CLUSTER-2

User Manual for

CIS Flight Operations

1. INSTRUMENT DESCRIPTION

1. SCIENTIFIC OBJECTIVES AND EXPERIMENT CAPABILITIES

The prime scientific objective of CIS is the study of the dynamics of magnetised plasma structures in the vicinity of the Earth's magnetosphere, with emphasis on the physics of the Earth's bow shock, the magnetopause boundary, the polar cusp, the geomagnetic tail and the plasma sheet. Past experience has demonstrated that the study of the macrophysics and microphysics requires that the local orientation and the state of motion of the plasma structures be determined as accurately as possible. The four Cluster spacecraft with relative separation distances that can be adjusted to spatial scales of the structures (a few hundred kilometers to several thousand kilometers) give for the first time the unambiguous possibility to distinguish spatial from temporal variations. These scientific objectives require the investigation of many different phenomena, including solar-wind/magnetopause interactions, substorms and auroras, reconnection, generation of field-aligned currents, polar cusps and upstream foreshock dynamics.

The Cluster spacecraft will encounter ionic plasma of vastly diverse characteristics in the course of one year (Figure 1). A highly versatile and reliable ionic plasma experiment is therefore needed.

The variety of conditions encountered in the various magnetospheric regions sets a number of requirements in order to provide scientifically valuable products everywhere.

1) A great dynamic range is necessary in order to detect fluxes as low as those of the lobes, but also those as high as solar-wind fluxes, throughout the solar cycle.
2) Hot populations are present in vast regions of the magnetosphere and of the magneto-sheath. In order to provide a satisfactory and uniform coverage of the phase space with sufficient resolution, a broad energy range and a full 4π angular coverage are necessary. The angular resolution should be sufficient to be able to separate multiple populations, such as gyrating or transmitted ions from the main population downstream of the bow shock, and to be able to detect fine structures in the distributions.
3) Cold beams, such as the solar wind, require a high angular and energy resolution in a limited energy and angular range. Because of the limited energy range required, a beam tracking algorithm should be implemented in order to be able to follow the beam in velocity space. Moreover, for example in the foreshock regions, any study of backstreaming ions requires the simultaneous observation of the solar-wind cold beam and of the backstreaming particles. Therefore, together with the solar-wind coverage described above, a coverage of the entire phase space excepting the sunward sector, with broad energy range, is also required.
4) In the case of sharp boundaries, such as discontinuities or boundary crossings, it is necessary not to miss any information at the discontinuity, thus a very efficient means of mode change, which allows adaptation to the local plasma conditions, should be provided.
5) Moments of the whole three-dimensional (3D) distribution (and of the sunward sector, in solar-wind mode) should be computed on-board, with high time resolution, to continuously generate key parameters, necessary for event identification.
6) To study detailed phenomena of magnetospheric plasma physics all the particle populations must be identified and characterized, therefore a 3D distribution is needed. In order to transmit the full 3D distribution, while overcoming the telemetry rate limitations, a compression algorithm must be introduced, which allows an increased amount of information to be transmitted.

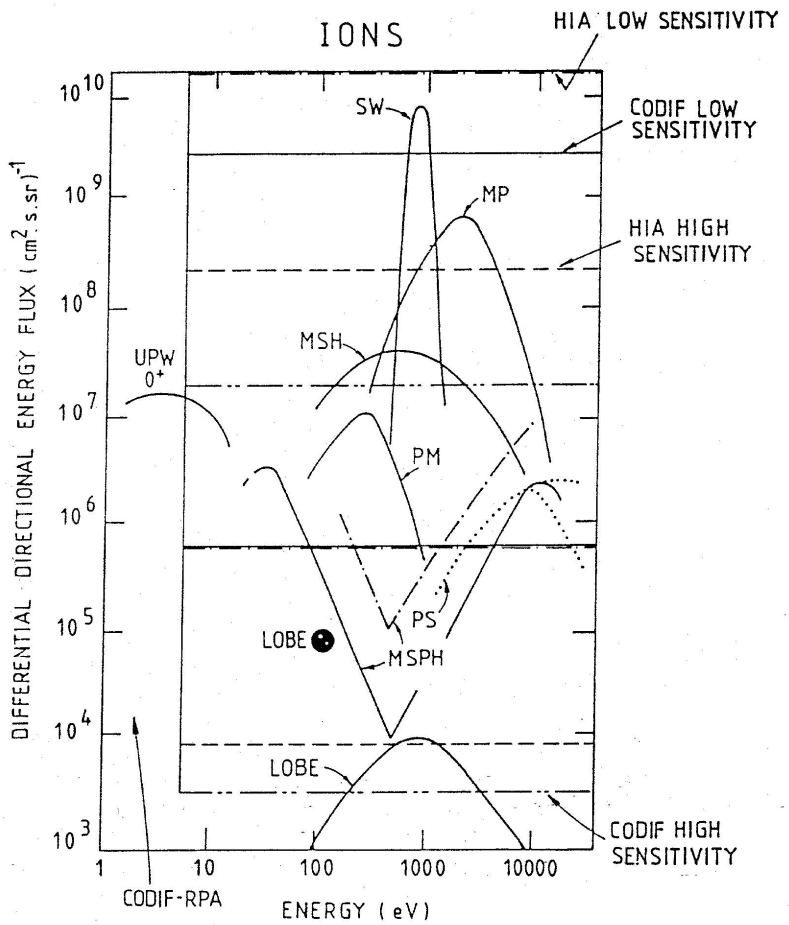


Figure 1. Representative ion differential directional energy fluxes to be encountered in the solar wind (SW), the magnetopause (MP), the magnetosheath (MSH), the plasma mantle (PM), the magnetosphere (MSPH), the plasma sheet (PS), the lobe and upwelling ions (UPW). The range studied by the low sensitivity of HIA is limited by - - - - - - - - - - ·, the range of the high sensitivity of HIA by ------------, the range of low sensitivity of CODIF by full lines, and the range of high sensitivity of CODIF by -.. - .. .. - .. - .. .. - .. - .

So, to meet the scientific objectives, the CIS instrumentation has been designed to satisfy the following criteria, simultaneously on the 4 spacecraft :

* Provide uniform coverage for ions over the entire 4π steradian solid angle with good angular resolution.
* Separate the major mass ion species, i.e. those which contribute significantly to the total mass density of the plasma (generally H^+, He^{++}, He^+, and 0^+).
* Have high sensitivity and large dynamic range ($\geq 10^7$) to support high-time-resolution measurements over the wide range of plasma conditions to be encountered in the Cluster mission (Figure 1).
* Have high (5.6° x 5.6°) and flexible angular sampling resolution to support measurements of ion beams and solar wind.
* Have the ability to routinely generate on-board the fundamental plasma parameters for major ion species and with one spacecraft spin time resolution (4 seconds). These parameters

include the density (*n*), velocity vector (**V**), pressure tensor (**P**), and heat flux vector (**H**)

* Cover a wide range of energies, from spacecraft potential to 40 keV e^{-1}.
* Have versatile and easily programmable operating modes and data-processing routines to optimize the data collection for specific scientific studies and widely varying plasma regimes.
* Rely as much as possible on well-proven sensor designs flown successfully on the AMPTE and Giotto missions.

To satisfy all these criteria, the CIS package consists of two different instruments: a Hot Ion Analyser (HIA) sensor and a time-of-flight ion COmposition and DIstribution Function (CODIF) sensor.

The CIS plasma package is versatile and is capable of measuring both the cold and hot ions of Maxwellian and non-Maxwellian populations (for example, beams) from the solar wind, the magnetosheath, and the magnetosphere (including the ionosphere) with sufficient angular, energy and mass resolutions to meet the scientific objectives. The time resolution of the instrument is sufficiently high to follow density or flux oscillations at the gyrofrequency of H^+ ions in a magnetic field of 10 nT or less. Such field strengths will be frequently encountered by the Cluster mission. Oscillations of O^+ at the gyrofrequency can be resolved outside 6-7 R_E. So this instrument package will provide all of the ionic plasma data required to meet the Cluster science objectives (Escoubet and Schmidt, 1997).

Cluster has been conceived as a global instrument which allows, using four spacecraft, vorticity, gradients, divergences,... to be determined and thus enables macroscopic quantities, for example the electric current from the Curl-***B*** to be measured. Electric currents perpendicular to the magnetic field can also been determined from the pressure gradient of particles. In the simplest case of an ideal magneto-hydromagnetic equilibrium, the perpendicular current density can be written $J_\perp=(B\mathrm{x}\nabla P)/B^2$. More details about the ∇P method accuracy can be found in Martz (1993) and in Martz and Sauvaud (1995). For a satellite distance which is small compared to the current filament transverse dimensions, the ∇P method gives good results. The Curl-*B* method can give less accurate results due to errors on the magnetic field and the satellite separation. On the contrary for a satellite distance which is comparable to the current filament dimensions, the mathematical error introduced by the non-linear variations of the pressure drives an error which becomes very large when a satellite is located outside the current filament. The Curl-*B* method is free of this latter error. Thus the Curl-*B* method and the pressure-gradient methods are complementary for estimating the electric currents.

With its capability to provide three-dimensional distribution functions simultaneously for several major species with high time resolution, the CIS instrument will make substantial contributions to the study of the solar-wind magnetosphere interaction, the dynamics of the magnetosphere, the physics of the magnetopause boundary, the polar cusp and the plasma sheet boundary layer, the upstream foreshock and solar-wind dynamics, the magnetic reconnection and the field-aligned current phenomena. For example an important contribution will be made to the understanding of the formation of the bow shock and its role in the heating and acceleration of incoming ion populations, to take just an example.

At the quasi-perpendicular bow shock the specular reflection of ions, their subsequent energy gain in the upstream $\mathbf{V}_{SW}$ x **B** convection electric field, and their final escape into the downstream region, are known to be important in the dissipation of energy at the shock. The scale length on which the scattering of the original ring distribution and the final thermalisation occurs can at best be guessed (Sckopke *et al.*, 1990). With separation distances from a few 100 km to a few 1000 km the vital scales of several ion gyro radii can be covered with the spacecraft configuration. In addition, CIS will provide the ion distribution functions separately for all major species with a time resolution of one spacecraft spin. Therefore, it will be possible to study the behaviour of He^{++} at the shock. Because of their higher energy all He^{++} ions penetrate the shock. Their bulk velocity is larger than that of the protons, and the entire He^{++} population therefore gyrates in the downstream region. This difference is particularly important. Although the He^{++} ions make up only ~ 6% of the solar wind density, their contribution to the heating downstream of the shock must be comparable to that of the few percent of protons which are reflected and then start to gyrate. Finally, He^{+} pick-up ions of interstellar origin in the solar wind (Möbius *et al.*, 1985, 1988; Gloeckler *et al.*, 1993) present another important source for ion reflection and downstream heating and thermalization. Because pick-up ions fill a sphere in velocity space with a radius equal to the solar wind speed, centred around the solar wind, ions will interact differently with the shock depending on their origin in velocity space. CIS will provide the resolution to determine the original pick-up distribution and the fate of the reflected ions.

The quasi-parallel bow shock is known to be the source of a diffuse energetic ion popu-lation and low-frequency waves. The recent success with hybrid simulations has demonstrated that the energetic ion and wave activity are necessary ingredients of the shock formation which itself is a high dynamic (or even quasi-cyclic) process (e.g. Quest, 1988; Burgess, 1989; Scholer and Terasawa, 1990). This simulation work has paved the way for a combined in-depth study of the evolution of the ion distributions across the shock and their temporal variation with the CIS instrument. As has been shown in a modelling with simulated spacecraft (Giacalone *et al.*, 1994), a close collaboration between the data analysis and simulations will be needed for this task. It can also be expected that the association of ion density enhancements with magnetic pulses upstream of the shock can be identified with CIS and the multi-spacecraft capabilities (Scholer, 1995) as opposed to statistical studies which only yield an average spatial distribution (Trattner *et al.*, 1994). These new measurements will significantly further our understanding of the wave-particle interactions at the bow shock and their importance for ion acceleration and shock structure.

2. THE HOT ION ANALYSER (HIA)

The Hot Ion Analyser (HIA) instrument combines the selection of incoming ions according to the ion energy per charge ratio by electrostatic deflection in a symmetrical quadrispherical analyser which has a uniform angle-energy response with a fast imaging particle detection system. This particle imaging is based on microchannel plate (MCP) electron multipliers and position encoding discrete anodes.

2.1. ELECTROSTATIC ANALYSER DESCRIPTION

Basically the analyser design is a symmetrical quadrispherical electrostatic analyser which has a uniform 360° disc-shaped field of view (FOV) and extremely narrow angular resolution capability. This symmetric quadrisphere or 'top hat' geometry (Carlson *et al.*, 1982) has been successfully used on numerous sounding rocket flights as well as on the AMPTE/IRM, Giotto and WIND spacecraft (Paschmann *et al.*, 1985; Rème *et al.*, 1987; Lin *et al.*, 1995).

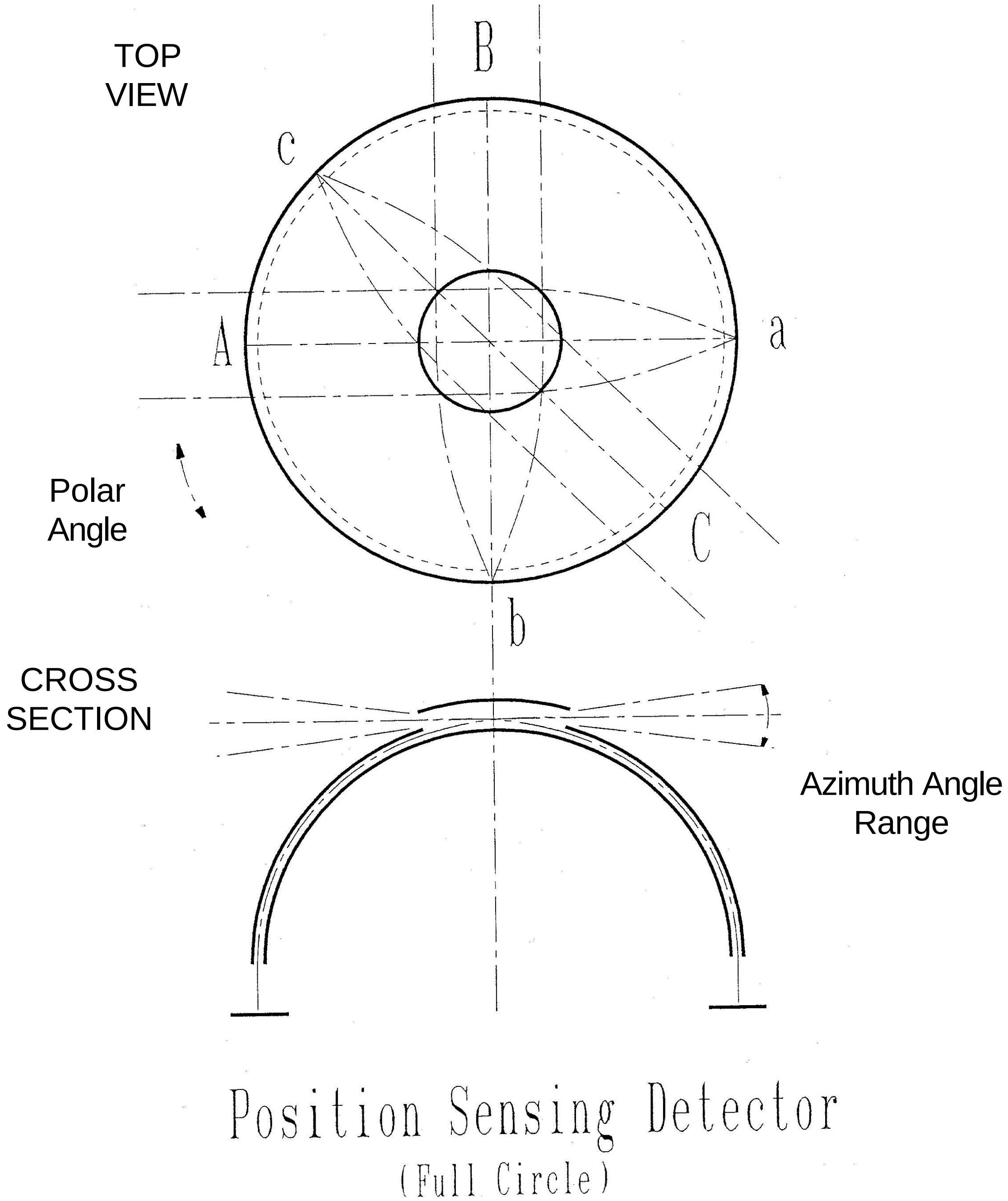


Figure 2. Particle orbits in a symmetrical quadrisphere.

