable detections of astronomical sources is produced, indicating the positions on the images with greatest flux. Only the first stage of IMAG will be used for the QLA, whereas the Standard Analysis will also use the refined reconstruction.

SPEC, LCR Extract data for each of the sources found by IMAG: tagging events that belong to each of the found sources; making lightcurves and spectra of each one.

Other executables for offline and interactive analysis do not belong to any ISDC level:

j_performance Monitors scientific output by displaying and plotting various quantities in an interactive way. This application is an extension of OSM, applied to the scientific as opposed to HK data such as the calibration spectra and the quantities derived in PRP. There will also be automatic comparison of previous performance parameters to search for undesirable trends.

j_ical An interactive application that allows members of the instrument team to track and update the instrument model tables required for calibration and correction. This includes spatial gain variation across the detector area; event position corrections and deadtime assessment for various trigger rates and interactive monitoring of the FRSS calibration spectra and gain fitting.

j_int_background An interactive application allowing the user to make their own background models based on scaling of models already in the background model catalogue. The background models so created can then be used by the IMA to aid in background determination before image reconstruction. This tool is designed to be quite flexible and generic, using very basic models with expected or observed traits, while allowing the user to create their own more complex models.

3.9.5 Simulation software

The JEM-X simulation software package has been developed at DSRI and is installed at ISDC as part of their observation simulator . The package contains the following software:

- Monte-Carlo ray-tracing
- storage of simulated event files, shadowgrams and reconstructed images
  in FITS files following the ISDC data structure formats.
- Production of files for simulation runs of software,
  both ISDC relevant software and ESOC simulator software.

The JEM-X team will produce the sets of files specified in general terms in EID-A section 7.5.3.3. The set will be split into files according to data-taking mode.

Files of simulated photons from catalogue sources are produced by the Southampton (Soton) group and used as input to the simulation software. Image reconstruction executables in the ISSW have been developed and tested using the simulated shadowgrams produced by this software.

A more detailed description of the simulation package can be found in the following documents:

- `Observation Simulator Architectural Design Document' Version 1.1 Dec. 21 1998.
  Available on the ISDC website.
- `Observation Simulator Users Manual´ version 1.2, January 17th, 2001
  http://www.isdc.ch/Observers/software/osim/um_1.2.ps.gz

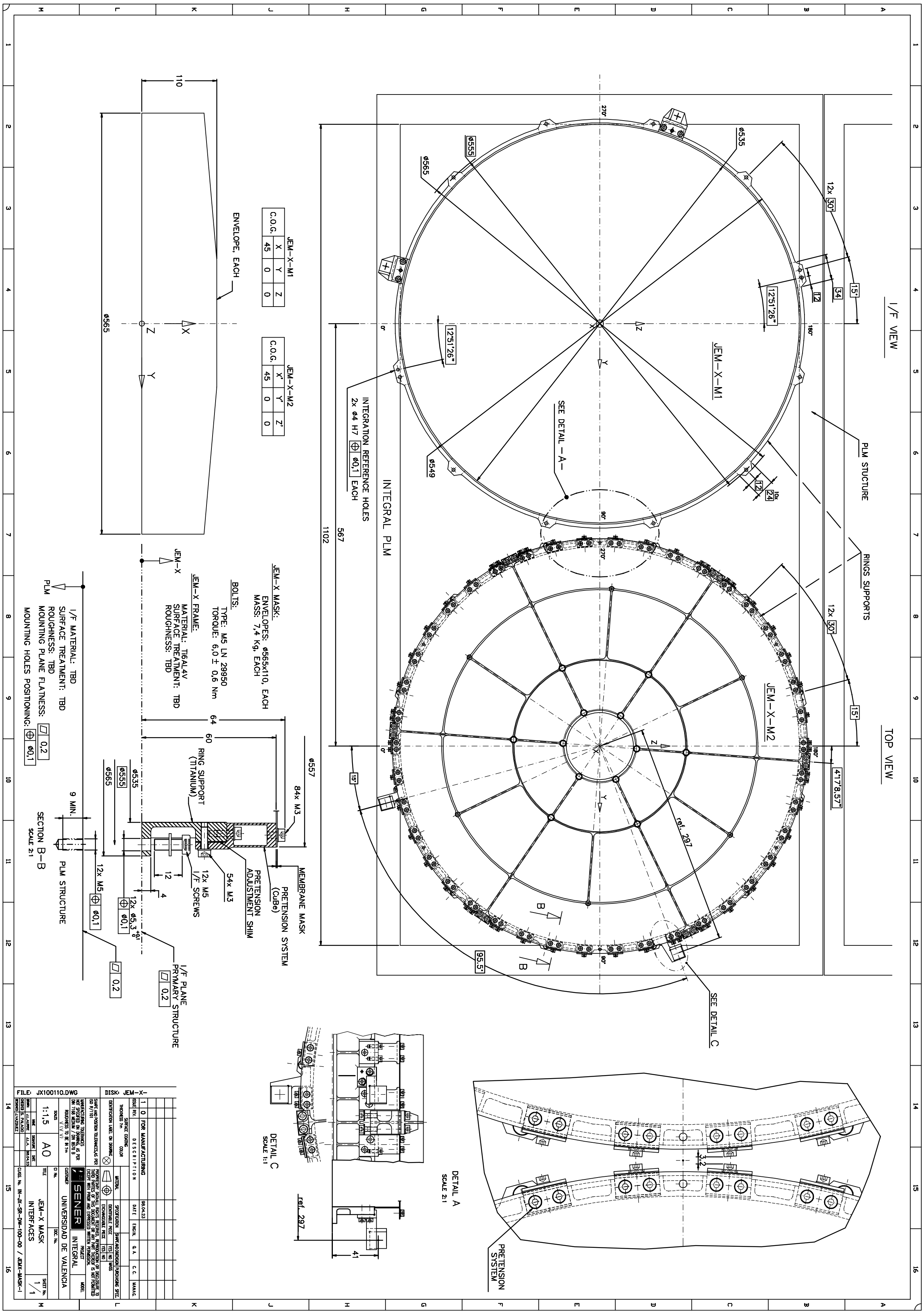
APPENDIX A

Mechanical Interface Control Document (MICD) according DRD-42-1.

The drawings can also be downloaded in PDF format from the DSRI JEMX FTP server as:

j-det-i_d.pdf	JEM-X #130100 rev. D (Detector/DFEE assembly)
J-mask-i.pdf	IN-JX-SR-DW-100-00 (Coded mask assembly)

Please note, that the drawings found in this appendix are not to scale.