The operating principles of the analyser are illustrated by cross-section and top views in Figure 2. The symmetric quadrisphere consists of three concentric spherical elements. These three elements are an inner hemisphere, an outer hemisphere which contains a circular opening, and a small circular top cap which defines the entrance aperture. This analyser is classified as quadrispherical simply because the particles are deflected through 90°. In either analyser a potential is applied between the inner and outer plates and only charged particles with a limited range of energy and initial azimuth angle are transmitted. The particle exit position is a measure of the incident polar angle which can be resolved by a suitable position-sensitive detector system. The symmetric quadrisphere makes the entire analyser, including the entrance aperture, rotationally symmetric. Trajectories are shown to illustrate the focusing characteristics which are independent of polar angle. Throughout the paper we will use the following convention: the angle about the spin axis is the azimuth angle whereas the angle out of the spin plane is called polar angle.

In conclusion the symmetrical quadrispherical analyser has good focusing properties, sufficient energy resolution, and the large geometrical factor of a quadrisphere. Because of symmetry, it does not have the deficiencies of the conventional quadrisphere, namely limited polar angle range and severely distorted response characteristics at large polar angles, and it has an uniform polar response.

The HIA instrument has 2 x 180° FOV sections parallel to the spin axis with two different sensitivities, with a ratio 20-30 (depending of the flight model and precisely known from calibrations), corresponding respectively to the 'high G' and 'low g' sections. The 'low g' section allows detection of the solar wind and the required high angular resolution is achieved through the use of 8 x 5.625° central anodes, the remaining 8 sectors having in principle 11.25° resolution; the 180° 'high G' section is divided into 16 anodes, 11.25° each. In reality, sectoring angles are respectively ~ 5.1° and ~ 9.7°, as demonstrated by calibrations (see section 2.5). This configuration provides 'instantaneous' 2D distributions sampled once per 62.5 ms (1/64 of one spin, i.e. 5.625° in azimuth), which is the nominal sweep rate of the high voltage applied to the inner plate of the electrostatic analyser to select the energy of the transmitted particles. For each sensitivity section a full 4π steradian scan is completed every spin of the spacecraft, i.e. 4 s, giving a full 3D distribution of ions in the energy range ~ 5 eV e^{-1} to 32 keV e^{-1} (the analyser constant being ~ 6.70).

Figure 3 provides a cross-sectional view of the HIA electrostatic analyser. The inner and outer plate radii are 37.75 mm and 40.20 mm respectively. The analyser has an entrance aperture which collimates the field of view, defines the two geometrical factors and blocks the solar UV radiation.

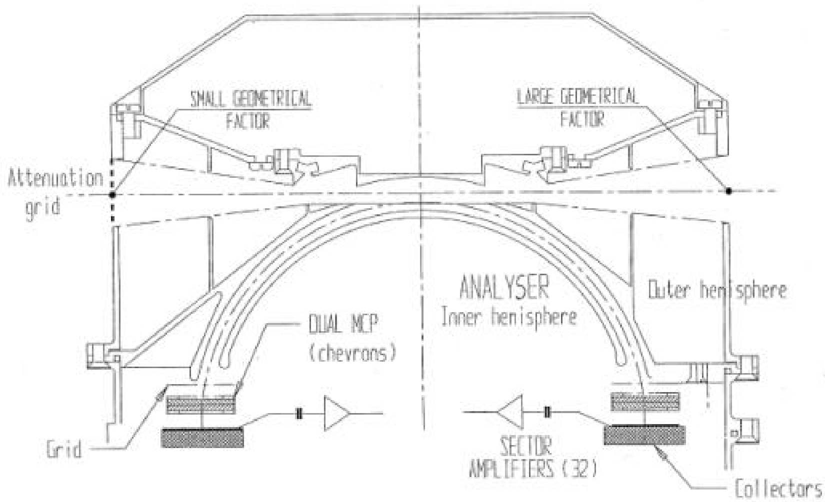


Figure 3. Principle of the HIA electrostatic analyser.

2.2. DETECTION SYSTEM

A pair of half-ring microchannel plates (MCP) in a chevron pair configuration detects the particles at the exit of the electrostatic analyser. The plates form a 2 x 180° ring shape, each 1 mm thick with an inter-gap of ~ 0.02 mm, with an inner diameter of 75 mm and outer diameter of 85 mm. The MCPs have 12.5 µm straight microchannels with a bias angle of 8° to reduce variations in MCP efficiency with azimuthal direction. The chevron configuration with double thickness plates provides a saturated gain of 2 x 10^6, with a narrow pulse height distribution. The plates have a high strip current to provide fast counting capability. For a better detection efficiency ions are post-accelerated by a ~ 2300 V potential applied between the front of the first MCP and a high-transparency grid located ~1 mm above. The anode collector behind the MCPs is divided into 32 sectors, each connected to its own pulse amplifier (Figure 4).

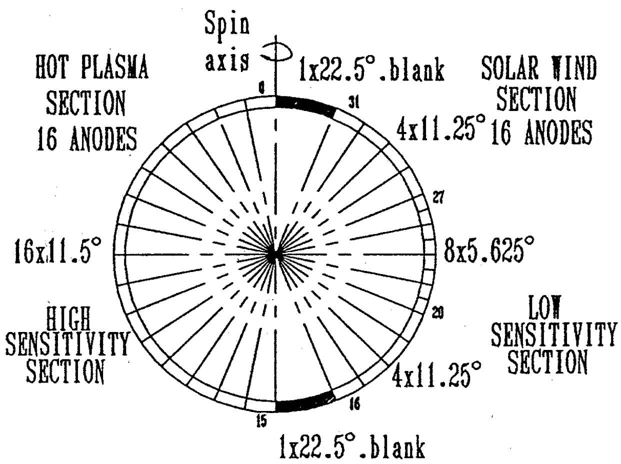


Figure 4. Principle of the HIA sectoring.

3.3. SENSOR ELECTRONICS

Signals from each of the 32 MCP sectors are sent through 32 specially designed very fast A121 charge-sensitive amplifier/discriminators (Figure 5) that are able to count at rates as high as 5 MHz. Output counts from the 32 sectors are accumulated in 48 counters (including 16 redundant counters for the solar wind), thus providing the basic angular resolution matrix according to the resolution of the anode sectoring.

According to the operational mode several angular resolutions can be achieved:

* in the normal resolution mode, the full 3D distributions are covered in ~ 11.2° angular bins ('high G' geometrical factor); this is the basic mode inside the magnetosphere;
* in the high resolution mode the best angular resolution, ~ 5.6° x 5.6°, is achieved within a 45° sector centred on the Sun direction, using the 'low g' geometrical factor section; this mode is dedicated to the detection of the solar wind and near-ecliptic narrow beams.

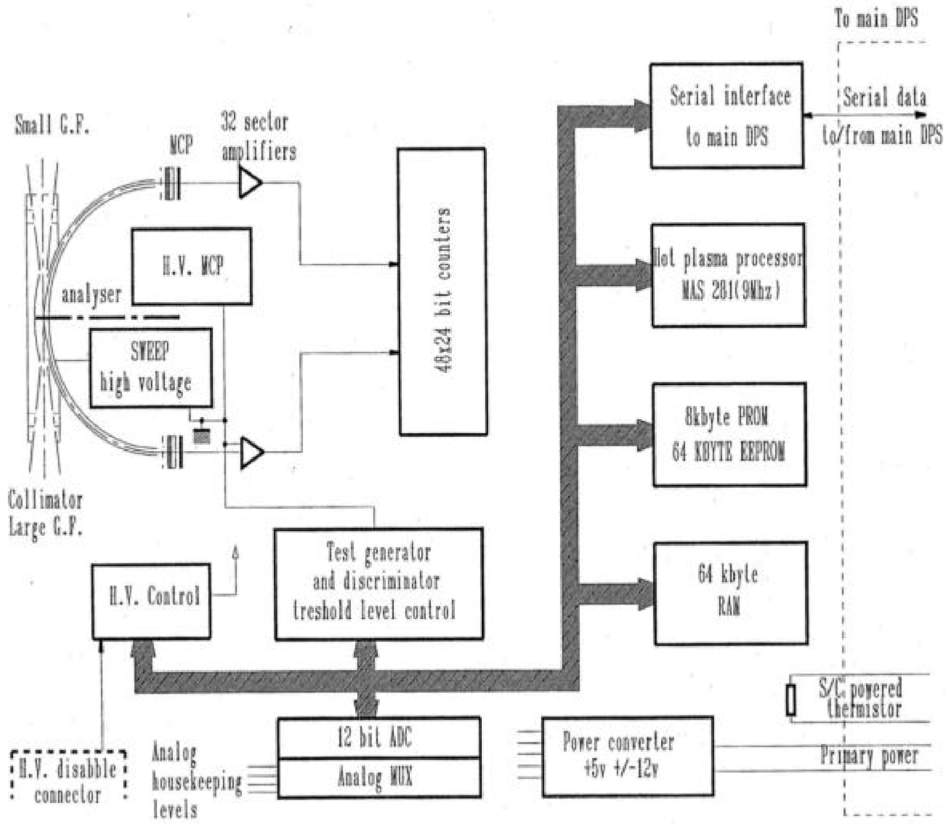


Figure 5. HIA functional block diagram.

Low power converter

The primary 28 V is delivered through the CODIF/DPS box to the HIA low-voltage power converter which provides + 5 V and ± 12 V for digital and analog electronics. In order to reduce the power consumption, HV power supplies are directly powered from the primary 28 V with galvanic insulation between the primary ground and the secondary ground.

High voltage power supplies

HIA needs a high-voltage power supply to polarise MCPs at ~ 2300-2500 V and a sweeping high voltage applied on the inner plate of the electrostatic analyser. The high voltages to polarise the MCPs are adjustable under control of the data processor system (DPS) microprocessor.

The energy/charge of the transmitted ions is selected by varying the deflection voltage applied to the inner plate of the electrostatic analyser, between 4800 and 0.7 V. The exponential sweep variation of the deflection voltage is synchronised with the spacecraft spin period. The sweep should consist of many small steps that give effectively a continuous sweep. The counter accumulation time defines the number of energy steps, i.e. 31 or 62 count intervals per sweep. The covered energy range and the sweeping time are controlled by the onboard processor through a 12 bit DAC and a division in two ranges for the sweeping high voltage. So the number of sweeps per spin, the amplitude of each sweep and the sweeping energy range can be adjusted according to the mode of operation (solar wind tracking, beam tracking, etc.). In the basic and nominal mode the sweep of the total energy range is repeated 64 times per spin, i.e. once every 62.5 ms, giving a ~ 5.6° resolution in azimuth resolution.

The HIA block diagram is shown in Figure 5.

2.4. IN-FLIGHT CALIBRATION TEST

A pulse generator can stimulate the 32 amplifiers under processor control. This way all important functions of the HIA instrument and of the associated on-board processing can easily be tested. A special test mode is implemented for health checking of the microprocessor by making ROM checksums and RAM tests. The sweeping high voltage can be tested by measuring the voltage value of each individual step and the MCP gain can be checked by occasionally stepping MCP HV and by adjusting the discrimination level of charge amplifiers.

Performances of the HIA sensor are shown in Table I and in Figure 1. The full sensor is shown in Figure 6.

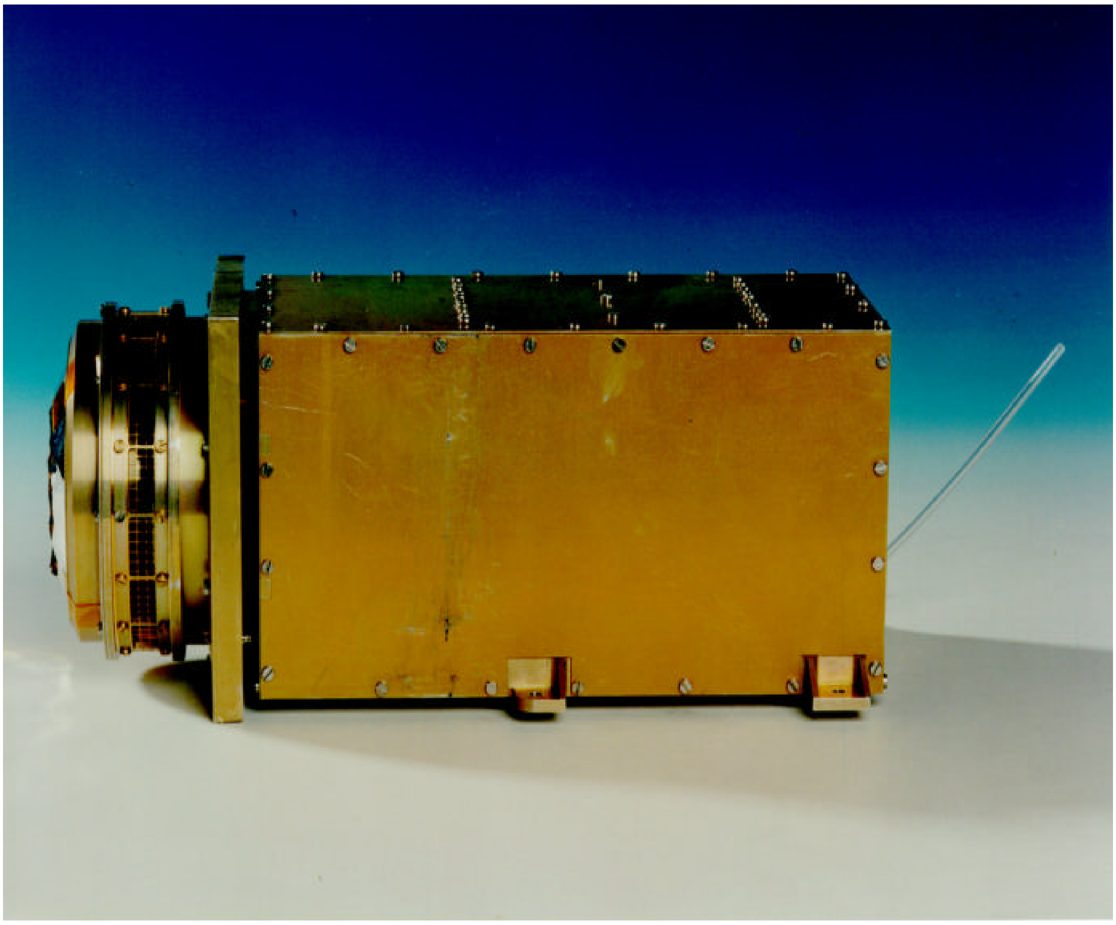


Figure 6. The HIA Sensor.

Table I. Main-measured parameters

MAIN-MEASURED PARAMETERS

- Full 3D ion distribution functions
- Flux as a function of time, mass and pitch angle
- Moments of the distribution functions : density, bulk velocity, pressure tensor, heat flux vector
- Beams

Analysers	**Energy Range**	**Energy Distribution (FWHM)**	**Time Resolution**		**Mass Resolution M/DM**	**Angular Resolution**	**Geometrical Factor (Total) (cm^2.sr.kev)**	**Dynamics (cm^2 sec sr)$^{-1}$**
			2D ms	**3D s**				
Hot Ion Analyser HIA	~ 5 eV/e – 32 keV/e	18%	62.5	4	-	~ 5.6° x 5.6°	3.5 x 10^{-4} E(keV) for one half 7.10^{-3} E(keV) for the other half	10^4 – 2 x 10^{10}
Ion Composition and Distribution Function Analyser CODIF	~ 0 - 40 keV/e Mass range 1 – 32 amu	16%	125	4	~ 4 - 7	~11.2° x 22.5°	2.16 x 10^{-3} cm^2 sr for one half 2.3 x 10^{-5} cm^2 sr for the other half 3.5 x 10^{-2} cm^2 sr for the RPA	3.10^3 - 3.10^9

Analyzers	**Full Instantaneous Field of View**	**Mass**	**Power (Nominal Operations)**
Hot Ion Analyser HIA	8° x 360°	2.45 kg	2.82 watts
Ion Composition and Distribution Function Analyser CODIF	8° x 360°	8.39 kg	6.96 watts

CIS total raw CIS Total Weight : **10.84 kg without harness**

Average power : **9.78 watts**

CIS Telemetry : **~ 5.5 kbit/s**

Expected total bit number (for the 4 spacecraft) : **10^{12} bits**

2.5. HIA PERFORMANCES

Pre-flight and extensive calibrations of all four HIA flight models were performed at the CESR vacuum test facilities in Toulouse, using large and stable ion beams of different ion species and variable energies, detailed studies of MCPs and gain level variations, MCP matching, angular-energy resolution for each sector from a few tens of eV up to 30 keV. Typical performances of the HIA instrument are reproduced in Figure 7. The analyser energy resolution $\Delta E/E$ (FWHM) is ~ 18%, almost independent of anode sectors and energy; thus the intrinsic HIA velocity resolution is ~ 9 %, only about half of the average solar wind spread value. This is equivalent to an angular resolution of ~ 5° and is thus quite consistent with the angular resolution capabilities of the instrument, i.e. ~ 5.9° (FWHM) in azimuthal angle, as indicated in Figure 7, and ~ 5.6° in polar angle. The polar resolution stays, as expected, almost constant, ~ 9.70°, over the 16 sectors (anodes 0 to 15) constituting the 'high G' section (Figure 8). Anodes 16 to 31 correspond to the 'low g' section and their response transmission is attenuated by a factor of 20-30 (depending of the flight model) due to the presence of a pin-hole grid placed in front of the 180° collimator; the polar resolution of sectors 20 to 27 is ~ 5.1°. Thus, when compared to the basic sectoring, ~ 5.6° and ~ 11.2°, all effective polar resolutions are reduced, due to existence of an insulation space between the discrete anodes, as well as by the presence of support posts within the field of view. Finally, experimental energy, angle resolutions and transmission factors are introduced in the geometrical factor used to compute moments of the distribution function.

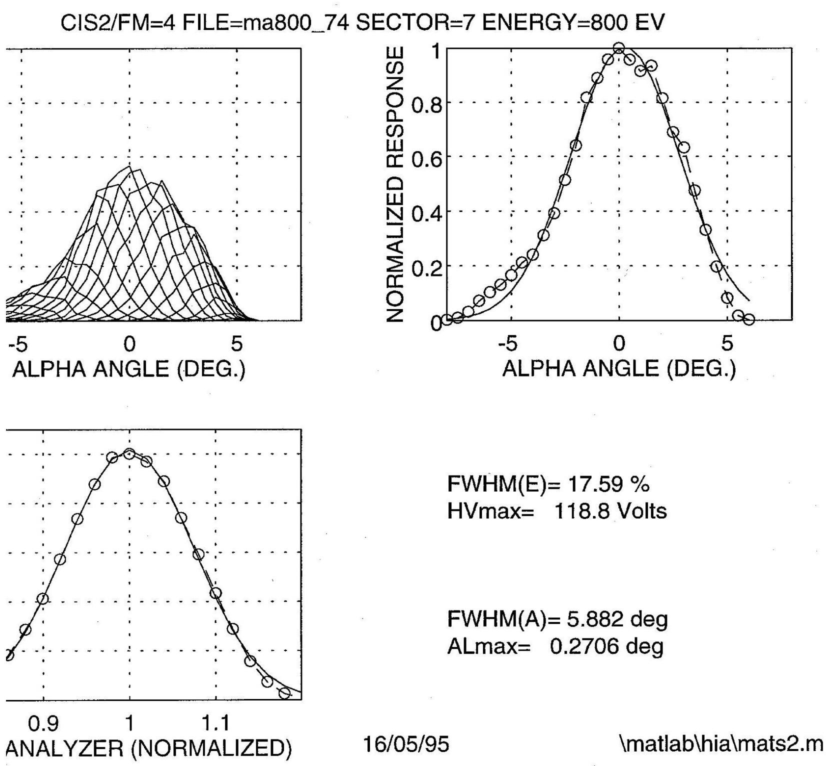


Figure 7. Typical energy and angular resolutions of the HIA analyser (flight model FM4), for an energy beam of 800 eV; the energy resolution is ~ 18% and the intrinsic azimuthal resolution ~ 5.9°.

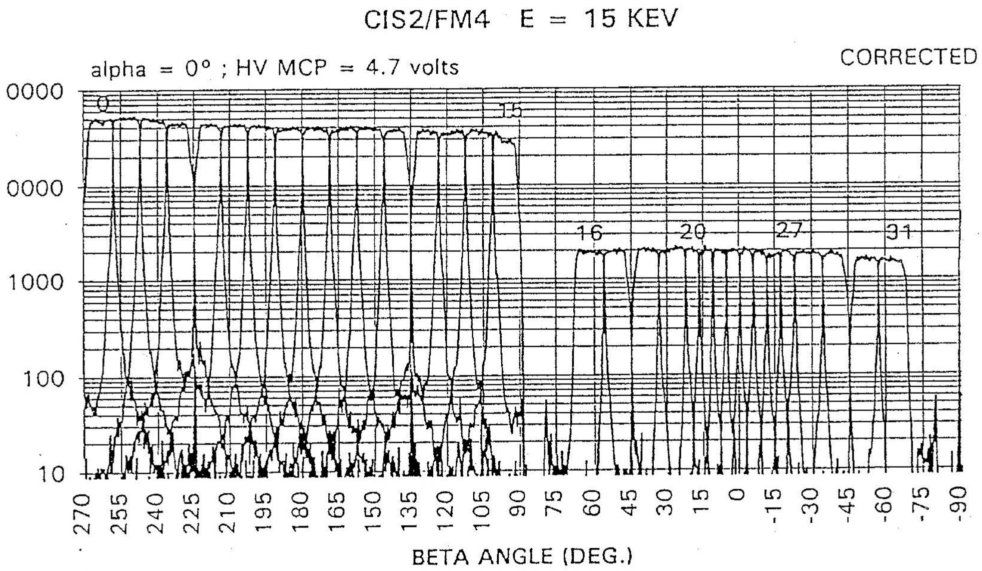


Figure 8. Calibrated relative transmission of the HIA polar sectors (beta angle in the vacuum chamber). Sectors 0-15 have ~ 9.7° (FHWM) angular resolution; transmission of sectors 16-31 is attenuated by a factor of ~25 and equatorial sectors 20-27 have ~ 5.1° (FWHM) angular resolution. 0-180° axis corresponds to the spacecraft spin axis.

2.5.1. UV Rejection

A number of very interesting events are expected to occur when the HIA spectrometers face the Sun (2 times/spin): of course the intense solar wind, but also, for example, tailward ion beams flowing along the PlasmaSheet Boundary Layer (PSBL). Also a number of measures are applied in order to suppress or limit the solar UV contamination. Part of the UV is rejected by the entrance collimator; moreover, the inner surface of the outer sphere is scalloped and both spheres (and all internal parts) are treated and coated with a special black cupric sulfide. Extensive vacuum chamber tests of the HIA analysers were performed, using a calibrated continuous discharge source for extreme UV at He-584 Å and Lα 1215 Å lines. Reduction of the solar UV light reflectance at the Lα line is demonstrated in Figure 9. The resulting maximum count rate recorded by the sunward looking sector (11.2° wide) is about 80 counts s^{-1} (for an intensity equivalent to 3 Sun intensity units) and the UV contamination is distributed over about ~100° in polar angle; such a contamination is acceptable in the solar wind as well as in the magnetosphere.

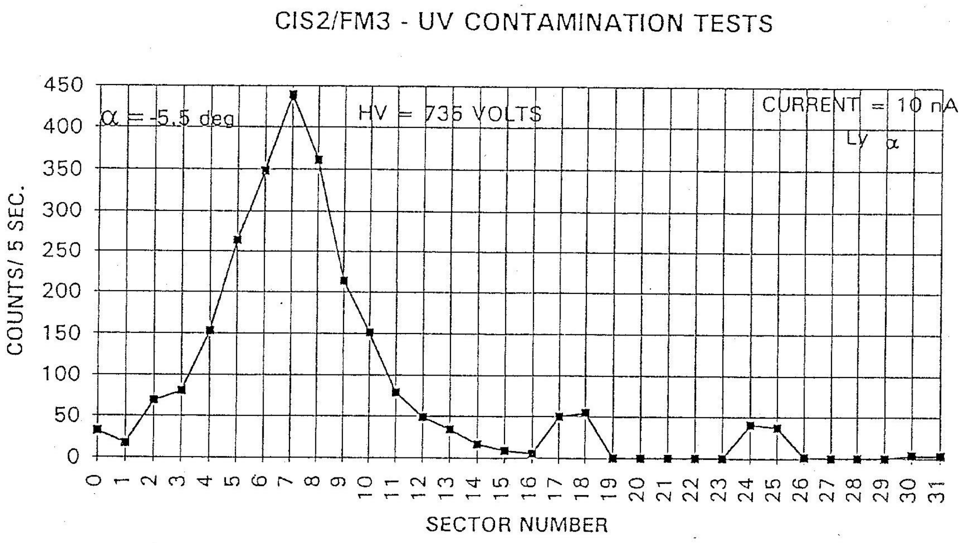


Figure 9. Azimuthal distribution of the solar UV count rate for each sector; the UV source is centered on sector 7 and the polar angle is -5° (when the UV sunlight hits the inner hemisphere). Lα intensity measured by a windowless Au photodiode is equivalent to ~3 Sun units.

3. THE ION COMPOSITION AND DISTRIBUTION FUNCTION ANALYSER (CODIF)

The CODIF instrument is a high-sensitivity mass-resolving spectrometer with an instantaneous 360° x 8° field of view to measure full 3D distribution functions of the major ion species (as much as they contribute significantly to the total mass density of the plasma), within one spin period of the spacecraft. Typically these include H^+, He^{++}, He^+ and O^+.

The sensor primarily covers the energy range between 0.02 and 40 keV/charge. With an additional Retarding Potential Analyser (RPA) device in the aperture system of the sensor with pre-acceleration for the energies below 25 eV e^{-1}, the range is extended to energies as low as the spacecraft potential. So, CODIF will cover the core of all plasma distributions of importance of the Cluster mission.

To cover the large dynamic range required for accurate measurements in the low-density plasma of the magnetotail on the one hand and the dense plasma in the magnetosheath/cusp/ boundary layer on the other, it is mandatory that CODIF employs two different sensitivities. The minimum number of counts in a distribution needed for computing the basic plasma parameters, such as the density, is about 100. These must be accumulated in 1 spin to provide the necessary time resolution. However, the maximum count rate which the time-of-flight system can handle is ~10^5 counts s^{-1} or 4 x 10^5 counts $spin^{-1}$. This means the dynamic range achievable with a single sensitivity is only 4 x 10^3.

Figure 1 shows the covered fluxes ranging from magnetosheath/magnetopause protons to tail lobe ions (which consist of protons and heavier ions); fluxes from ~ 10^3 to over 10^8 must be covered, requiring a dynamic range of larger than 10^5. This can only be achieved if CODIF incorporates two sensitivities, differing by a factor of 100. CODIF therefore will consist of two sections, each with 180° field of view, with different (by a factor of 100) geometrical factors. This way one section will always have count rates which are statistically meaningful and at the same time can be handled by the time-of-flight electronics. The exception is solar wind H^+ which will often saturate the instrument, but will be measured with HIA.

The CODIF instrument combines ion energy per charge selection by deflection in a rotationally symmetric toroidal electrostatic analyser with a subsequent time-of-flight analysis after post-acceleration to $\geq$ 20 keV e^{-1}. A cross section of the sensor showing the basic principles of operations is presented in Figure 10.

The energy-per-charge analyser is of a rotationally symmetric toroidal type, which is basically similar to the quadrispheric top-hat analysers. It has an uniform response over 360° of polar angle. The energy per charge selected by the electrostatic analyser E/Q, the energy gained by post-acceleration $e.U_{ACC}$, and the measured time-of-flight through the length d of the time-of-flight (TOF) unit, τ, yield the mass per charge of the ion M/Q according to : $M/Q = 2(E/Q + e.U_{ACC}) / (d/\tau)^2.\alpha$. The quantity α represents the effect of energy loss in the thin carbon foil (~ 3 μg cm^{-2}) at the entry of the TOF section and depends on particle species and incident energy.

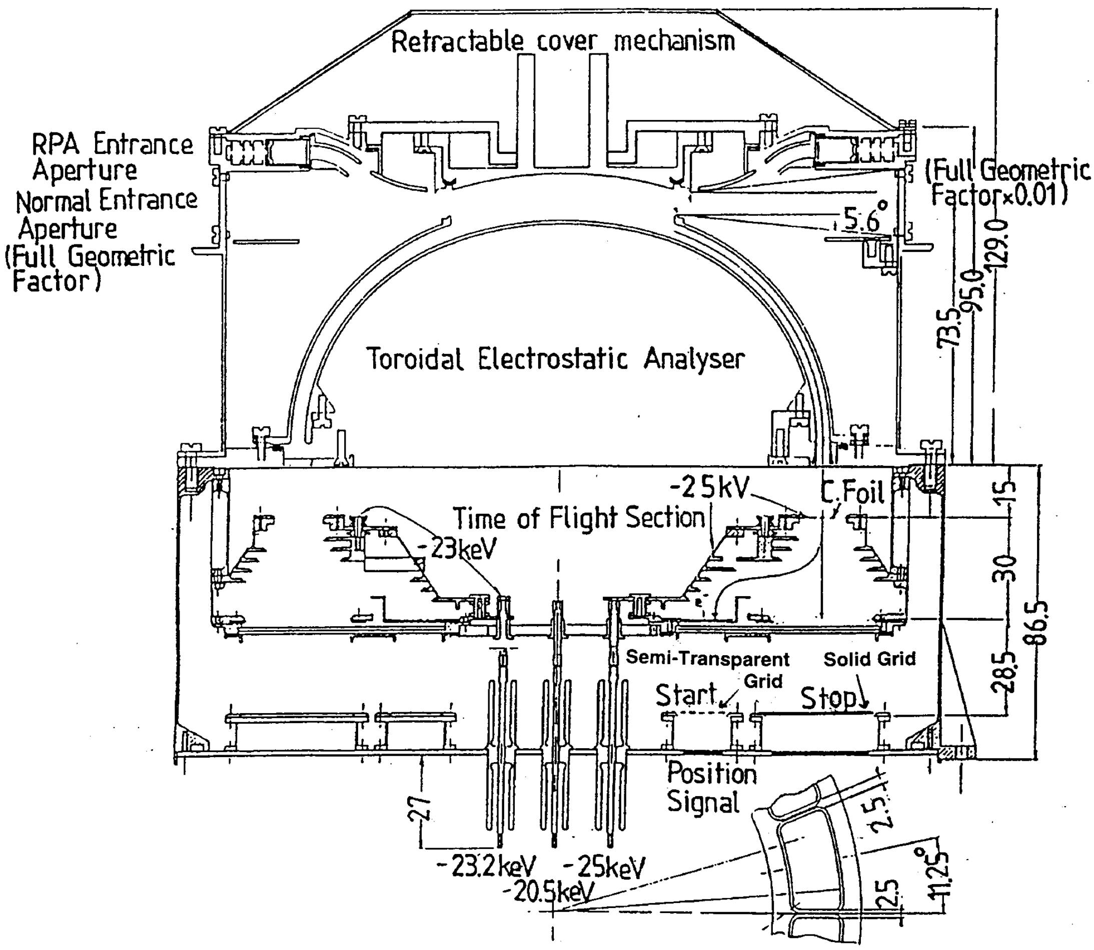


Figure 10. Cross-sectional view of the CODIF sensor. The voltages in the TOF section are shown for a 25 kV post-acceleration.

3.1. ELECTROSTATIC ANALYSER DESCRIPTION

The electrostatic analyser (ESA) has a toroidal geometry which provides optimal imaging just past the ESA exit. This property was first demonstrated by Young *et al.* (1988). The ESA consists of inner and outer analyser deflectors, a top-hat cover and a collimator. The inner deflector consists of toroidal and spherical sections which join at the outer deflector entrance opening (angle of 17.9°). The spherical section has a radius of 100 mm and extends from 0 to 17.9° about the *z*-axis. The toroidal section has a radius of 61 mm in the poloidal plane and extends from 17.9° to 90°. The outer deflector covers the toroidal section and has a radius of 65 mm. The top-hat cover consists of a spherical section with a radius of 113.2 mm, which extends from 0 to 16.2°. It thus fits inside the entrance aperture of the outer deflector. The top-hat cover contains an O-ring outside the spherical section, which together with a lip on the outer deflector provides a seal of the sensor interior during integration and launch activities when the protection retractable cover will be closed. The outer deflector and the top-hat cover will be at signal ground under normal operation, but will be biased at about -100 V during RPA operation. The inner deflector will be biased with voltages varying from -1.9 to -4950 V to cover the energy range in normal ESA operation and set to about -113 V for the RPA.

The fact that the analyser has complete cylindrical symmetry provides the uniform response in polar angle. A beam of parallel ion trajectories is focused to a certain location at the exit plane of the analyser. The exit position, and thus the incident polar angle of the ions, is identified using the information from the start detector (see Section 3.2) . The full angular range of the analyser is divided into 16 channels of 22.5° each. The broadening of the focus at the entrance of the TOF section is small compared to the width of the angular channels.