I/F VIEW
TOP VIEW
JEM-X-M1
JEM-X-M2
INTEGRAL PLM
PLM STUCTURE
RINGS SUPPORTS
SEE DETAIL -A-
SEE DETAIL C
INTEGRATION REFERENCE HOLES
2x Ø4 H7 EACH
ENVELOPE, EACH
JEM-X MASK:
ENVELOPES: Ø565x110, EACH
MASS: 7,4 Kg. EACH
BOLTS:
TYPE: M5 LN 29950
TORQUE: 6,0 ± 0,6 Nm
JEM-X FRAME:
MATERIAL: Ti6AL4V
SURFACE TREATMENT: TBD
ROUGHNESS: TBD
I/F MATERIAL: TBD
SURFACE TREATMENT: TBD
ROUGHNESS: TBD
MOUNTING PLANE FLATNESS:
MOUNTING HOLES POSITIONING:
MEMBRANE MASK
PRETENSION SYSTEM (CuBe)
PRETENSION ADJUSTMENT SHIM
RING SUPPORT (TITANIUM)
I/F SCREWS
I/F PLANE PRYMARY STRUCTURE
PLM STRUCTURE
SECTION B-B
DETAIL C
DETAIL A
PRETENSION SYSTEM
FILE: JX100110.DWG
FOR MANUFACTURING
SENER
UNIVERSIDAD DE VALENCIA
INTEGRAL
JEM-X MASK INTERFACES

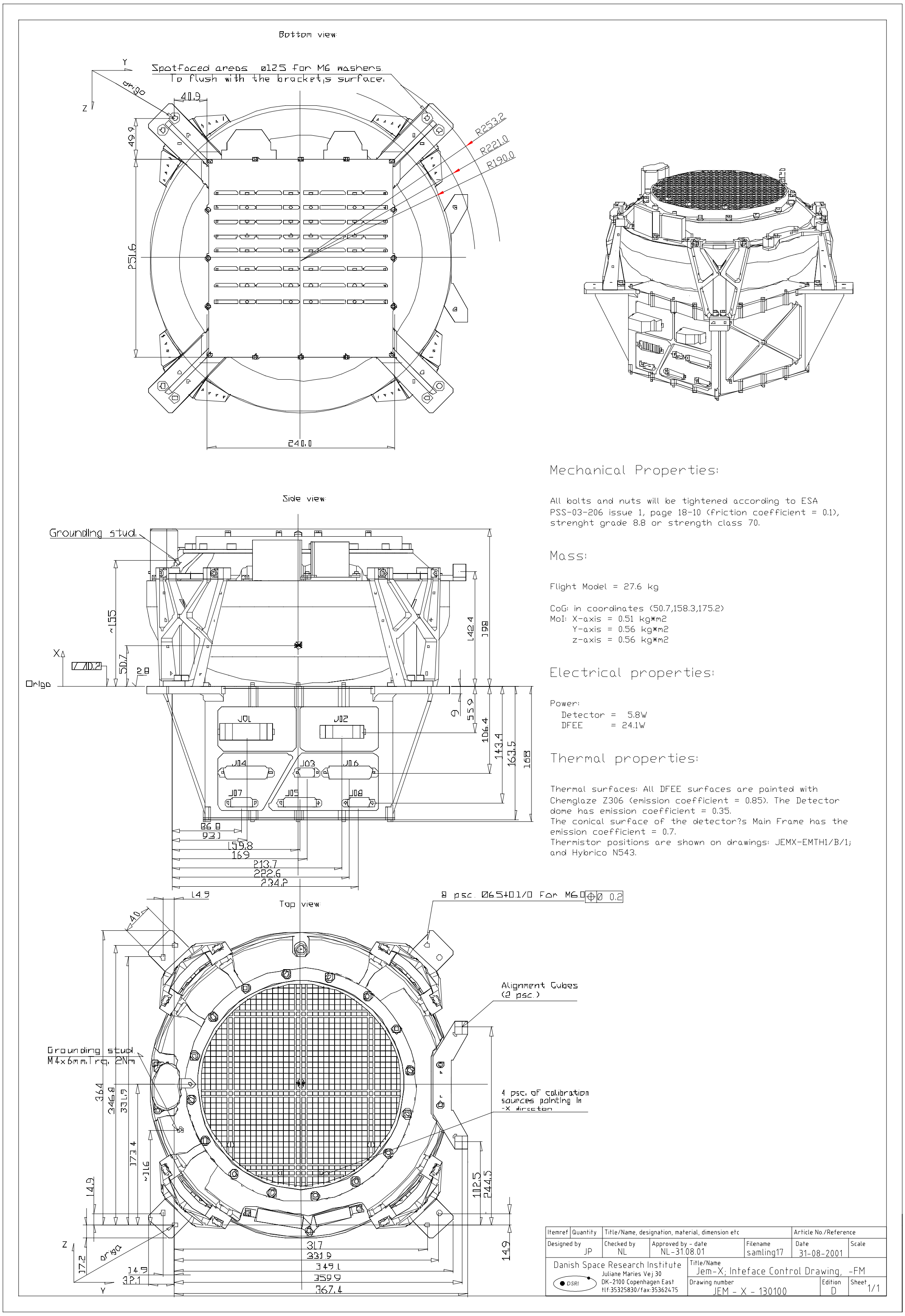
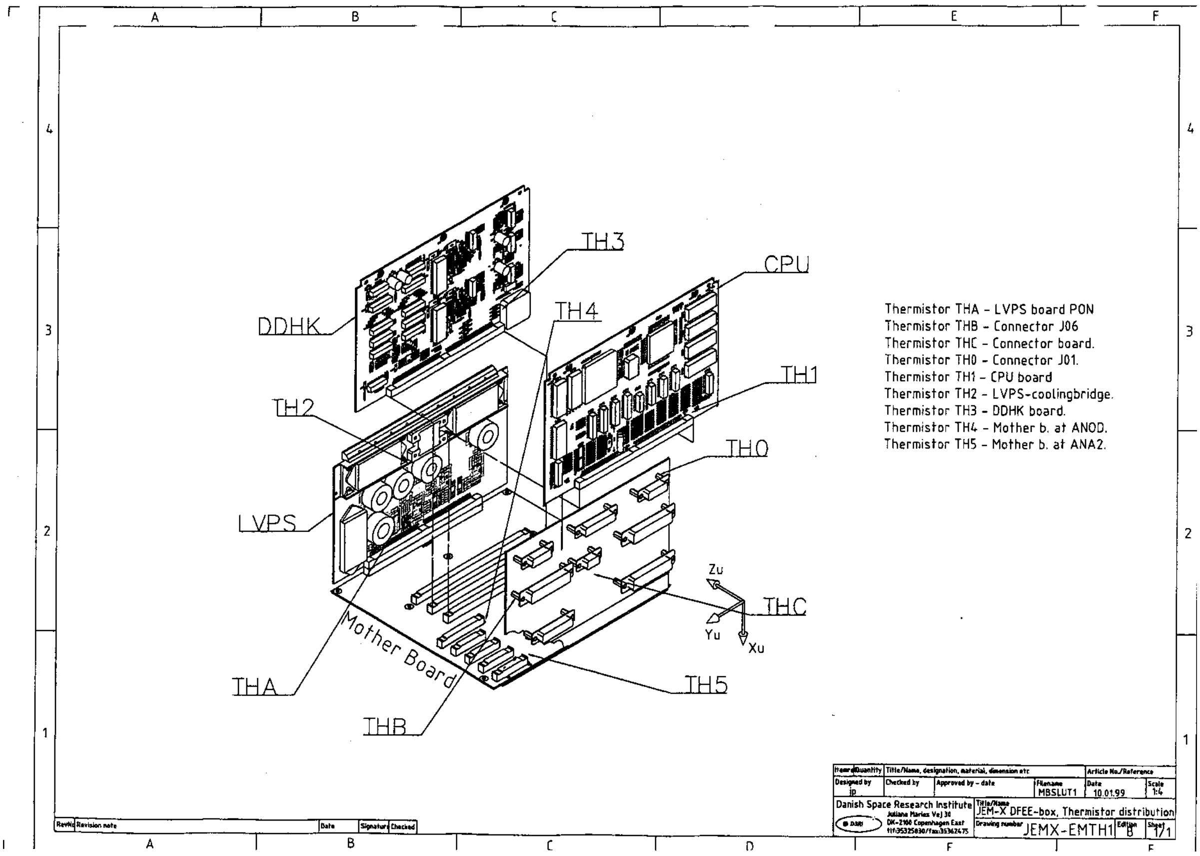