As illustrated in Figure 10, the analyser is surrounded by a cylindrical collimator which serves to define the acceptance angles and restricts UV light. The collimator consists of a cylindrical can with an inner radius of 96 mm. The entrance is covered by an attenuation grid with a radius of 98 mm which is kept at spacecraft ground. The grid has a 1% transmission factor over 50% of the analyser entrance and > 95% transmission over the remaining 50%. The high transmission portion extends over the azimuthal angle range of 0 to 180° where 0° is defined along the spacecraft spin axis. The low transmission portion, whose active entrance only extends from 22.5° to 157.5° in order to avoid the counting of any crossover from the other half, has a geometric factor that is reduced by a factor of $\approx$ 100 in order to extend the dynamic range to higher flux levels. On the low-sensitivity half, the collimator consists of a series of 12 small holes vertically spaced by approximately 1.9° around the cylinder. These apertures have acceptance angles of 5° FWHM, so there are no gaps in the polar angle coverage. The ion distributions near the polar axis are highly over-sampled during one spin relative to the equatorial portion of the aperture. Therefore, count rates must be weighted by the sine of the polar angle to normalise the solid-angle sampling for the moment calculations and 3D distributions.

The analyser has a characteristic energy response of about 7.6, and an intrinsic energy resolution of $\Delta E/E \cong 0.16$. The entrance fan covers a viewing angle of 360° in polar angle and 8° in azimuth. With an analyser voltage of 1.9- 4950 V, the energy range for ions is 15 - 40000 eV e^{-1}. The deflection voltage is varied in an exponential sweep. The full energy sweep with 30 contiguous energy channels is performed 32 times per spin. Thus a partial two-dimensional cut through the distribution function in polar angle is obtained every 1/32 of the spacecraft spin. The full 4π ion distributions are obtained in a spacecraft spin period. Including the effects of grid transparencies and support posts in the collimator each 22.5° sector has a respective geometric factor $A\Delta E/ED\Theta\pi/8 = 2.16 \times 10^{-3}$ cm^{2}sr in the high sensitivity side and 2.3×10^{-5} cm^{2}sr where *A* denotes the aperture area and $\Delta\Theta$ the acceptance angle in azimuth. The acceptance in polar angle is $\pi/8$. The detection efficiencies of the time-of-flight system vary with particle energy, species and individual MCP assembly and therefore are treated separately in section 3.5.

The outer plate of the analyser is serrated in order to minimize the transmission of scattered ions and UV. For the same reason the analyser plates are covered with a copper black coating. Behind the analyser the ions are accelerated by a post-acceleration voltage of 16-25 kV, such that also thermal ions have sufficient energy before entering the TOF section.

Retarding Potential Analyser

In order to extend the energy range of the CODIF sensor to energies below 15 eV e^{-1}, an RPA assembly is incorporated in the two CODIF apertures (see Figures 11 and 12). The RPA provides a way selecting low-energy ions as input to the CODIF analyser without requiring the ESA inner deflector to be set accurately near 0 V. The RPA collimates the ions, provides a sharp low-energy cutoff at a normal incident grid, pre-accelerates the ions to 100 eV after the grid, and deflects the ions into the ESA entrance aperture. The RPA will pass a 1 mm wide beam with ± 5° of polar angle range and to about 10° of azimuthal angle about the center axis of each of the entrance apertures over the 360° field of view, giving a geometric factor of 0.035 cm^2 sr. Collimation in azimuthal angle to ±10° of normal incidence to the RPA grid limits the entrance area to about half. The energy pass of the ESA is about 5-6 eV at 100 eV of pre-acceleration, assuming all deflection voltages are optimised. This energy pass is very sensitive to the actual RPA deflection optics, so that deflection voltages will have to be determined at about the 1% level.

The RPA consists of a collimator, RPA grid and pre-acceleration region, and deflection plates. The collimator section is kept at spacecraft ground.

The deflection system provides a method of steering the RPA low-energy ions into the CODIF ESA.

The RPA grid and pre-acceleration region consist of a pair of cylindrical rings, sandwiched between resistive ceramic material. Both inner and outer cylindrical rings contain apertures separated by posts every 22.5°, similar to the ESA collimator entrance, to allow the ions to pass through the assembly. The RPA grid is attached to the inner surface of the outer cylindrical ring. This outer ring has a small ledge which captures the RPA grid and which also provides the initial optical lens that is crucial to the RPA operation. Both inner and outer cylindrical rings are in good electrical contact with the resistive kapton (silver epoxy). During RPA operation the outer cylindrical ring is biased from spacecraft ground to about + 25 V and provides the sharp low-energy RPA cutoff. This voltage is designated V_{rpa} in Figure 11. The inner cylindrical ring tracks the outer ring voltage and is biased at -100 V + V_{rpa}. The inner cylindrical ring, the ESA outer deflector, and the ESA top-hat cover are electrically tied to the RPA deflector.

The RPA deflection plates consist of three toroidal deflectors located above the ESA collimator entrance and one deflector disk located below the collimator entrance. The three toroidal deflectors are used to deflect the ions into the ESA. The deflector disk is used to prevent low-energy ions from entering the main aperture and to collect any photoelectrons produced inside the analyser, while in RPA mode.

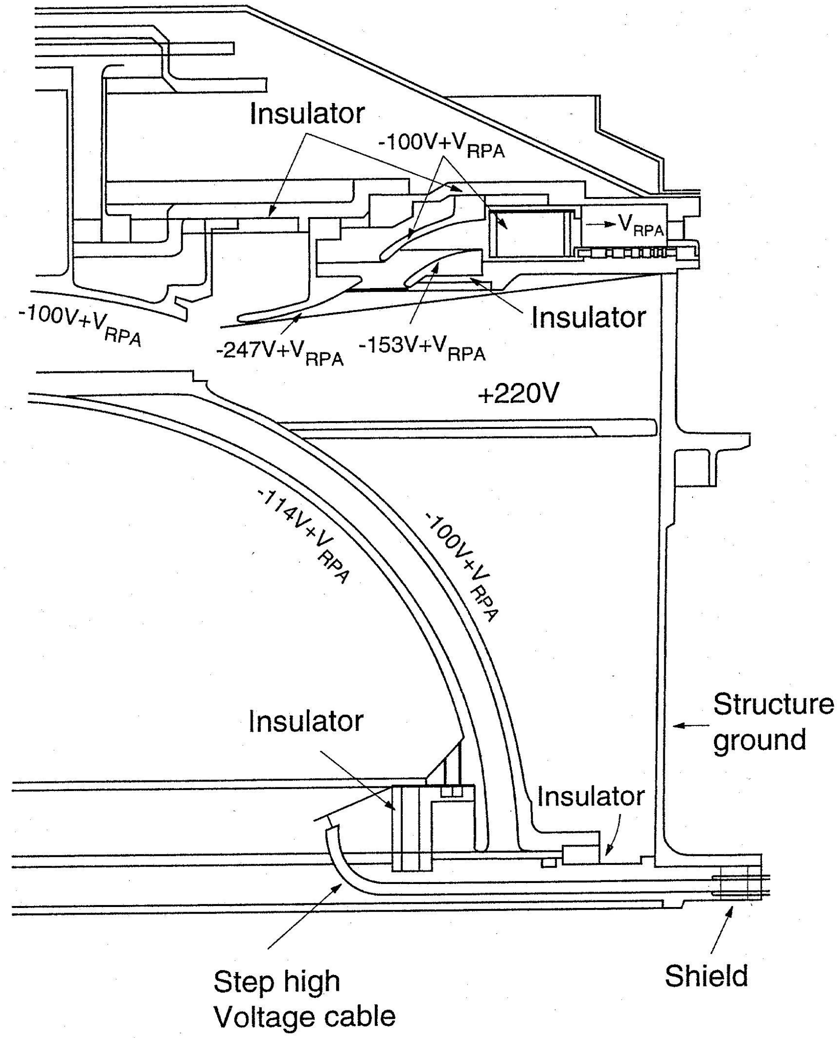


Figure 11. Geometry of the CODIF RPA.

3.2. TIME-OF-FLIGHT AND DETECTION SYSTEM

The CODIF sensor uses a time-of-flight technology (Möbius *et al.*, 1985). The specific parameters of the time-of-flight spectrometer have been chosen such that a high detection efficiency of the ions is guaranteed. High efficiency is not only important for maximizing the overall sensor sensitivity, but it is especially important for minimising false mass identification resulting from false coincidence at high counting rate. Too thin a carbon foil would result in a significant reduction in the efficiency of secondary electron production for the 'start' signal, while an increase in thickness does not change the secondary electron emission significantly (Ritter, 1985). Under these conditions a post-acceleration of ≥ 20 kV is necessary for the mass resolution of the sensor.

After passing the ESA the ions are focussed onto a plane close to the entrance foil of the time-of-flight section (Figure 12). The TOF section is held at the post-acceleration potential (between -16 kV and -25 kV) in order to accelerate the ions into the TOF section with a minimum energy greater than 20 keV charge^{-1}. With this potential configuration the ion image on the foil extends from r = 70 mm to r = 80 mm at high energies, and the image diameter is reduced to 3 mm or less at energies lower than 5 keV.

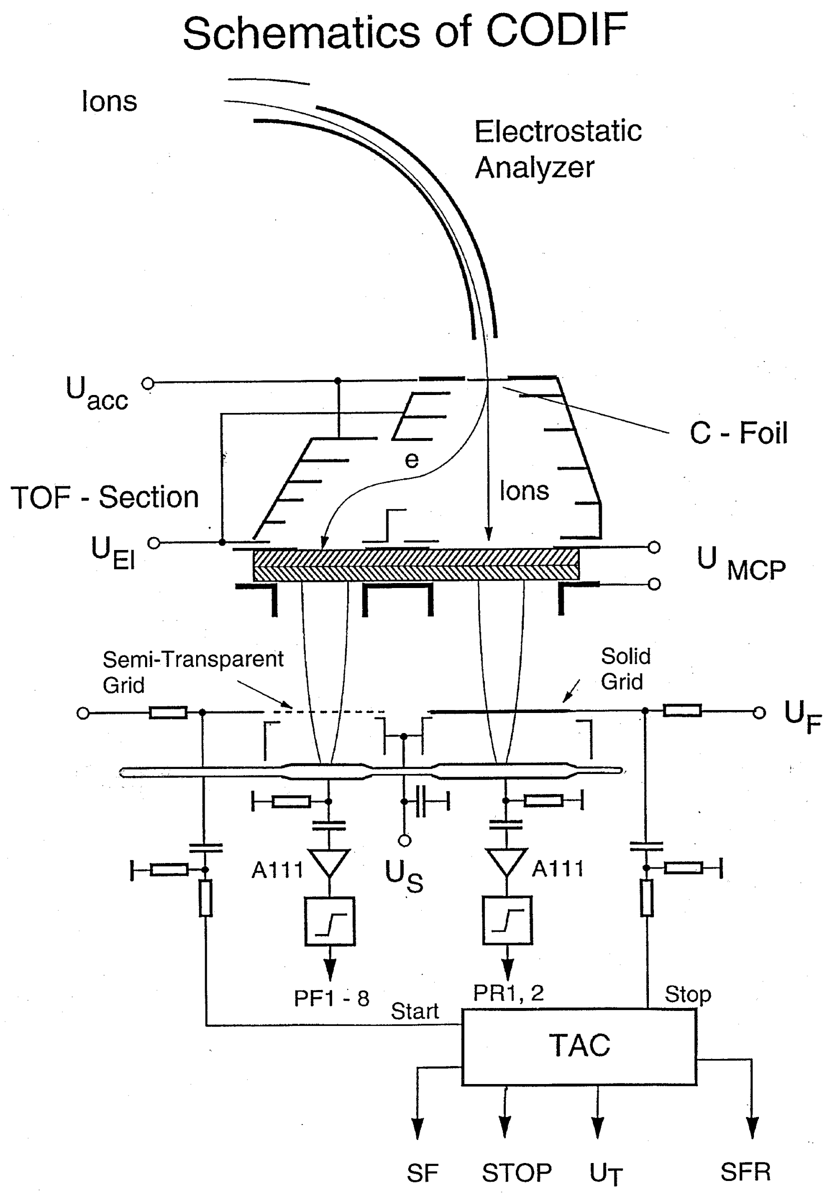


Figure 12. Schematics of CODIF sensor.

In the TOF section, the velocity of the incoming ions is measured. The flight path of the ions is defined by the 3 cm distance between the carbon foil at the entrance and the surface of the 'stop' microchannel plate (MCP). The start signal is provided by secondary electrons, which are emitted from the carbon foil during the passage of the ions. The entrance window of the TOF section is a 3µg cm^{-2} carbon foil, which is an optimum thickness between the needs of low-energy loss and straggling in the foil and high efficiency for secondary electron production. The electrons are accelerated to 2 keV and deflected onto the start MCP assembly by a suitable potential configuration.

The secondary electrons also provide the position information for the angular sectoring. The carbon foil is made up of separate 22.5° sectors, separated by narrow metal strips. The electron optics are designed to strongly focus secondary electrons originating at a foil onto the corresponding MCP start sector.

Between the two sections with different geometrical factors a non-conducting plate with conducting strips in the appropriate equipotential configuration will ensure that no electrons and ions can penetrate into the other section.

The MCP assemblies are ring-shaped with inner and outer radii of 6 x 9 cm and 3 x 5 cm for the stop and start detectors, respectively. In order to achieve a high efficiency for the detection of ions at the stop MCP, a positive bias voltage is applied to collect secondary electrons from the 40 % dead area of the MCP and the carbon foil.

The signal output of the MCPs is collected on a set of segmented plates behind the start MCPs (22.5° each), behind the stop MCPs (90° each), and on thin wire grids with ≈ 50% transmission at a distance of 10 mm in front of the signal plates, all being at ground potential (see Figure 10). Thus almost all of the post-acceleration voltage is applied between the rear side of the MCPs and the signal anodes. All signal outputs are coupled to 50 Ω impedance preamplifier inputs via a capacitor-resistor network. The timing signals are derived from the 50% transmission grids, separately for the high- and the low-sensitivity TOF section. The position signals, providing the angular information in terms of 22.5° sectors, are derived from the signal plates behind the start MCP.

Table I summarises the main performances of the HIA and CODIF sensors.

3.3. SENSOR ELECTRONICS

The sensor electronics (Figure 13) of the instrument comprise two time-to-amplitude converters (TACs) to measure the time-of-flight of the ions between the start carbon foil and the stop MCPs, two sets of eight position discriminators at the start MCPs, two sets of two position discriminators at the stop MCPs, and the event selection logic. Each individual ion is pulse-height-analysed according to its time-of-flight, incidence in azimuthal (given by the spacecraft spin) and polar angle (given by the start position), and the actual deflection voltage.

The eight position signals for each TOF section (in order to achieve the 22.5° resolution in polar angle) are independently derived from the signal anodes, while the timing signals are taken from the grids in front of the anodes. Likewise, the stop MCPs, consisting of four individual MCPs, are treated separately to carry along partial redundancy. By this technique the TOF and the position signals are electrically separate in the sensor. The position pulses are fed into charge-sensitive amplifiers and identified by pulse discriminators, the signal of which is directly fed into the event selection logic.

The TOF unit is divided into two TOF channels. The outputs of the 50 % transmission grids in front of the signal anode of the MCPs are capacitively coupled to two input stages of the TOF electronics. These input stages consist of a preamplifier (rise time < 0.9 ns) and a fast timing discriminator using a tunnel diode, and are contained in custom-made hybrids. The outputs of these hybrids are used to drive the TAC. The TAC provides an output signal whose amplitude is proportional to the time delay between the start and stop pulses. In addition, the TAC generates logical output signals for each start and stop pulse. The measured overall timing accuracy of the electronics for an amplitude of 100 mV of the start and stop pulse is 0.2 ns. The TAC output pulse is pulse-height analysed by a fast analog-to-digital converter (ADC) with a conversion time of < 6 µs.

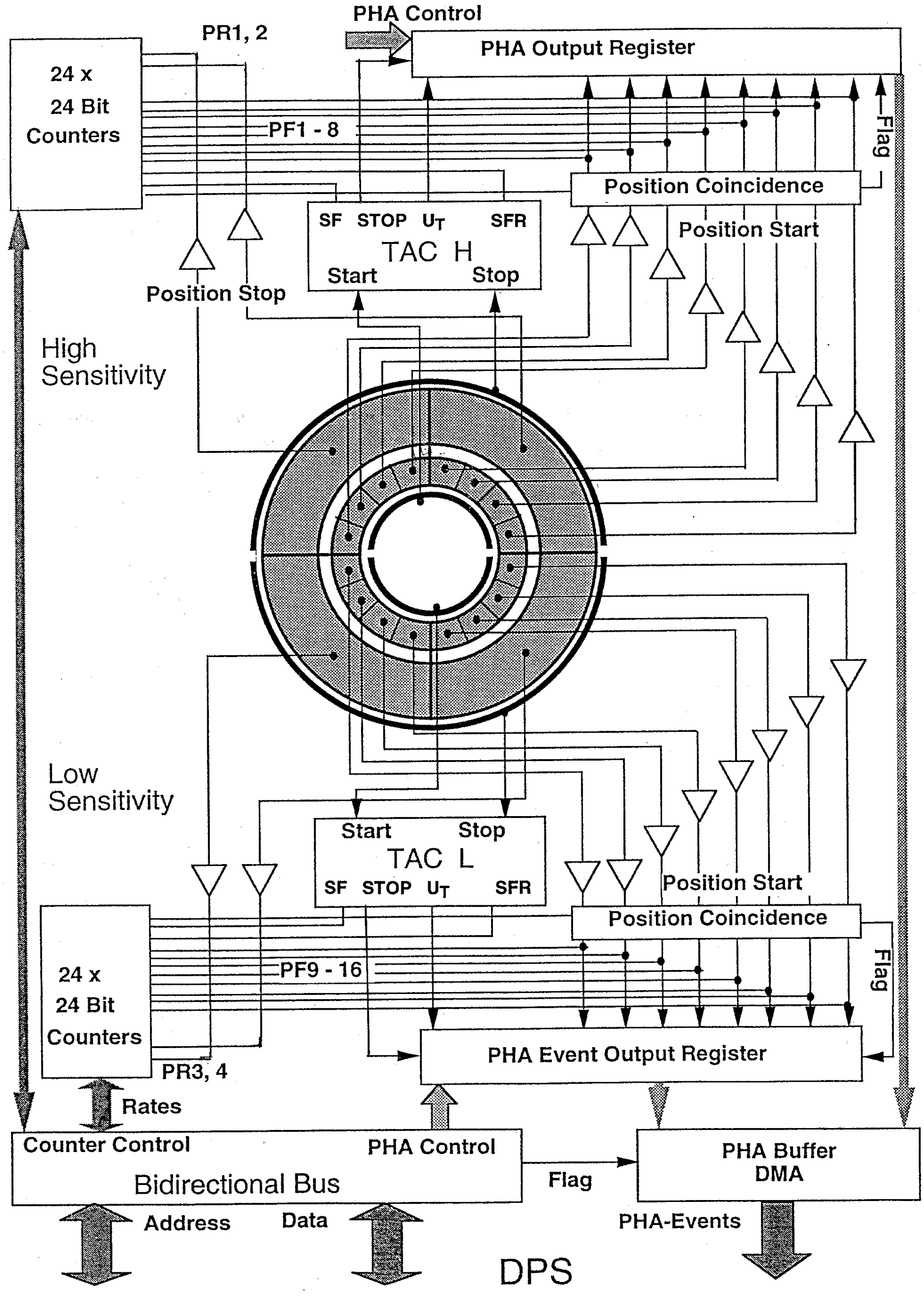


Figure 13. Functional block diagram of the CODIF sensor electronics.

The conditions for valid events are established in the event-selection logic. The respective coincidence conditions can be changed via ground command. Several count rates are accumulated in the sensor electronics. There are monitor rates of the individual start and stop detectors to allow continuous monitoring of the carbon foil and MCP performance. The total count rates of TOF coincidence show the valid events accumulated for each TOF section. These rates can be compared with the total stop count rates in order to monitor in-flight the efficiency of the start and stop assemblies. There is a digital monitoring of all essential housekeeping values, like the deflection HVs, the post-acceleration voltage, the MCP HVs, and all the supply voltages of the electronics. In addition, the temperatures of the detector and electronics compartment are monitored. A simplified block diagram of the CODIF sensor electronics is presented in Figure 14.

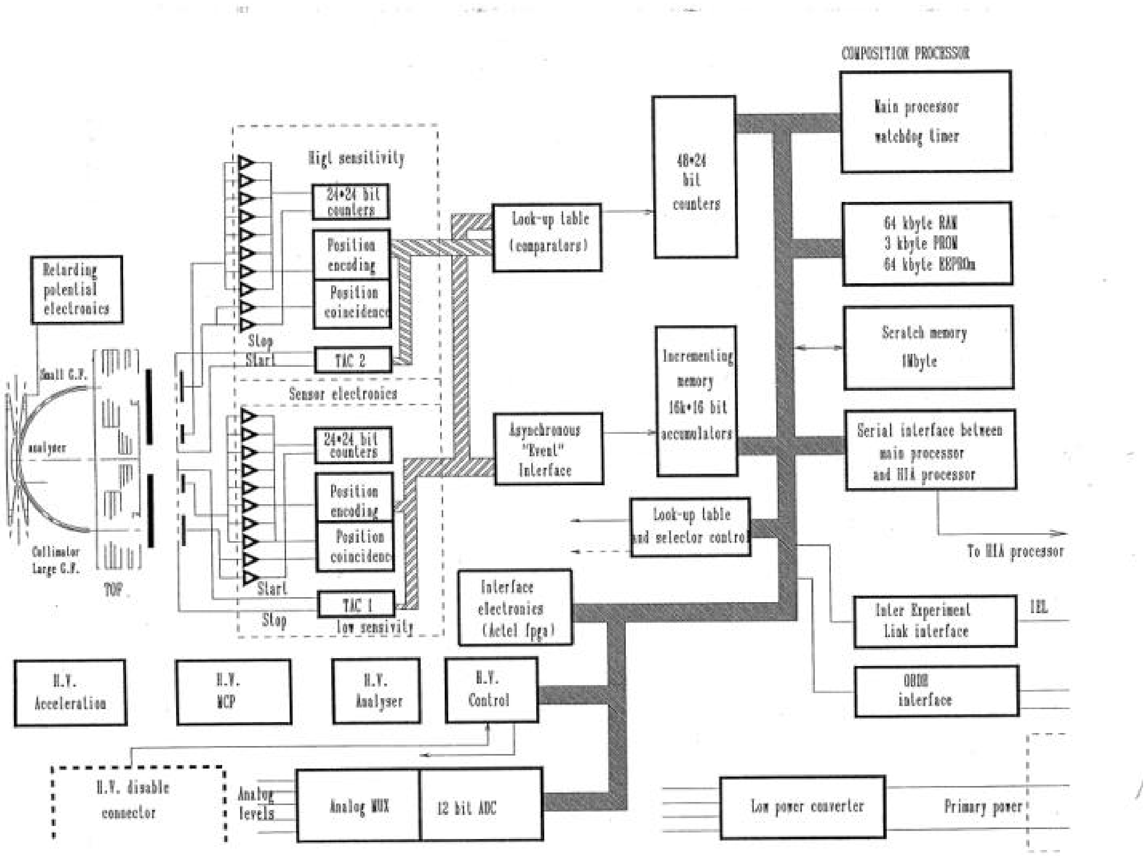


Figure 14. CODIF overall functional block diagram.

In order to protect the MCPs, the solar-wind protons and the solar-wind alpha particles will be blocked from detection by a simple scheme during the sweeping cycle, as shown in Figure 15 (actually there are 4 consecutive sweeps that are modified when G is facing the solar wind, whereas they are not modified when g is facing the solar wind). The sweep, starting at high energies, is shown for the high-sensitivity section in the upper panel and for the low-sensitivity section in the lower panel in log E and azimuthal angle. The voltage sweep, which starts at high energies, is stopped above the alphas when the high-sensitivity section is facing the solar wind. The result is a small data gap for both sections of the sensor simultaneously. The primary purpose introducing this scheme is to avoid short-time gain depression of the MCP area which would otherwise persist for the order of 1 s after the impulsive high count rate that would result from the solar wind.

3.3.1. Counters and incrementing memory

Each half of the CODIF sensor (high and low sensitivity) has eight angular bins and at least 64 TOF bins. A look-up table is used to combine TOF and energy into four mass species. The 32 combined mass/angle signals from each of the two parts of the analyser are sent into a selector circuit. The CODIF processor selects upon command which part of the analyser is used. The 32 selected mass/angle signals feed the 48 counters, which are read out by the CODIF processor once per energy step. These counter values are used for moments, distribution functions, etc.

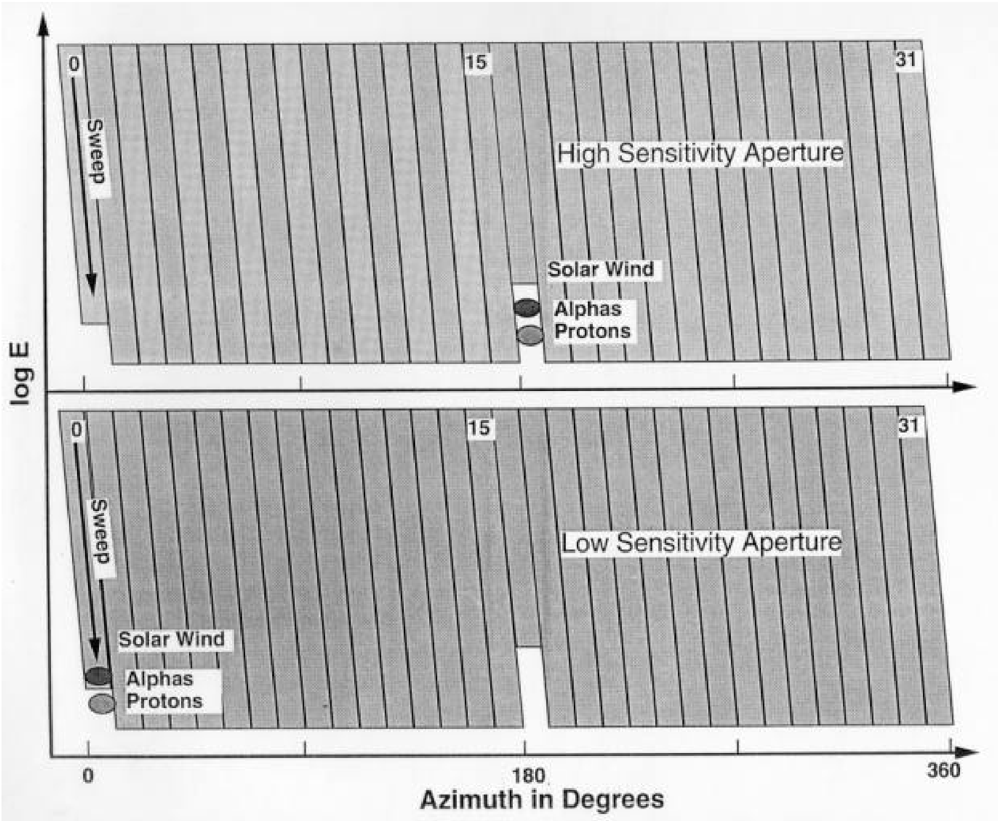


Figure 15. Energy sweeping scheme of CODIF in the solar wind. The sweep is shown in log *E* versus azimuthal angle for the high-sensitivity section (*upper panel*) and low-sensitivity section (*lower panel*), starting at the high energy end. When looking into the solar wind, the sweep stops above the alpha particles for the high-sensitivity section and above the protons for the low-sensitivity section.

In addition to the counters, the CODIF has an incrementing memory accumulator used to make high-mass-resolution spectrograms. This memory can hold a full distribution (with limited angular resolution), so that long time averages can be made without using processor resources (memory, read-out time). According to the actual count rates, the CODIF processor selects which sensivity range (hence which half of the analyser) to accumulate. The TOF data from the selected half of the analyser are combined with the energy step and a look-up table and accumulated into 64 mass channels. The eight angle bins from the selected half are combined with the spacecraft rotation sweep angle with another look-up table into 16 angular sectors with about 45° resolution. The 16 angles and 64 masses are combined with 16 energy bins to address the incrementing memory. The incrementing memory requires 16 x 64 x 16 = 16 384 accumulators.

3.3.2. High voltage system

A sweep-voltage high-voltage power supply generates an exponential voltage waveform from 1.9 to 4950 V for the electrostatic analyser. A ≥ 20 kV static supply feeds the post-acceleration voltage, which can be adjusted via ground command. Another adjustable supply is used for the

MCPs and the collection of secondary electrons. It supplies up to 5 kV and is floated on top of post-acceleration voltage. All high-voltage power supplies are run from the spacecraft raw power instead of from the low-voltage power converter. Thus the efficiency factor of the low-voltage power converter does not apply to the corresponding power consumption. Our design still garantees a galvanic separation of secondary and primary power.

3.4. OTHER ELEMENTS

3.4.1. Retractable Cover

A retractable cover is used for CODIF, mainly to avoid carbon foil damage during launch operations.

3.4.2. In-flight Calibration

Upon command, an in-flight-calibration (IFC) pulse generator can stimulate the two independent TOF branches of the electronics according to a predefined program. Within this program all important functions of the sensor electronics and the subsequent on-board processing of the data can be automatically tested. Temporal variations of calibration parameters can be measured. The in-flight calibration can also be triggered by ground command in a very flexible way, e.g. for trouble shooting purposes. In addition, the known prominent location of the proton signal can, if necessary, serve as a tracer of changes in the sensor itself.

3.5. CODIF PERFORMANCES

3.5.1. Resolution in Mass per Charge

The instrumental resolution in mass per charge is determined by a combination of the following effects:

* energy resolution of the electrostatic deflection analyser ($\Delta E/E$ = 0.16);
* TOF dispersion caused by the angular spread of the ion trajectories because of the characteristics of the analyser and the straggling in the carbon foil (the angular spread of = 13° leads to $\Delta\tau/\tau$ = 0.03);
* TOF dispersion caused by energy straggling in the carbon foil ($\Delta\tau/\tau$ up to = 0.08 for 25 keV O^+);
* electronic noise in the TOF electronics and secondary-electron flight time dispersion (typically 0.3 ns).

The resulting TOF dispersion amount $\Delta\tau/\tau \leq 0.1$, which finally leads to a M/Q resolution between 0.15 for H^+ and 0.25 for low energy O^+. A sample TOF spectrum for various 25 keV ions is shown in Figure 16 from calibration measurements with the CODIF sensor. It is demonstrated that all major ions are well separated by the sensor.

3.5.2. Time-of-Flight efficiency curves

The TOF efficiency is a function of the ion species and the total energy, the sum of the original ion energy plus the energy gained in the post-acceleration potential. The efficiency was also found to be a function of the position at which the ion enters the instrument. An efficiency versus energy curve is determined for each species, with an overall normalisation factor necessary for each azimuthal position. The efficiencies take into account the probability of getting a 'start' and 'stop' signal, plus the probability that an event will satisfy the valid event conditions. Figures 17 and 18 show the efficiency curves for He and for N^+. These curves were determined using data from Flight

Model 1. Data from all positions on the high-sensitivity side of the instrument are shown. The He curve is applicable to both He^+ and He^{++}. The N^+ and O^+ efficiencies are quite close, so the N^+ curve is used to represent the N^+ and O^+ group measured by the instrument. Table II shows the position factors needed for each pixel and species for Flight Model 1. Note that this information is model-dependent, and this table is shown just as an example of the amount of variablity that is observed.

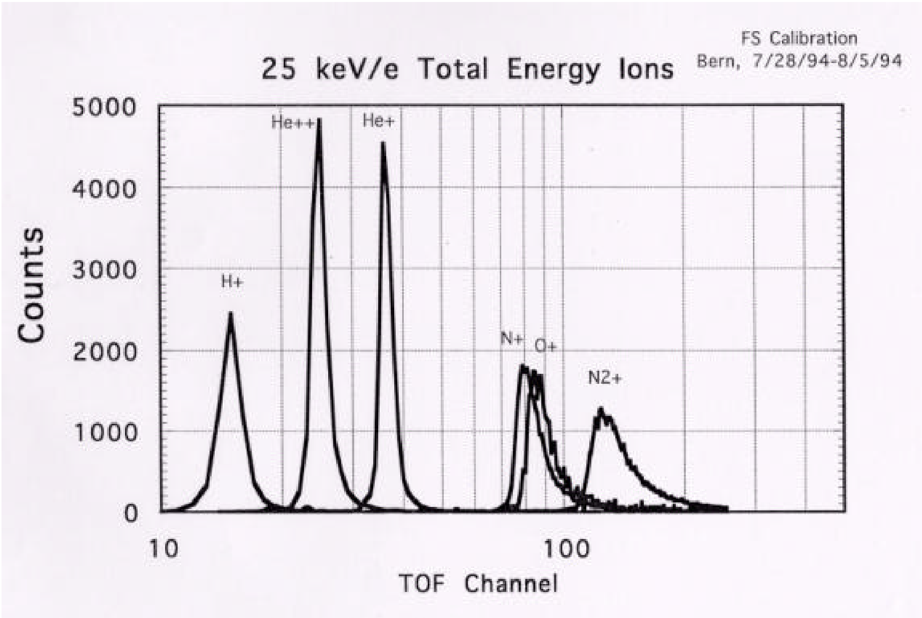


Figure 16. Time-of-flight spectrum of 25 keV H^+, He^{++}, He^+, N^+, O^+, and N_2^+ ions, as measured with the Flight Spare model of CODIF during a calibration at the University of Bern.