Bottom view
Spotfaced areas ø12.5 for M6 washers
To flush with the bracket,s surface.
R253.2
R221.0
R190.0
240.0
Side view
Grounding stud
Origo
J01
J02
J04
J03
J06
J07
J05
J08
Top view
8 psc Ø6.5+0.1/0 for M6.0
Alignment Cubes (2 psc)
Grounding stud M4x6mm,Trq. 2Nm
4 psc. of calibration sources pointing in -X direction
Mechanical Properties:
All bolts and nuts will be tightened according to ESA PSS-03-206 issue 1, page 18-10 (friction coefficient = 0.1), strenght grade 8.8 or strength class 70.
Mass:
Flight Model = 27.6 kg
CoG: in coordinates (50.7,158.3,175.2)
MoI: X-axis = 0.51 kg*m2
Y-axis = 0.56 kg*m2
z-axis = 0.56 kg*m2
Electrical properties:
Power:
Detector = 5.8W
DFEE = 24.1W
Thermal properties:
Thermal surfaces: All DFEE surfaces are painted with Chemglaze Z306 (emission coefficient = 0.85). The Detector dome has emission coefficient = 0.35.
The conical surface of the detector?s Main Frame has the emission coefficient = 0.7.
Thermistor positions are shown on drawings: JEMX-EMTH1/B/1; and Hybrico N543.
Itemref
Quantity
Title/Name, designation, material, dimension etc
Article No./Reference
Designed by JP
Checked by NL
Approved by - date NL-31.08.01
Filename samling17
Date 31-08-2001
Scale
Danish Space Research Institute
Juliane Maries Vej 30
DK-2100 Copenhagen East
tlf:35325830/fax:35362475
DSRI
Title/Name Jem-X; Inteface Control Drawing, -FM
Drawing number JEM - X - 130100
Edition D
Sheet 1/1

Figure 30

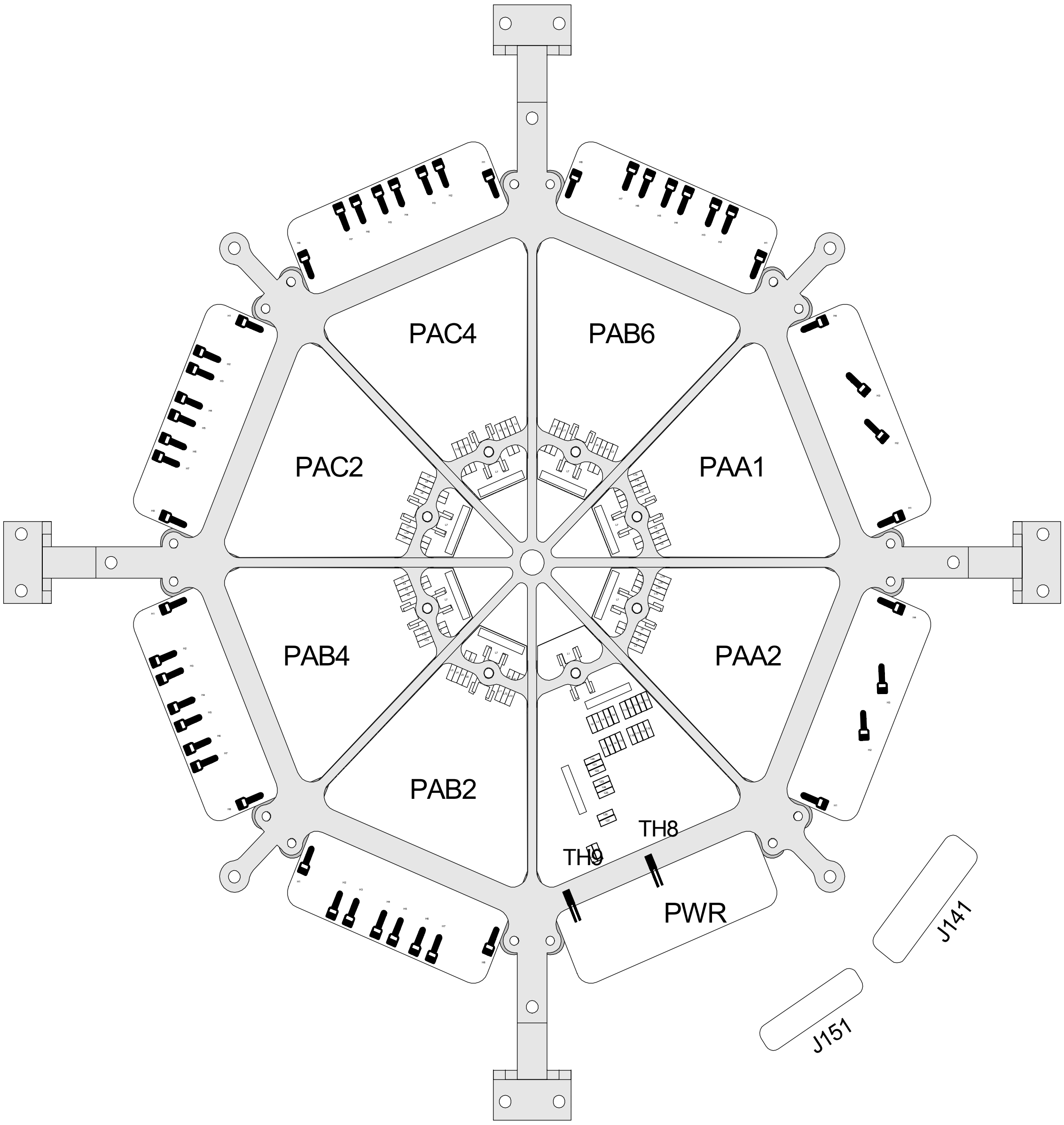
Figure showing the location of 9 of the 11 thermosensors (THA, THB, THC and TH0-5) located inside



Figur A3

the DFEE box. The last two sensors in this box, TH6 and TH7, are located in High Voltage Supply, which occupies the space next to the LVPS Board.

Figure showing the DAE spider with the 8 double sided, triangular circuit boards. The two thermosensors and the two pressuresensors are located on the PWR board indicated on the figure. Both thermosensors measures the same temperature, the temperature of the DAE electronics and the detector gas. The precise locations of the sensors on the PWR-board is shown in Figure A5.



Figur A4

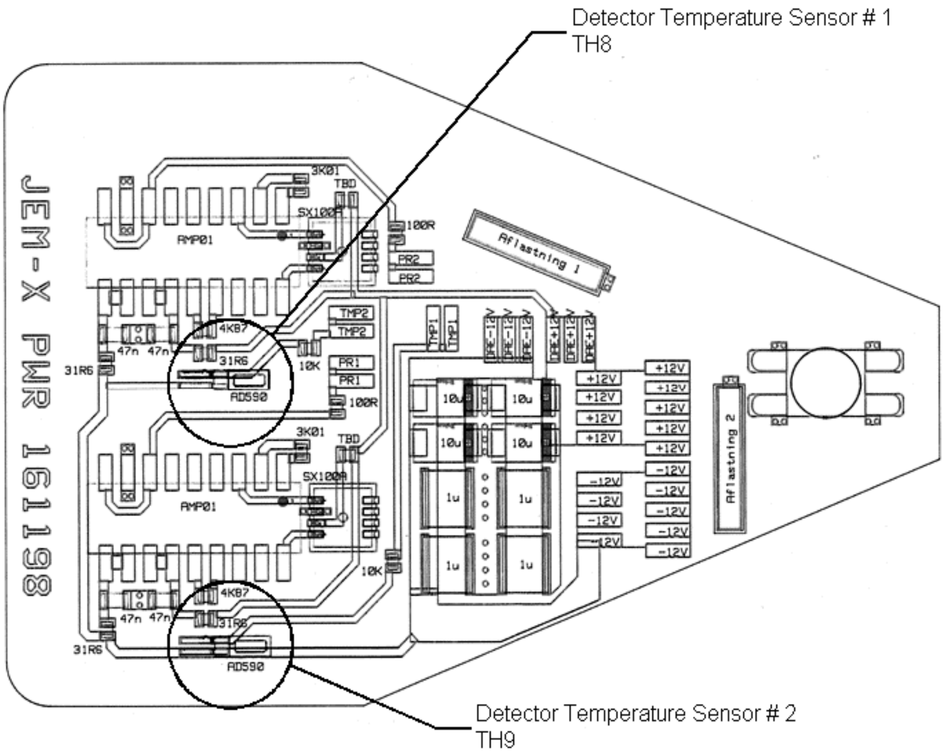


Figure A5

Figure showing the location on the DAE power board of the two AD590 thermosensors. The pressure sensors are the 8-pin IC's marked SX1000.

APPENDIX B

Electrical Interface Control Document (EICD) according to DRD44-1.

Introduction

– **Purpose**

The purpose of this document is to establish the Electrical I/F characteristics of JEM-X.

JEM-X consists of:

The Detector Unit (DAE) and the Electronics Unit (DFEE). The two units are delivered integrated as one unit (JEM-X). JEM-X has two different electrical interfaces:

- External from the DFEE to the S/C via the DPE, RTU and PDU
- Internal between the DFEE and the DAE.

List of Acronyms

DAE	Detector Analog Electronics
DFEE	Digital Front End Electronics
DPE	Data Processing Electronics
EGSE	Electrical Ground Support Equipment
EICD	Electrical Interface Control Document
EID	Experiment Interface Document
ESA	European Space Agency
HS	High Speed
I/F	Interface
JEM-X	Joint European X-Ray Monitor
LS	Low Speed
PDU	Power distribution Unit
RTU	Remote Terminal Unit
S/C	Spacecraft

– **Applicable Documents**

Experiment Interface Document (EID) - Part A

– Connector Definition

3.1 The DFEE has the following connector types:

3.1.1 DFEE connectors for external interfaces

ID.	Connector type	Comments	To
J04	ESA/SCC-3401-002-01B-DDMA-50S-NMB-FO	House Keeping	DPE
J05	ESA/SCC-3401-002-01B-DBMA-25P-NMB-FO	Command	RTU
J06	ESA/SCC-3401-002-01B-DDMA-50S-NMB-FO	Serial Communication	DPE
J07	ESA/SCC-3401-002-01B-DAMA-15P-NMB-FO	Main Power	PDU-M
J08	ESA/SCC-3401-002-01B-DAMA-15P-NMB-FO	Redundant Power	PDU-R

3.1.2 DFEE connectors for internal interfaces.

ID.	Connector type	Comments	To
J01	ESA/SCC-3401-002-01B-DDMA-50S-NMB-FO	Analog Signals	DAE
J02	ESA/SCC-3401-002-01B-DBMA-25S-NMB-FO	Control Signals	DAE
J03	ESA/SCC-3401-002-01B-DEMA-9P-NMB-FO	Test	Test Computer

3.2 The DAE has the following connector types:

3.2.1 DAE connectors for internal interfaces.

ID.	Connector type	Comments	To
HV	Ceramaseal Hermetic Type FDTH 12 kV	High Voltage	DFEE
J14	Ceramaseal Hermetic D Type	Analog Signals	DFEE
J15	Ceramaseal Hermetic D Type	Control Signals	DFEE

– Connector Interconnection

The interconnections from the DFEE to the DPE, RTU and PDU are shown in the Interconnection Block Diagram in annex 1.

– External Interface Pin Allocation

The tables in annex 2 show the pin allocation for the DFEE unit connectors to the DPE, RTU and PDU.

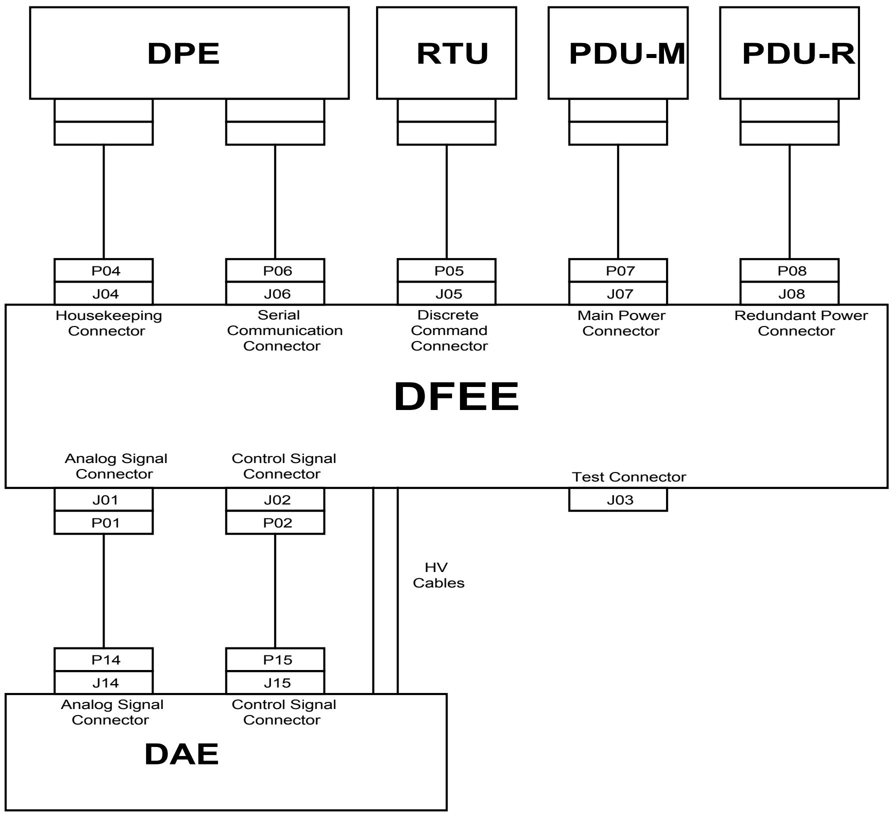
– Internal Interface Pin Allocation.