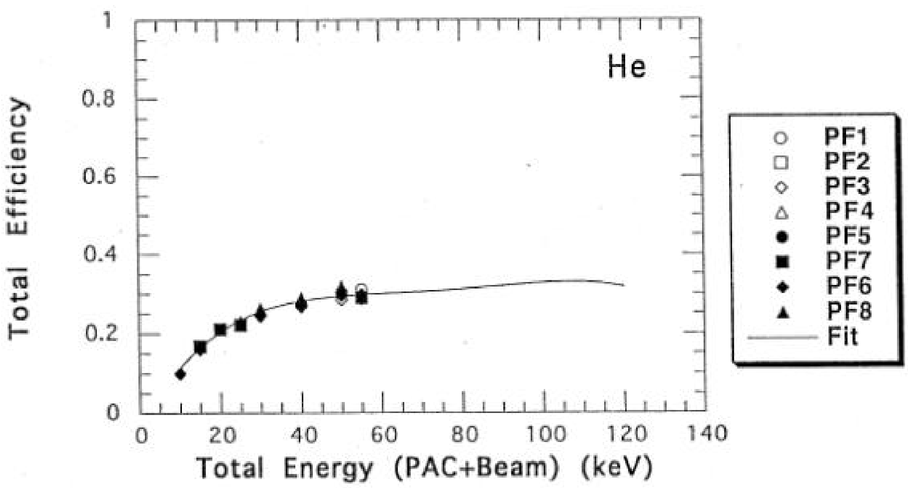


Figure 17. CODIF time-of-flight for Helium. PF1 through 8 indicate the individual angular sectors of 22.5° each of the high resolution side of the sensor.

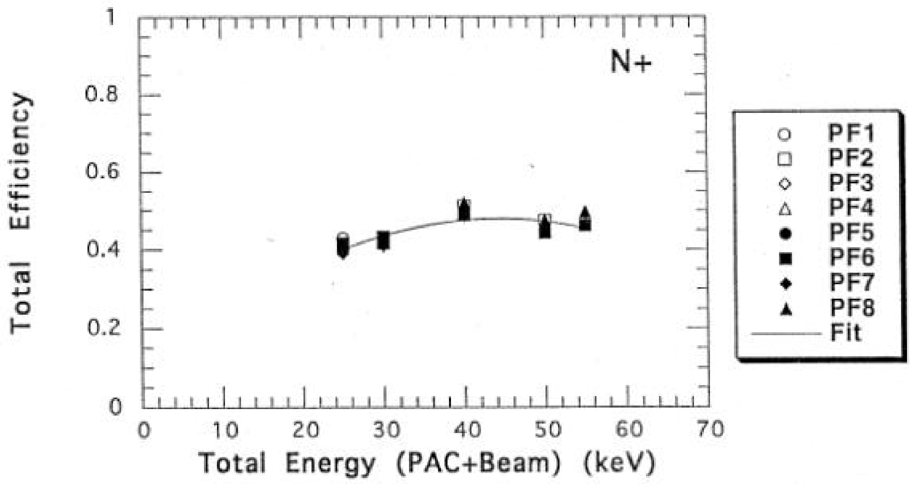


Figure 18. CODIF time-of-flight efficiency for N^+ ions.

3.5.3. Immunity to Background

Compared to a single detector instrument, the TOF sensors have an inherently better immunity to background, because of the start-stop coincidence requirement. The main source of background in these instruments is chance coincidence counts due to penetrating radiation and to events not detected by either start or stop MCP because detection efficiencies are less than 100% according to the relation: $R_{CHANCE} = R^2_{SIGNAL}\ \mu_1 (1-\mu_2)\mu_2(1-\mu_1)\Delta\tau$, where R_{SIGNAL} is the input rate of the ion species with maximum flux, $\Delta\tau$ is the total TOF window, and μ_1 and μ_2 are the efficiencies of the start and stop assemblies, respectively. It can be easily seen that low efficiencies reduce the signal-to-noise ratio significantly. Therefore, great care has been applied to ensure as high efficiencies as possible for both start and stop detectors. The stop detector has an efficiency exceeding 90 %. The efficiency of the start detector assembly is limited by the secondary electron emission of the foil. For protons of 25 keV the emission efficiency is reduced to ~ 50 % (Ritter, 1985). Similar values have been reached with the laboratory model of the sensor. Figure 19 shows the background-to-signal ratio versus incident proton flux level for 25 keV O^+ (the TOF window for the integration of counts is $\Delta\tau/\tau = 0.25$). It is demonstrated that the mass density of the plasma can still be determined with an accuracy of 10 % (O^+/H^+ ratio better than 0.006) for proton fluxes as high as = 10^8 (10^{10}) ions s^{-1} cm^{-2} sr^{-1} with the full (or reduced) aperture, respectively.

A possible background due to UV photons is negligible, since the deflection plates are covered with copper black and photons undergo at least three scatterings before reaching the TOF system.

3.5.4. Dynamic Range

The design of the electrostatic analyser guarantees a large geometrical factor in the high- sensitivity section $A\Delta E/E\Delta\tau\pi$ = 0.025 cm^2.sr. The energy bandwidth is $\Delta E/E$ = 0.16. The efficiency of the TOF unit is about 0.5. Differential energy fluxes as low as ~ 3 x 10^3 ions s^{-1} cm^{-2} sr^{-1} can be detected by the instrument with the full time resolution of 1 spin period and about 5 counts $energy^{-1}$ channel. The sensitivity is increased for longer integration time accordingly. Therefore the dynamic range reaches seven decades. The upper flux limit of the instrument amounts to 3 x 10^9 ions s^{-1} cm^{-2} sr^{-1}, which leads to a count rate of 10^5 counts s^{-1} in one TOF unit (near saturation of the analysing electronics) and still guarantees a mass density determination to better than 10 % accuracy for the reduced aperture geometry.

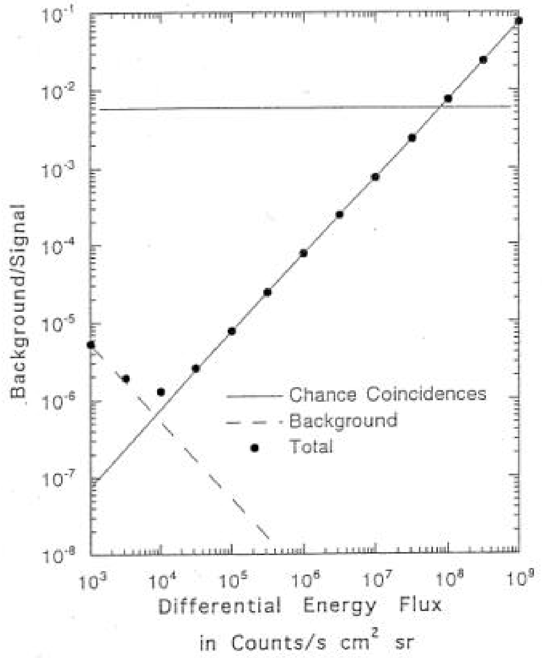


Figure 19. Background-to-signal ratio versus absolute proton flux for background due to chance coincidence of events creating only a start or a stop pulse (full line, computed for the actual start and stop efficiencies of CODIF). At low flux levels the background due to penetrating radiation and intrinsic effects of the MCPs prevails (broken line, taken from AMPTE SULEICA flight data (Möbius *et al.*, 1985)). The combination of both effects is shown by the solid circles. The horizontal line represents the limit for 10% accuracy of the mass density, if O^+ is the minor species.

Table II. Total position adjustment for CIS fligh model 1.

Total Position Adjustment for CIS Flight Model 1			
Pixel	**H^+**	**He**	**N^+**
1.000	**0.424**	**0.496**	**0.560**
2.000	**0.826**	**0.848**	**0.767**
3.000	**0.882**	**0.951**	**0.892**
4.000	**0.397**	**0.512**	**0.565**
5.000	**0.905**	**0.944**	**0.918**
6.000	**1.101**	**1.056**	**1.086**
7.000	**1.199**	**1.042**	**0.950**
8.000	**0.911**	**0.775**	**0.860**
10.000	**0.705**	**0.776**	**0.760**
11.000	**0.997**	**0.980**	**0.951**
12.000	**1.255**	**1.227**	**1.012**
13.000	**2.838**	**2.406**	**1.688**
14.000	**0.470**	**0.524**	**0.739**
15.000	**0.949**	**0.919**	**0.969**

Performances of the CODIF sensor are summarised in Table I and in Figure 1. The full CODIF sensor is shown in Figure 20.

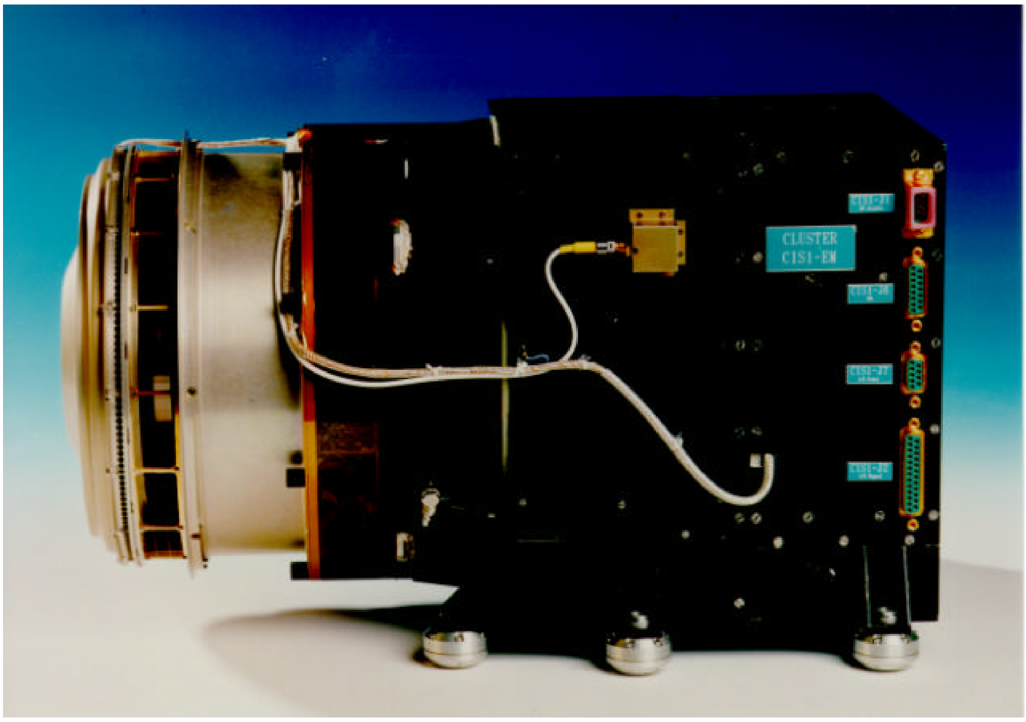


Figure 20. The CODIF sensor.

4. DATA PROCESSING SYSTEM

4.1. ON-BOARD DATA-PROCESSING SYSTEM

Because of the high sensitivity and high intrinsic velocity-space resolution of the CIS instruments, continuous transmission of the complete 3D ion distributions sampled at the full time and angular resolution would require impossibly large bit rates. So, extensive on-board data-processing is a fundamental aspect of the CIS experiment. The CIS flight software has been designed to meet the scientific requirements of the mission even in limited transmission bit-rate allocation conditions.

First, the instrument data system (DPS) controls the operation and data collection of the two CODIF and HIA instruments, formats the data for the telemetry channel, and receives and executes commands. In addition, the DPS analyses and compresses on-board the tremendous amount of data to maximise the scientific return despite the limited CIS telemetry allocation. The DPS and the CODIF instrument are integrated in one box called CIS-1 and HIA is integrated in another box called CIS-2.

4.1.1. Moments

Moments of the distribution functions measured by the analysers will be computed by the DPS and continuously transmitted with maximum time resolution (1 spin period or 4 s). Main on-board calculated moments for CODIF and HIA instruments, to within a multiplicative factor dependent on the analyser geometrical factors, are given by the sums of Table III. These moments include particle density N_i (including partial densities over several energy ranges for CODIF, and sunward and anti-sunward densities for HIA), the three components of the flow vector V_i , the six unique components of the momentum flux tensor, and the heat flux vector. From these, the full pressure tensor can be deduced as well as the temperature anisotropies $T_{//}/T_{\perp}$. We anticipate that full 4π space coverage of the analysers and their clean response function will guarantee a high accuracy for the on-board computed moments. To calculate moments, integrals over the distribution function are approximated by summing products of measured count rates with appropriate energy/angle weighting over the sampled distribution. As already said, moments for HIA and for CODIF (for four masses) are computed once per spin.

Besides instrument sensitivity and calibration, the accuracy of computed moments is mainly affected by the finite energy and angle resolution, and by the finite energy range. The requirement on instrumental accuracy is best demonstrated in the measurements of mass flow through the magnetospheric boundary and in the computation of the current density in current layers like the magnetopause and the Flux Transfer Events (FTEs). Directional errors in the bulk velocity of less than 2° and relative errors less than 5 % in the product of bulk velocity times number density of the different species are highly desirable. As for the mass flow, quantitative tests of other conservation laws (stress and energy balance) require measurements of plasma moments with uncertainties less than 5 %. Paschmann *et al.* (1986) tested the capability of the AMPTE/IRM plasma instrument in a simulation study. For parameters typically observed in high-speed flow events, the simulation shows that density, velocity, temperature and pressure are accurately measured to within 5 %. With the better azimuthal coverage and resolution of the CIS instruments, improved accuracy (in comparison to AMPTE/ IRM) of the plasma moments is expected (Martz, 1993). The accuracy requirements concerning the analysis of two- and three- dimensional current structures as well as shear and vortex flows, i.e. measurements strongly related to the four spacecraft aspect, are fulfilled by the capability of the instrument.

4.1.2. Reduced distributions

Other reduced distributions, including pitch-angle distributions, averages (over 2 to 5 spin periods) or snapshots of the 3D distributions, will be computed with resolutions dependent upon the specific scientific objectives and telemetry rate. The two-dimensional pitch-angle distribution requires far less telemetry than the full distribution, thus allowing higher time resolution. Pitch- angle distributions can be transmitted when the magnetic field direction (provided on-board by the magnetometer) is in the field of view of the detector.

4.1.3. On-board processing unit

Accomplishing these computations in real time is a heavy processing burden, and requires a sophisticated data system, both in terms of hardware and software. The data system is based on a set of two microprocessors (Figure 21). The main processor, located in the CIS-1 box, interfaces with the spacecraft On-Board Data Handling System (OBDH), the magnetometer, the plasma wave experiments (DWP), and the CIS-2 processor. It is in charge of formatting telemetry data, receiving and executing commands or passing them to the other processor, and controlling the burst memory. It also controls, collects and analyses data from the CODIF. The second processor is included in CIS-2 box and controls, collects and analyses data from the HIA. The main processor is interfaced with the second one by a serial data line; the HIA processor will compress the data so that the serial link can transmit at the highest data rates.