The tables in annex 3 show the pin allocation between the DFEE unit connectors and the DAE.

– Interface Circuits.

The Interface Circuits are shown in Annex 4

Annex 1. Connector Interconnections.



Annex 2. External Interface Pin Allocation.

Unit: DFEE		Function: Housekeeping		Checked by:											Issue	
Connector Identification: J04				Connector type: ESA/SCC-3401-02-01B-DDMA-50												
Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm)	Load Impedanc (Kohm)	Frequency (Hz)	Voltage (V)	Load Capacity to GND	Source Capacity to GND	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specific Harness Requirements	To Unit
1		ANA0+	+5V Digital monitor	ANA											TP26	DPE
18		ANA0 -	+5V Digital monitor RTN	ANA											TP26	DPE
2		ANA1+	+5V Current monitor	ANA											TP26	DPE
19		ANA1 -	+5V Current monitor RTN	ANA											TP26	DPE
3		ANA2+	+5V Analog monitor	ANA											TP26	DPE
20		ANA2 -	+5V Analog monitor RTN	ANA											TP26	DPE
4		ANA3+	-5V Analog monitor	ANA											TP26	DPE
21		ANA3 -	-5V Analog monitor RTN	ANA											TP26	DPE
5		ANA4+	+12V Analog monitor	ANA											TP26	DPE
22		ANA4 -	+12V Analog monitor RTN	ANA											TP26	DPE
6		ANA5+	+12V Current monitor	ANA											TP26	DPE
23		ANA5 -	+12V Current monitor RTN	ANA											TP26	DPE
7		ANA6+	-12V Analog monitor	ANA											TP26	DPE
24		ANA6 -	-12V Analog monitor RTN	ANA											TP26	DPE
8		ANA7+	-12V Current monitor	ANA											TP26	DPE
25		ANA7 -	-12V Current monitor RTN	ANA											TP26	DPE
9		ANA8+	Pressure monitor 1	ANA											TP26	DPE
26		ANA8 -	Pressure monitor 1 RTN	ANA											TP26	DPE
10		ANA9+	Pressure monitor 2	ANA											TP26	DPE
27		ANA9 -	Pressure monitor 2 RTN	ANA											TP26	DPE
11		ANA10+	Detector temperature 1	ANA											TP26	DPE
28		ANA10 -	Detector temperature 1 RTN	ANA											TP26	DPE
12		ANA11+	Detector temperature 2	ANA											TP26	DPE
29		ANA11 -	Detector temperature 2 RTN	ANA											TP26	DPE
17			NC													
13	Thermistor	YSI_TH0	Thermistor 0	ANA											TP26	DPE
14	Thermistor	YSI_TH0_RTN	Thermistor 0 RTN	ANA											TP26	DPE
30	Thermistor	YSI_TH1	Thermistor 1	ANA											TP26	DPE
31	Thermistor	YSI_TH1_RTN	Thermistor 1 RTN	ANA											TP26	DPE
42	Thermistor	YSI_TH2	Thermistor 2	ANA											TP26	DPE
43	Thermistor	YSI_TH2_RTN	Thermistor 2 RTN	ANA											TP26	DPE
15	Thermistor	YSI_TH3	Thermistor 3	ANA											TP26	DPE
16	Thermistor	YSI_TH3_RTN	Thermistor 3 RTN	ANA											TP26	DPE
44	Thermistor	YSI_TH4	Thermistor 4	ANA											TP26	DPE
45	Thermistor	YSI_TH4_RTN	Thermistor 4 RTN	ANA											TP26	DPE
46	Thermistor	YSI_TH5	Thermistor 5	ANA											TP26	DPE
47	Thermistor	YSI_TH5_RTN	Thermistor 5 RTN	ANA											TP26	DPE
32			NC													
33			NC													
48		REL0	DPE HVC off	DIG											TP26	DPE
49		REL0_RTN	DPE HVC off RTN	DIG											TP26	DPE
50			NC													
34		ANA12+	HF FIFO FLAG (HFF0+)	DIG											TP26	DPE
35		ANA12-	HF FIFO FLAG RTN (HFF0-)	DIG											TP26	DPE
36		ANA13+	HVPS Temperature 1	ANA											TP26	DPE
37		ANA13-	HVPS Temperature 1 RTN	ANA											TP26	DPE
38		ANA14+	HVPS Temperature 2	ANA											TP26	DPE
39		ANA14-	HVPS Temperature 2 RTN	ANA											TP26	DPE
40		ANA15+	Spare AN. Channel	ANA											TP26	DPE
41		ANA15-	Spare AN. Channel RTN	ANA											TP26	DPE

Unit: DFE	Function: Discrete Cor		Checked by:									Issue			
Connector Identification: J05			Conn: ESA/SCC-3401-002-01B-DBMA-25P-NMB-FO												
Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm)	Load Impedanc (Kohm)	Frequency (Hz)	Voltage (V)	Load Capacity to GND	Source Capacity to GND	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specif Harness Reqmts	To Unit
1			NC													
2			NC													
3			NC													
4			NC													
5			NC												TP2	RTU
18			NC												TP2	RTU
6	ON/OFF		S/C HVC off A	DIG											TP2	RTU
19	ON/OFF		S/C HVC off RTN A	DIG											TP2	RTU
7			NC													
8	Thermistor	YSI_THA	Thermistor A	ANA											TP2	RTU
21	Thermistor	YSI_THA_RTN	Thermistor A RTN	ANA											TP2	RTU
9	Thermistor	YSI_THB	Thermistor B	ANA											TP2	RTU
22	Thermistor	YSI_THB_RTN	Thermistor B RTN	ANA											TP2	RTU
10	Thermistor	YSI_THC	Thermistor C	ANA											TP2	RTU
23	Thermistor	YSI_THC_RTN	Thermistor C RTN	ANA											TP2	RTU
11			NC													
24			NC													
12			NC													
13			NC													
14			NC													
15			NC													
16			NC													
17			NC													
20			NC													
25			NC													