Table III. Moment definitions

Moment Definitions

To within a multiplicative factor dependent on the analyzer geometric factor, the moments are given by the following sums:

Density:

$$N = \sum_E 1/V(E) \times \sum_\phi \sum_\theta C(\theta,\phi,E)$$

Bulk Velocity:

$$NV_x = \sum_E \sum_\phi \cos(\phi) \times \sum_\theta \cos(\theta) \times C(\theta,\phi,E)$$

$$NV_y = \sum_E \sum_\phi \sin(\phi) \times \sum_\theta \cos(\theta) \times C(\theta,\phi,E)$$

$$NV_z = \sum_E \sum_\phi \sum_\theta \sin(\theta) \times C(\theta,\phi,E)$$

Heat Flux Vector:

$$NH_x = \sum_E V^2(E) \times \sum_\phi \cos(\phi) \times \sum_\theta \cos(\theta) \times C(\theta,\phi,E)$$

$$NH_y = \sum_E V^2(E) \times \sum(\phi) \sin(\phi) \times \sum_\theta \cos(\theta) \times C(\theta,\phi,E)$$

$$NH_z = \sum_E V^2(E) \times \sum_\phi \sum_\theta \sin(\theta) \times C(\theta,\phi,E)$$

Pressure Tensor:

$$NP_{xx} = \sum_E V(E) \times \sum_\phi \cos^2(\phi) \times \sum_\theta \cos^2(\theta) \times C(\theta,\phi,E)$$

$$NP_{yy} = \sum_E V(E) \times \sum_\phi \sin^2(\phi) \times \sum_\theta \cos^2(\theta) \times C(\theta,\phi,E)$$

$$NP_{zz} = \sum_E V(E) \times \sum_\phi \sum_\theta \sin^2(\theta) \times C(\theta,\phi,E)$$

$$NP_{xy} = \sum_E V(E) \times \sum_\phi \cos(\phi) \times \sin(\phi) \times \sum_\theta \cos^2(\theta) \times C(\theta,\phi,E)$$

$$NP_{xz} = \sum_E V(E) \times \sum_\phi \cos(\phi) \times \sum_\theta \cos(\theta) \times \sin(\theta) \times C(\theta,\phi,E)$$

$$NP_{yz} = \sum_E V(E) \times \sum(\phi) \sin(\phi) \times \sum_\theta \cos(\theta) \times \sin(\theta) \times C(\theta,\phi,E)$$

where: E is energy

V is velocity

Θ,ϕ are the analyzer viewing angles

$C(\theta,\phi,E)$ are the measured counts

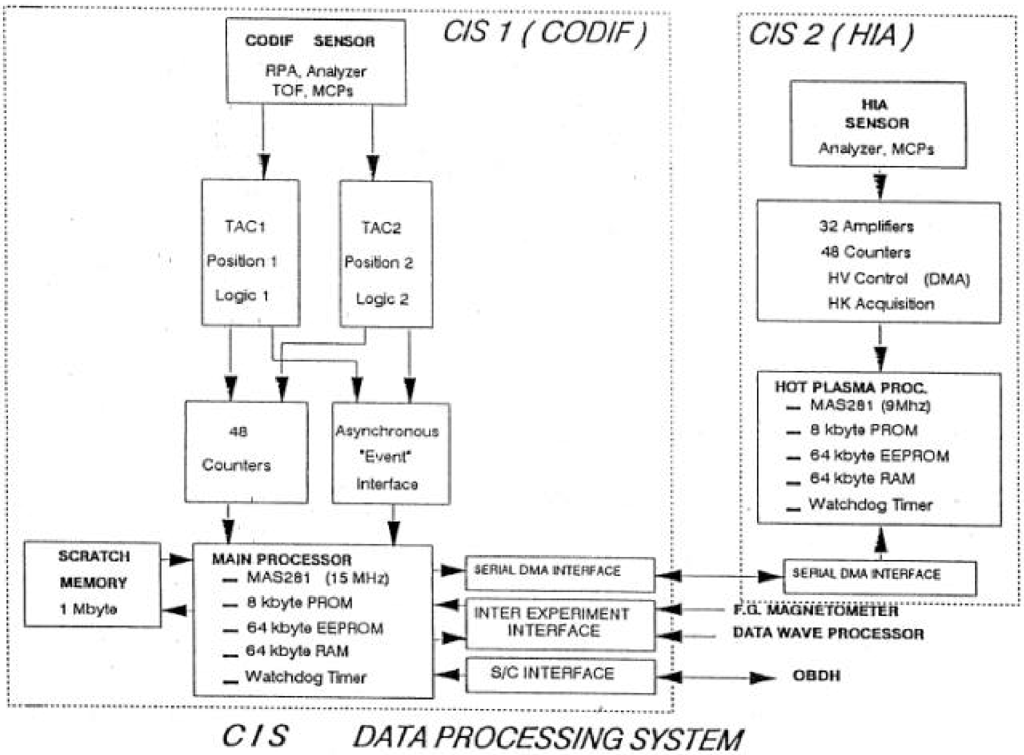


Figure 21. CIS data-processing system.

Each processor system consists of a Marconi MAS281 microprocessor, together with RAM, EEPROM and ROM memories, and a 'watchdog' timer. The 'watchdog' timer is used to monitor the health of the operation, software and reset the processor if the operation is abnormal. This allows the processors to recover automatically from transient problems such as radiation- induced single-event upsets. The software is designed to come up in a safe operating mode on reset. All hardware is radiation-hardened to the greatest extent possible, with spot shielding being used on any parts that are not sufficiently hard to withstand the Cluster environment.

4.1.4. Scratch Memory

The CIS experiment acquires data at nearly the fastest useful rate. In order to store a series of many two- and three-dimensional distributions at full time resolution, a 1 Mbyte memory is included in the instrument, so that discontinuities can be studied in detail. This scratch memory is read when the spacecraft is in BM3 telemetry mode, or in NM1 mode 15 when the appropriate flag is set in the software.

4.2. TELEMETRY

4.2.1. Data Products

Tables IV and V give HIA and CODIF scientific telemetry products, respectively. Products consist of on-board computed moments, one-, two- and three-dimenstional distributions and pitch-angle distributions. The high flexibility in selecting data products to be transmitted at a given period depends upon the telemetry mode, bit rate sharing between CIS-1 and -2, and of course of the plasma environment; energy, angle, and time resolutions can be optimised to extract maximum information relevant to the scientific objectives. Data format changes are programmed within the instrument and do not require any reformatting of the spacecraft or ground data systems.

Table IV. HIA scientific telemetry products

HIA SCIENTIFIC TELEMETRY PRODUCTS					
Quantity	**Product no.**	**Accum. Size**	**Basic Time** (spin)	**Total** (bits)	**bit/s**
I. HOT POPULATIONS (large geometrical factor section)					
Moments 3Df **(n,3v,6P,3H)**	**P2**	**468** words **16** spins **1** packet	**1**	**468 x 16 + 32**	**117.5**
Hot 3D Max Resolution (Large G Section) 62E x 8q **x 16**f	**P5**	**3968** words **4** packets	**1**	**63488 + 192**	**15920**
3D 31E x 88W	**P6**	**1364** words **2** packets	**1**	**21824 + 96**	**5480**
3D 31E x 42W	**P7**	**651** words **1** packet	**1**	**10416 + 48**	**2616**
1D 62E	**P9**	**8** spins **1** packet	**1**	**496 x 8 + 32**	**125**
1D 31E	**P18**	**8** spins **1** packet	**1**	**248 x 8 + 32**	**63**
2D Azim. Distribution (integrated over polar angles) 31E x 16f	**P10**	**496** words **2** spins	**1**	**3968 x 2 + 48**	**998**
2D Polar Distribution (integrated over azim. Angles) 31E x 16q	**P11**	**496** words **2** spins	**1**	**3968 x 2 + 32**	**996**
2D Polar Distribution 31E x 16q **for 3 sectors** (solar wind, antisolar and flanks)	**P20**	**1488** words **2** spins	**1**	**11904 x 2 + 32**	**2976**
2D Pitch Angle Distrib. Cut (2 slices/spin when *B* is in the field of view) **31E x 16**q **x 2 slices**	**P12** **P19**	**496** words **1** spin **2** spins	**0.5 x 2** **1**	**3968 x 2 + 48** **3968 x 2 + 64**	**1996** **1008**
3D 16E x 88W	**P15**	**704** words **1** packet	**1**	**11264 + 48**	**2828**
3D 30E x 88W	**P16**	**1320** words **2** packets	**1**	**21120 + 96**	**5304**
3D 62E x 88W	**P17**	**2728** words **3** packets	**1**	**43648 + 144**	**10948**
3D 31E x 8q **x** 16f **(*)**	**P21**	**1984** words **2** packets	**1**	**31744 + 96**	**7960**
3D 31E x 8q **x** 16f **compressed (**)**	**P23**	**992** words **2** packets	**1**	**15872 + 5 x 2 x 16**	**4008**
II. COLD POPULATIONS - SOLAR WIND (small geometrical factor section)					
Cold moments for solar wind 2DE **(n,3v,6P,3H)**	**P4**	**156** words **16** spins	**1**	**312 x 16 + 16 x 18**	**82.5**
3D 31E x 8q **x 8**f **(cold 3D)**	**P8**	**992** words **1** packet	**1**	**15872 + 32**	**3976**
2D Cold Azim. Distrib. (q **integration) 31E x 8**f **(5.6°**	**P13**	**496** words **4** spins	**1**	**1984 x 4 + 32**	**498**

each)					
2D Cold Polar Distrib. (f) integration) 31E x 8q (5.6° each)	**P14**	**496 w**ords **4 s**pins	**1**	**1984 x 4 + 32**	**498**
3D 31E x 8q x 16f (*)	**P22**	**1984 w**ords **2 p**ackets	**1**	**31744 + 32**	**7944**
3D 31E x 8q x 16f compressed (**)	**P24**	**992 w**ords **1 p**acket	**1**	**15872 + 4 x 16**	**3984**
III. PROM PRODUCTS					
PROM HIA Sweep Diagnostics	**P0**	**1**	**1**	**1024 + 32**	**264**
PROM HIA 48C, 32E	**P1**	**1**	**1**	**12288 + 32**	**3080**
IV. VARIOUS PRODUCTS					
HIA Memory I/O Read	**P61**	**1**	**-**	**32 + 32**	**16**
HIA Memory Dump	**P62**	**1**	**-**	**4112 + 32**	**1036**

ϕ: azimuthal angle — Packet header: 2 x 16 bits = 32 bits
θ: polar angle — Frame Header: 9 x 16 bits = 144 bits / 5.1522 sec
Ω: solid angle — *(duration independent of the TM mode)*
1 word = 16 bits
*: calibration products
**: compression ≥ 2 (2.5 should be expected; 2 assured)

For example HIA produces typically a data volume of 32 polar sectors times 62 energies times 32 azimuth sectors, 16 bit-words, sampled in one spin period (4s). Such a very high data rate has to be handled by a real-time operating system in order to elaborate and compress data to a few kbit s^{-1} telemetry stream output. All information is transmitted as log-compressed 8-bit-words, except moments which are transmitted with 12 bits. Pitch-angle distributions are instantaneous measurements when **B** is in the field of view of the instruments, and typical full 3D distributions are reduced to 88Ω (solid angles) by taking into account oversampling in the polar regions.

A linear compression scheme is implemented as a part of the on-board CIS software, which allows the possibility to transmit compressed 3D distributions more often. The compression factor can be adjusted by setting new values to the compression parameters. A number of simulations have proven that a factor of two in the compression factor can easily be reached without any loss of data. The chosen algorithm for this compression is based on the evaluation of the dispersion of the maximum of a data token around the average of the data token itself. If the maximum (Max) satisfies the following:

$$\text{Max} - k^* \sqrt{(Max)} < \text{Token}_{\text{Average}}$$

where k is an ajustable parameter factor to set the dispersion, the data are assumed to be equal to the $\text{Token}_{\text{Average}}$ which is transmitted as representative of the whole token. Otherwise the token length is scaled by a factor two and the above inequality is applied until the relation is satisfied or the token length has been reduced to one. If k is assumed to be 0 the compression becomes error-free.

Table V. Some CODIF scientific telemetry products

CODIF SCIENTIFIC TELEMETRY PRODUCTS					
Quantity	**Product no.**	**Packet numbers**	**Basic Time** (spins)	**Total** (bits)	**bit/s**
I. HOT POPULATIONS					
Moments **3DE(n,3v,6P,3H) x 4M**	**P7**	**1**	**1**	**1872 + 32**	**476**
3D 64M x 8E x 6W *(6W : 2 polar, 4 perpendicular)*	**P11**	**2**	**2**	**24576 + 64**	**3080**
3D protons 1M x 16E x 88W	**P12**	**1**	**1**	**11264 + 32**	**2824**
3D protons 1M x 31E x 88W	**P13**	**2**	**1**	**21824 + 64**	**5472**
3D protons 1M x 31E x 24W	**P14**	**1**	**1**	**5952 + 32**	**1496**
3D He^{++} **1M x 16E x 88**W	**P15**	**1**	**1**	**11264 + 32**	**2824**
3D He^{++} **1M x 31E x 88**W	**P16**	**2**	**1**	**21824 + 64**	**5472**
3D He^{+}, O^{+} **2M x 16E x 88**W	**P17**	**2**	**1**	**22528 + 64**	**5648**
3D He^{+}, O^{+} **2M x 31E x 88**W	**P18**	**4**	**1**	**43776 + 128**	**10944**
3D He^{+} **1M x 16E x 88**W	**P32**	**1**	**1**	**11264 + 32**	**2824**
3D O^{+} **1M x 16E x 88**W	**P33**	**1**	**1**	**11264 + 32**	**2824**
3D He^{+} **1M x 31E x 88**W	**P34**	**2**	**1**	**21824 + 64**	**5472**
3D O^{+} **1M x 31E x 88**W	**P35**	**2**	**1**	**21824 + 64**	**5472**
2D 4M x 31E x 16f * **2D 2M x 16E x 16**f (protons + He^{++})** or **4M x 16E x 8**f **	**P19** **P21** **P20**	**1** **1** **1**	**1** **1** **1**	**15872 + 32** **4096 + 32** **4096 + 32**	**3976** **1032** **1032**
2D protons 1M x 31E x 32f	**P22**	**1**	**1**	**7936 + 32**	**1992**
2D PAD Cut 4M x 16E x 8q *(2slices/ spin when B is in the field of view)* **	**P23**	**1/slice**	**0.5**	**4096 x 2 + 2 x 32**	**2064** **(1032/slice)**
2D PAD Cut 4M x 31E x 8q *(2slices/ spin when B is in the field of view)* *	**P24**	**1/slice**	**0.5**	**7936 x 2 + 2 x 32**	**3984**
Monitor Counting Rates **18 signals x 16E x 16**f	**P27**	**8**	**32 spins**	**36864 + 256**	**290**
Live Pulse Height Data (selected events) **Time of flight: 8 bits** **Azim. Position: 5 bits** **Energy Step: 7 bits** **Sector: 3 bits** **Proton mode: 1 bit**	**P28**	**1**		**24 x k + 32 every 2 spins** **k > 1**	**Depending of k value**
II. RPA MODES					
RPA diagnostic product **3D 4M x 31E x 88** W	**P29**	**4**	**1 spin**	**45056 + 256**	**11328**

III. COLD POPULATIONS					
Cold Populations Moments **3DE(n,3v,6P,3H) x 4M**	**P9**	**1**	**1**	**1872 + 32**	**476**

IV. COMPRESSED PRODUCTS					
3D H^+ 1M x 16E x 88W	**P39**	**1**	**1**	**-**	**-**
3D H^+ 1M x 31E x 88W	**P40**	**2**	**1**	**-**	**-**
3D H^+ 1M x 31E x 24W	**P41**	**1**	**1**	**-**	**-**
3D He^{++} 1M x 16E x 88W	**P42**	**1**	**1**	**-**	**-**
3D He^{++} 1M x 31E x 88W	**P43**	**2**	**1**	**-**	**-**
3D He^+/O^+ 2M x 16E x 88W	**P44**	**2**	**1**	**-**	**-**
3D He^+/O^+ 2M x 31E x 88W	**P45**	**4**	**1**	**-**	**-**
3D He^+ 1M x 16E x 88W	**P46**	**1**	**1**	**-**	**-**
3D O^+ 1M x 16E x 88W	**P47**	**1**	**1**	**-**	**-**
3D He^+ 1M x 31E x 88W	**P48**	**2**	**1**	**-**	**-**
3D O^+ 1M x 31E x 88W	**P49**	**2**	**1**	**-**	**-**
V. BURST PRODUCTS					
Burst Memory Counters	**P36**	**16**	**1**	**(16384 + 32) x 16**	**65664**
Burst Status	**P37**	**1**	**1**	**448 + 32**	**120**
Burst Trigger	**P38**	**1**	**-**	**2912 + 32**	**736**
VI. VARIOUS PRODUCTS					
PROM product. Sweep Diagnostics	**P0**	**1**	**1**	**4096 + 32**	**1032**
PROM product. 48C, 32E	**P1**	**1**	**1**	**12288 + 32**	**3080**
PROM product. 2 x 18C, 32E	**P2**	**1**	**1**	**9216 + 32**	**2312**
PROM/EEPROM product. Raw events	**P3**	**1**	**1**	**16384 + 32**	**4104**
PROM product. Full events	**P4**	**1**	**1**	**16384 + 32**	**4104**
PROM/EEPROM prod. WEC IEL data	**P5**	**1**	**1**	**512 + 32**	**136**
PROM/EEPROM prod. FGM IEL date	**P6**	**1**	**1**	**4096 + 32**	**1032**
Memory I/O Read	**P61**	**1**	**-**	**32 + 32**	**16**
Memory Dump	**P62**	**1**	**-**	**4112 + 32**	**1036**

ϕ: azimuthal angle (spin phase angle)
θ: polar angle
Ω: solid angle
β: near 90° pitch angles (the highest possible angle) for gyrotropic distributions (for 4 high energies)
4M: protons, a + 2 other masses

* best possibility
** basic use
(*) possibility to have different time of resolution for the different masses

Packet Header: 32 bits

Basically, for HIA, the high-sensitivity section has full 180° coverage and hot population data are computed using data from this section. When there is a cold population like the solar wind, providing data products from the small geometrical factor, the rest of the spin (360° - 45°) is not ignored, but, using the large geometrical factor section, data are taken and transmitted.