Unit: DFEE		Function: Serial Communication		Checked by:										Issue	
Connector Identification: J06			Conn type: ESA/SCC-3401-002-01B-DDMA-50S-NMB-FO												
Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm	Load Impedanc (Kohm)	Frequency (Hz)	Load Impency (Hz)	Voltage (V)	Load Capac to GND (pF)	Src Capac to GND (pF)	Rise Time (uS)	Pulse Width (uS)	Sensitivity	To Unit
1			NC												
2	RS422HSL	DTH0+	5Mb/s Data	DIG											DPE
35	RS422HSL	DTH0-	5Mb/s Data RTN	DIG											DPE
3	RS422HSL	ENH0+	Data Enable	DIG											DPE
36	RS422HSL	ENH0-	Data Enable RTN	DIG											DPE
4			NC												DPE
37			NC												DPE
5	RS422HSL	CKH0+	5MHZ Clock	DIG											DPE
38	RS422HSL	CKH0-	5MHZ Clock RTN	DIG											DPE
6			NC												
7	RS422LSL	DTR0+	4Kb/s Transmit	DIG											DPE
40	RS422LSL	DTR0-	4Kb/s Transmit RTN	DIG											DPE
8	RS422LSL	DTF0+	4Kb/s Receive	DIG											DPE
41	RS422LSL	DTF0-	4Kb/s Receive RTN	DIG											DPE
9	RS422LSL	RTSN+	Request To Send	DIG											DPE
42	RS422LSL	RTSN-	Request To Send RTN	DIG											DPE
10	RS422LSL	CLK0+	4KHz Clock	DIG											DPE
43	RS422LSL	CLK0-	4KHz Clock RTN	DIG											DPE
11			NC												
12			NC												
13	RS422HSL	INST_CLK+	4MHz Timing	DIG											DPE
46	RS422HSL	INST_CLK-	4MHz Timing RTN	DIG											DPE
14	RS422LSL	EXT_BCP2+	1Hz Timing	DIG											DPE
47	RS422LSL	EXT_BCP2-	1Hz Timing RTN	DIG											DPE
15	RS422LSL	EXT_CLK8N+	8Hz Timing	DIG											DPE
48	RS422LSL	EXT_CLK8N-	8Hz Timing RTN	DIG											DPE
16	RS422LSL	EXT_BCP1+	1/8z Timing	DIG											DPE
49	RS422LSL	EXT_BCP1-	1/8z Timing RTN	DIG											DPE
17			NC												
18			NC												
19			NC												
20			NC												
21			NC												
22			NC												
23			NC												
24			NC												
25			NC												
26			NC												
27			NC												
28			NC												
29			NC												
30			NC												
31			NC												
32			NC												
33			NC												

Unit: DF | **Function: Main Power** | **Checked by:** | **Issue**

Connector Identification: J07 | Connector type: ESA/SCC-3401-002-01b-DAMA-15P-NMB-

Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm	Load Impedanc (Kohm)	Frequency (Hz)	Voltage (V)	Load Capacity to GND	Source Capacity to GND	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specific Harness Requirements	To Unit
1			NC													
2		PBUSN	28V Power Bus 1	DC				0	28						TP24	PDU
10		PBUSN_RTN	28V Power Bus 1 RTN	DC				0	0						TP24	PDU
3		PBUSN	28V Power Bus 1	DC				0	28						TP24	PDU
11		PBUSN_RTN	28V Power Bus 1 RTN	DC				0	0						TP24	PDU
4			NC													
5			NC													
6			NC													
7			NC													
8			NC													
9			NC													
12			NC													
13			NC													
14			NC													
15			NC													

Unit: DF | **Function: Redundant Power** | **Checked by:** | **Issue**

Connector Identification: J08 | Connector type: ESA/SCC-3401-002-01b-DAMA-15P-NMB-FO

Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm	Load Impedanc (Kohm)	Frequency (Hz)	Voltage (V)	Load Capacity to GND	Source Capacity to GND	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specific Harness Requirements	To Unit
1			NC													
2		PBUSR	28V Power Bus 2	DC				0	28						TP24	PDU
10		PBUSR_RTN	28V Power Bus 2 RTN	DC				0	0						TP24	PDU
3		PBUSR	28V Power Bus 2	DC				0	28						TP24	PDU
11		PBUSR_RTN	28V Power Bus 2 RTN	DC				0	0						TP24	PDU
4			NC													
5			NC													
6			NC													
7			NC													
8			NC													
9			NC													
12			NC													
13			NC													
14			NC													
15			NC													

Annex 3. Internal Interface Pin Allocation.

Unit: DFEE | **Function: Analog Signal** | **Checked by:** | **Issue**

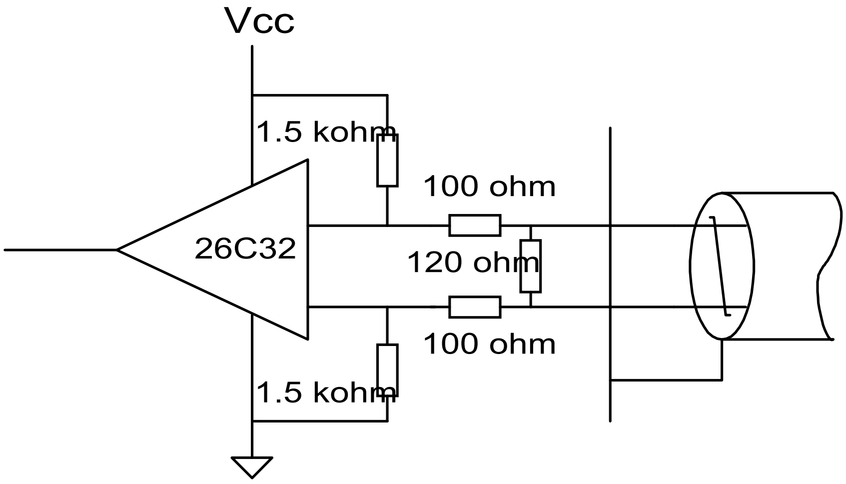
Connector Identification: J01 | Connector type: ESA/SCC-3401-02-01B-DDMA-50S-NMB-FO

Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance	Load Impedanc	Frequency (Hz)	Voltage (V)	Load Cap to GND	Srce Capac to GND	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specific Harness Requirements	To Unit	Connector	Pin Number
1		BACK0	Backplane Signal 0	ANA											TP26	DAE	J14	
2		BACK1	Backplane Signal 1	ANA											TP26	DAE	J14	
3		BACK2	Backplane Signal 2	ANA											TP26	DAE	J14	
4		BACK3	Backplane Signal 3	ANA											TP26	DAE	J14	
5		BACK4	Backplane Signal 4	ANA											TP26	DAE	J14	
6		BACK5	Backplane Signal 5	ANA											TP26	DAE	J14	
7		BACK6	Backplane Signal 6	ANA											TP26	DAE	J14	
8		BACK7	Backpiane Signal 7	ANA											TP26	DAE	J14	
9		BACK8	Backplane Signal 8	ANA											TP26	DAE	J14	
10		BACK9	Backplane Signal 9	ANA											TP26	DAE	J14	
11		BACK10	Backplane Signal 10	ANA											TP26	DAE	J14	
12		BACK11	Backplane Signal 11	ANA											TP26	DAE	J14	
13		BACK12	Backplane Signal 12	ANA											TP26	DAE	J14	
14		BACK13	Backplane Signal 13	ANA											TP26	DAE	J14	
15		BACK14	Backplane Signal 14	ANA											TP26	DAE	J14	
16		BACK15	Backplane Signal 15	ANA											TP26	DAE	J14	
17		BACK16	Backplane Signal 16	ANA											TP26	DAE	J14	
18		BACK17	Backplane Signal 17	ANA											TP26	DAE	J14	
19		A_GND	Analog Ground	ANA											TP26	DAE	J14	
20		BACK18	Backplane Signal 18	ANA											TP26	DAE	J14	
21		A_GND	Analog Ground	ANA											TP26	DAE	J14	
22		BACK19	Backplane Signal 19	ANA											TP26	DAE	J14	
23		A_GND	Analog Ground	ANA											TP26	DAE	J14	
24		ANOD0	Anode Signal 0	ANA											TP26	DAE	J14	
25		A_GND	Analog Ground	ANA											TP26	DAE	J14	
26		ANOD1	Anode Signal 1	ANA											TP26	DAE	J14	
27		A_GND	Shield	ANA											TP26	DAE	J14	
28		VETO	Veto Signal	ANA											TP26	DAE	J14	
29		A_GND	Analog Ground	ANA											TP26	DAE	J14	
30		PR1	Pressure Transducer 1	ANA											TP26	DAE	J14	
31		A_GND	Analog Ground	ANA											TP26	DAE	J14	
32		PR2	Pressure Transducer 2	ANA											TP26	DAE	J14	
33		A_GND	Analog Ground	ANA											TP26	DAE	J14	
34		CATH0	Cathode signal 0	ANA											TP26	DAE	J14	
35		CATH1	Cathode signal 1	ANA											TP26	DAE	J14	
36		CATH2	Cathode signal 2	ANA											TP26	DAE	J14	
37		CATH3	Cathode signal 3	ANA											TP26	DAE	J14	
38		CATH4	Cathode signal 4	ANA											TP26	DAE	J14	
39		CATH5	Cathode signal 5	ANA											TP26	DAE	J14	
40		CATH6	Cathode signal 6	ANA											TP26	DAE	J14	
41		CATH7	Cathode signal 7	ANA											TP26	DAE	J14	
42		CATH8	Cathode signal 8	ANA											TP26	DAE	J14	
43		CATH9	Cathode signal 9	ANA											TP26	DAE	J14	
44		CATH10	Cathode signal 10	ANA											TP26	DAE	J14	
45		TMP1	Temperature Transducer 1	ANA											TP26	DAE	J14	
46		TMP2	Temperature Transducer 2	ANA											TP26	DAE	J14	
47		DAE+12V	+12V til DAE	DC				0							TP26	DAE	J14	
48		DAE+12V	+12V til DAE	DC				0							TP26	DAE	J14	
49		DAE-12V	-12V til DAE	DC				0							TP26	DAE	J14	
50		DAE-12V	-12V til DAE	DC				0							TP26	DAE	J14	

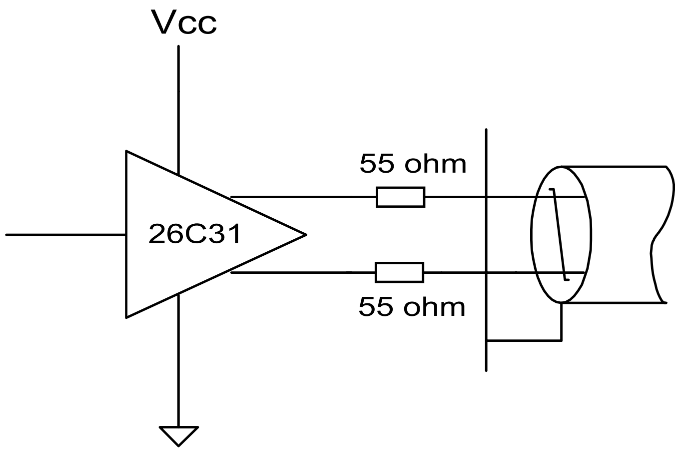
Unit: DFEE		Function: Test		Checked by:									Issue			
Connector Identification: J03					Connector type: ESA/SCC-3401-002-01B-DEMA-9P-NMB-FO											
Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm)	Load Impedanc (Kohm)	Frequency (Hz)	Voltage (V)	Load Capacity to GND (pF)	Source Capacity to GND (pF)	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specific Harness Requirements	To Unit
1		TSTO+	Test Out	DIG												NA
2		TSTO-	Test Out RTN	DIG												NA
3		TSTI+	Test In	DIG												NA
4		TSTI-	Test In RTN	DIG												NA
5																
6																
7																
8																
9																

Unit: DAE		**Function: Control Signal**		**Checked by:**											**Issue**		
Connector Identification: J15				**Connector type: Hermetic Ceramaseal**													
Pin Number	Signal Type	Signal Name	Signal Description	Electrical Type	Current (mA)	Source Impedance (Kohm)	Load Impedanc (Kohm)	Frequency (Hz)	Voltage (V)	Load Capacity to GND	Source Capacity to GND	Rise Time (uS)	Pulse Width (uS)	Sensitivity	Specific Harness Requirements	To Unit	
1		CALON	Calibration On/Off	DIG											TP26	DAE	
2		CALON	Calibration On/Off	DIG											TP26	DAE	
3		D_GND	Shield(Not connected at J 15)	DC													
4		NC															
5		ANO_CON0	Anode Control 0	DIG											TP26	DAE	
6		ANO_CON0	Anode Control 0	DIG											TP26	DAE	
7		ANO_CON1	Anode Control 1	DIG											TP26	DAE	
8		ANO_CON1	Anode Control 1	DIG											TP26	DAE	
9		ANO_CON2	Anode Control 2	DIG											TP26	DAE	
10		ANO_CON2	Anode Control 2	DIG											TP26	DAE	
11		ANO_CON3	Anode Control 3	DIG											TP26	DAE	
12		ANO_CON3	Anode Control 3	DIG											TP26	DAE	
13		CALV	Calibration Level	DC											TP26	DAE	
14		D_GND	Shield(Not connected at J 15)	DC													
15		NC															
16		NC															
17		NC															
18		NC															
19		NC															
20		NC															
21		NC															
22		NC															
23		NC															
24		NC															
25		CALV	Calibration Level	DC											TP26	DAE	

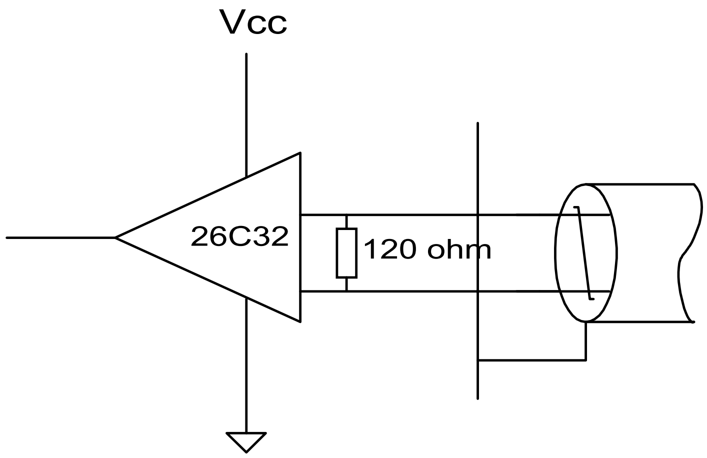
Annex 4. Interface Circuits.



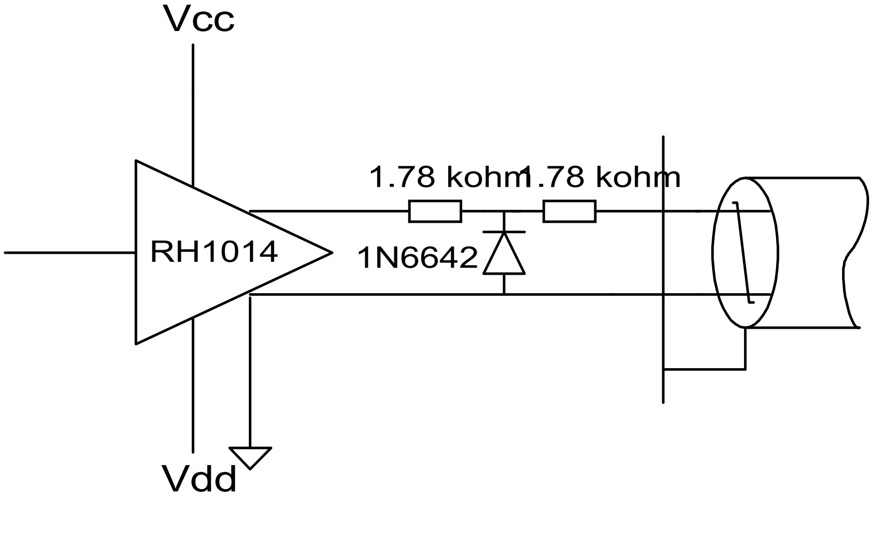
Interface Circuit 1
High Speed Interface Circuit for ENABLE, CLOCK,



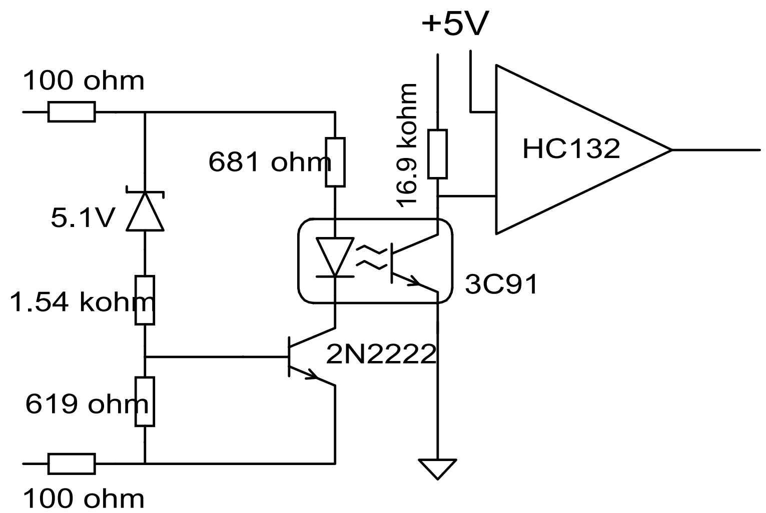
Interface Circuit 2
Interface Circuit for HS-DATA,
LS-TRANSMIT, and TEST Signal



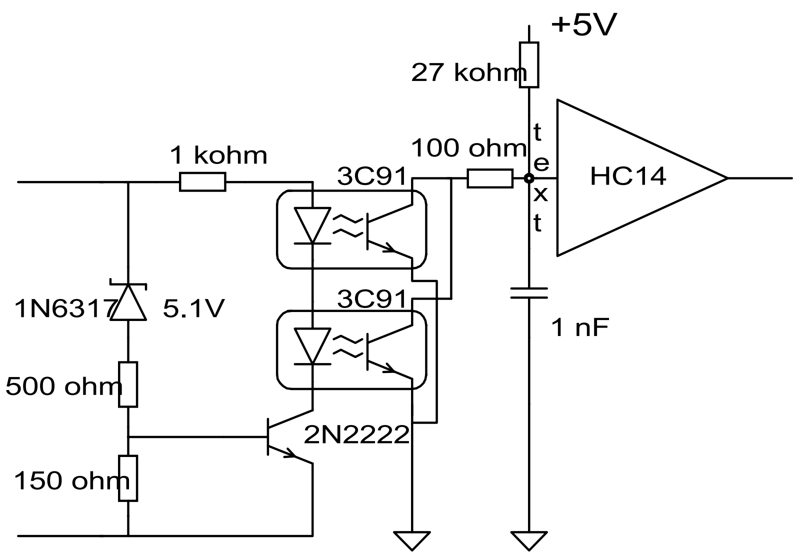
Interface Circuit 3
Low Speed Interface Circuit for RECEIVE, CLOCK, and REQUEST Signal



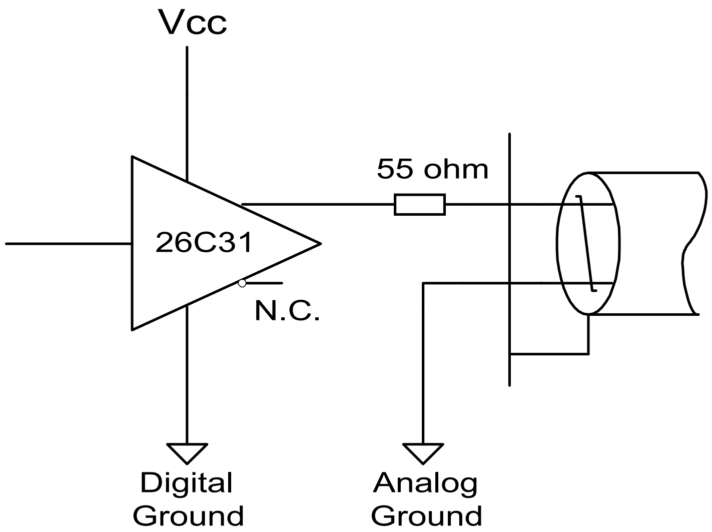
Interface Circuit 4
Interface Circuit for all ANALOG Signals



Interface Circuit 5
HV OFF Command Interface from DPE



Interface Circuit 6
HV OFF Command Interface from RTU



Interface Circuit 7
Interface Circuit for FIFO-FLAG