For CODIF, 4M stands for the four major species : H^+, He^{++}, O^+ and He^+. 64M 3D distributions can be read out at a slow rate. They give more detailed information about the presence of minor species. 4M, 88Ω (solid angles), 3D distributions should be read out as often as possible, after all the other data types have been accommodated. A priority scheme for the time resolution is given according to the abundance of the species:

H^+ highest resolution,
He^{++} or O^+ highest resolution or slower by a factor of 2,
He^+ or other species factor of 2 or factor 4 slower.

4.2.2. Remote-sensing distribution

Close to boundaries a distribution of four angles at 90° pitch-angle (phase 0°, 90°, 180°, 270°) is accumulated for two species (H^+ and O^+) in the four highest energies. This allows the boundary motions to be traced.

4.2.3. Live Pulse Height data

For each particle CODIF measures the following parameters:

Time-of-flight:	8 bits	(giving 256 values)
Azimuthal position:	5 bits	(32 sectors)
Proton mode:	1 bit	
Energy step:	7 bits	(one between 128 elementary steps)
Pixel number:	3 bits	
Total:	24 bits	each

4.2.3. Monitor Rates

To check the performance and the counting efficiency of CODIF certain monitor rates have to be accumulated and transmitted with the science data:

2 Start	(each time-to-amplitude converter)
2 Coincidence	(each time-to-amplitude converter)
16 Start position	
4 Stop position	

To cut down in bit rate a specific scheme is proposed by which only every fourth energy step and every eighth sector are transmitted at a time. A cycle is completed after 32 spins.

4.2.4. Telemetry Formats

Instrument science and housekeeping data are read out over a single serial interface; the two types are differentiated by separate word gates. Telemetry is collected as a series of blocks, a fixed number per telemetry frame. Telemetry frames are always 5.152222 s in duration independent of telemetry mode, and are synchronised by a 'Reset' pulse that occurs at the beginning of each frame. Housekeeping data consists of 54 bytes per telemetry frame. Science can be collected in a variety of modes with different bit-rates; these modes are subdivided into 'Normal' and 'Burst' Modes, differentiated by the number of blocks per frame (10 for normal and 62 for burst). The different bit rates for Normal Mode are generated by changing the number of words per block.

Mode	Name	Bit s^{-1}	Block Size	Blocks/frame	Bytes/frame
NM1	Normal mode	5 527	356	10	3 560
NM2	Ion mode	6 521	420	10	4 200
NM3	Electron mode	4 503	290	10	2 900
BM1	Normal Burst mode	26 762	278	62	17 236
BM2	WEC/WBB TR mode	6 546	68	62	4 216
BM3	Event Memory readout	29 456	306	62	18 972

BM3 is a special mode to dump the instrument scratch memory only; it is not an ordinary operating mode.

Two contingency modes exist in which all available data will go either to CIS-1 (CODIF) or to CIS-2 (HIA).

The four Cluster spacecraft will fly through a number of different plasma environments, and there must be a mechanism to change the mode of the instrument with a minimum number of commands when moving from one region to another. The CIS instruments have a large amount of flexibility either in the selection of the operating mode or in the reduction of the data necessary to fit the available telemetry bandwith. The instrument must be capable of making many changes to the operational details in response to a few commands.

Table VI shows the 16 CIS basic operation modes with the bit-rate sharing between CODIF and HIA, defined for each spacecraft bit-rate mode. The CIS instruments will operate in the different regions of the Earth's environment in these 16 operative modes that, for the five telemetry regimes foreseen (forgetting HK and BM3 modes), give a total amount of 80 science data transmission schemes. Each basic scheme corresponds to a given sequence of products, spanning from the momenta of the ion distributions to the 3D.

Roughly speaking, all these 16 operative regimes can be grouped into solar-wind tracking oriented modes, solar-wind study modes with the priority on the backstreaming ions, magnetospheric modes, an RPA mode and a calibration mode. Moreover part of these solar-wind and magnetospheric modes are duplicated in a similar mode in which 3D compression is introduced.

For the HIA instrument two basic modes of operations, mixing basic products defined in Table IV have been implemented according to the plasma populations encountered along the Cluster orbit: so-called (a) 'magnetospheric' modes, and (b) 'solar-wind' modes. In both modes moments are systematically transmitted, computed every spin from the data acquired on the high-sensitive half-hemisphere ('high G' section) when the spacecraft are inside the magnetosphere, and from the attenuated half-hemisphere section ('low g') when the spacecraft are in the interplanetary medium. This way one of the goals of the mission, i.e. to be able to produce high-resolution (4 s) moments by on-board computation, has been fullfilled for all the listed regimes apart from the calibration mode. The computed moments are used on-board to drive automatic operative mode changes (when this option has been remotely enabled) to better follow fluctuations which require fast-sensitivity-adapting capabilities or to select the best energy sweep regime to cover the local solar wind distribution.

'Magnetosphere' basic modes stay relatively simple, i.e. the full energy-angle ranges are systematically covered and the different data products (including moments) are deduced from the 62E x 88Ω energy solid angle count rate matrices accumulated on the 'high G' section.

'Solar wind' modes allow a precise and fast measurement (4s) of the ion flow parameters (H^+, He^{++}). For that, in the solar wind, the sweep energy range is automatically reduced and adapted every spin, centred on the main solar wind velocity by using a criterion based on the H^+ thermal and bulk velocities computed during the previous spin. Moreover, detailed 3D distributions (e.g. for upstreaming ions and/or for interplanetary disturbances) are included in the basic products transmitted to the telemetry.

In both regions, and within the HIA telemetry allocation, a maximum bit rate has been allowed for transmission as often as possible of full size (or reduced) 3D distributions. From Table VII it can be anticipated that Burst Modes should be considered as those having the highest expected scientific return.

Finally, to best fit the sampling activity to the plasma environment, if an auto-switching variable has been asserted, it is possible to run the instrument in the auto-change mode from magnetospheric to solar-wind configuration and *vice versa*. The switching criteria are presently based on locally measured plasma Mach number checks.

Science data packets include a number of data products from both HIA and CODIF in a flexible format. Data are time-tagged in such a way as to allow absolute timing of the data on the ground. The format allows bit rate allocations to the various data products to be changed relatively easily with minimal impact on ground processing. All auxiliary data necessary to analyse the data, such as instrument operational mode and timing information, are included in science data products, as it could be difficult to recombine housekeeping packets with the science packets.

Finally, housekeeping data (81 bit s^{-1}), extensively used during spacecraft development tests, give all the information needed to follow the health and safety of the instrument.

Table VII shows the scientific products of HIA transmitted nominally in the various telemetry modes.

4.3. PROCESSING UNIT

One of the decisive variables which affects the instrument operation is the telemetry mode; when the telemetry mode changes, the CIS instrument receives a single command and changes accordingly its bit rate allocation and data product collection mechanism to match the available telemetry. Some instrument parameters stay mode-independent and are programmable, such as MCP voltage.

The DPS is made of a small PROM, some EEPROM, and some RAM memories. The non-volatile EEPROM memory contains most of the on-board code and parameter tables, the RAM memory is used primarily to hold data blocks and some operational parameters and the PROM memory contains the bootstrap code needed to load or change the EEPROM. The EEPROM memory cannot be read while it is being programmed, and programming takes several millisec per block; it contains most of the operational parameters so that they do not have to be reloaded on power-up.

As a basic philosophy the default operational parameters are kept in EEPROM memory, while the current operational parameters are in RAM memory. The telemetry mode independent parameters are copied from the defaults on processor reset (this is called the 'Fixed Table'). The 'Operational

Table VI. CIS operations modes

CIS OPERATION MODES										
			TELEMETRY MODE CIS-2 BITRATE (bps)				TELEMETRY MODE CIS-1 BITRATE (bps)			
MODE		Mode Name	NM1	NM2	NM3	BM1	NM1	NM2	NM3	BM1
0	SW-1	SOLAR WIND / SW tracking	1 272	1 272	1 272	7 000	4 255	5 252	3 231	19 762
1	SW-2	SOLAR WIND / 3D backstreaming ions	1 272	1 272	1 272	7 000	4 255	5 252	3 231	19 762
2	SW-3	SOLAR WIND / SW tracking	2 135	2 135	2 135	13 162	3 392	4 386	2 368	13 600
3	SW-4	SOLAR WIND / 3D backstreaming ions	2 135	2 135	2 135	13 162	3 392	4 386	2 368	13 600
4	SW-C1	COMPRESSION SW-3 (+3Ds) solar wind tracking	2 135	2 135	2 135	13 162	3 392	4 386	2 368	13 600
5	SW-C2	COMPRESSION SW-4 (+3Ds) backstreaming ions	2 135	2 135	2 135	13 162	3 392	4 386	2 368	13 600
6		RPA								
7	PROM	PROM OPERATION								
8	MAG-1	MAGNETOSPHERE 1	1 272	1 272	1 272	7 000	4 255	5 252	3 231	19 762
9	MAG-2	MAGNETOSPHERE 2	2 135	2 135	2 135	13 162	3 392	4 386	2 368	13 600
10	MAG-3	MAGNETOSPHERE 3	3 124	4 148	2 135	13 162	2 403	2 373	2 368	13 600
11	MAG-4	MAG-1 SHEATH/TAIL	1 272	1 272	1 272	7 000	4 255	5 252	3 231	19 762
12	MAG-5	MAG-2 SHEATH/TAIL	2 135	2 135	2 135	13 162	3 392	4 386	2 368	13 600
13	MAG-C1	COMPRESSION MAG-1 + 3Ds	1 272	1 272	1 272	7 000	4 255	5 252	3 231	19 762
14	MAG-C2	COMPRESSION MAG-4 + 3Ds sheath/tail	1 272	1 272	1 272	7 000	4 255	5 252	3 231	19 762
15	CAL.	CALIBRATION								

CIS (HIA + CODIF):
NM1: 5527 bit/s
NM2: 6521 bit/s
NM3: 4503 bit/s
BM1: 26762 bit/s

Normal modes: NM1 or BM1

Baseline is to have identical modes on the 4 spacecraft

Table VII. Examples of basic operational modes of the CIS-2 (HIA) experiment grouped in 4 tables according to the space region of interest. For each telemetry mode (NM1, NM2, …) different combinations of scientific products (see their definition in Table IV) are defined, computed from count rates provided by the high-sensitive half analyser ('high G' section) and/or the low geometrical factor half ('low g' section). Each basic mode (MAG-1, MAG2, …, SW-2, SW-3, …) in a given telemetry mode refers to Table VI.

CIS2: SCIENTIFIC MODES

MAGNETOSPHERIC MODES						HIGH G SECTION							
TELEMETRY MODE				HIA Bit rate (bit/s)		M	1D	2D			3D		
OPERATION MODE						P2	P9	P10	P11	P12	P6	P15	P17
NM1	NM2/BM2	NM3	BM1	Alloc.	HIA	Mom.	62E	2Dϕ AZ	2Dθ POL	2DαPAD	31Ex88Ω	16Ex88Ω	62Ex88Ω
5527	6521/6546	4503	26762			117.5	125	998	996	1996/1008	5480	2828	10948
MODES 8-11				1272	1238							3 sp	
MODES 6-9-12 (&10 NM3)				2135	2070						3 sp		
MODE 7				2135	2112								
10				3124	3071							1 sp	
	MODE 10			4148	4079					1 sl.			
			6-7-8-11	7000	6731					1 sl.			
			9-10-12	13162	13062					2 sl.			

SOLAR WIND MODES						HIGH G SECTION					Low g SECTION			
TELEMETRY MODE				HIA Bit rate (bit/s)		1D	2D		3D		M	2D		3D
OPERATION MODE						P18	P10	P20	P6	P15	P4	P13	P14	P8
NM1	NM2/BM2	NM3	BM1	Alloc.	HIA	31E	2DϕAZ	2DθPOL	31Ex88Ω	16Ex88Ω	M	2Dθ POL	2Dϕ AZ	31Ex8θx8ϕ
5527	6521/6546	4503	26762			63	998	2976	5480	2828	82.5	498	498	3976
MODE 0				1272	1275		5 sp							/4 sp
MODE 2				2135	2141									/2 sp
			MOD 0-6	7000	6869				2 sp					
			MODE 2	13162	12531									
MODE 1				1272	1088					3 sp				/18 sp
MODE 3				2135	2074				3 sp			/2 sp		/18 sp
			MODE 1	7000	6307									/5 sp
			MODE 3	13162	6464									/15 sp

COMPRESSION MAGNETOSPHERE						HIGH G SECTION		
TELEMETRY MODE				HIA Bit rate (bit/s)		M	1D	3D
OPERATION MODE						P2	P9	P23
NM1	NM2/BM2	NM3	BM1	Alloc.	HIA	Moments	1D62 E	31Ex8θx16ϕ
5527	6521/6546	4503	26762			117.5	124.5	3206 [COMP=2.5]
MODES 13-14				1272	~1270			~ 3 sp
			13 -14	7000				

COMPRESSION SOLAR WIND						HIGH G SECTION		Low g SECTION			
TELEMETRY MODES Operation Modes (see Table)				HIA Bit rate (bps)		3D		M	2D		3D
						P6	P23	P4	P13	P14	P24
NM1	NM2 BM2	NM3	BM1	Alloc.	HIA	31E x88Ω	31Ex8θx16ϕ	M	2Dθ POL	2Dϕ AZ	31Ex8θx8ϕ
5527	6521 6546	4503	26762			5480	3206 [COMP=2.5]	78.5	498	498	1992 [COMP=2]
PRIORITY: SOLAR WIND											
MODE 4				2 165	~1732						
			MODE 4	13162	~4844						
PRIORITY: UPSTREAMING IONS											
MODE 5				2 165	2076		2 sp.				/16 sp.
			MODE 5	13162							/5 spins

3 sp.: integrated over 3 spins **/3 sp.**: once every 3 spins **1,2 sl.**: 1 or 2 slices

Mode Table' is copied from the default table to set up a new mode after commanding. Sometimes it may also be desirable to follow automatic operational mode changes based only on science data (e.g. moments) collected by the instrument. The 'Telemetry Allocation Table' is a subset of the Operational Mode default Table; when the telemetry rate changes, the appropriate Telemetry Allocation Table is copied from the default table for the new rate and the current operational mode.

The CIS-1 and CIS-2 instruments have separate tables, but of course are controlled by the same telemetry rate and operation mode commands.

4.4. GROUND SCIENCE DATA PROCESSING

The CIS raw telemetry will be pipeline-processed at the French Cluster Data Centre at CNES, Toulouse, where CESR-developed software will be running. Level-1 and Level-2 data products will thus be systematically generated. Level-1 files correspond to decommutated and decompressed data, organised in flat files, in full time resolution, one file per spacecraft-day-data product. Level-2 files are CDF files in physical units, and they include density for the major ion species, bulk velocity, parallel and perpendicular temperature. These files will be organised following the Cluster Science Data System (CSDS) recommendations, and they will populate two data bases: the Prime Parameter Data Base (PPDB: 4 spacecraft, 4 s resolution) and the Summary Parameter Data Base (SPDB: 1 spacecraft, 1 min resolution). The contents of these data bases will be distributed to other National Data Centres on a daily basis. The PPDB will be accessible to the whole Cluster community, and the SPDB will be public domain. Due to their broad accessibility, and to the quality of their data products, these data bases will permit joint analysis of plasma parameters from several instruments, further enhancing the science return of the Cluster mission.

The health and the performance of the CIS instrument will be monitored at various levels, by using files retrieved via the network from the Cluster Data Disposition System (DDS) , both at JSOC and at CESR.

5. CONCLUSION

The general characteristics of the two CIS instruments, including scientific performances, weight and raw power, are summarised in Table I. Note that the entrance of each sensor is put about 10 cm outside the spacecraft platform in order to have an unobstructed field of view and to minimise the effect of the spacecraft potential on the trajectories of the detected low-energy particles. The two planes of view of CODIF and HIA are parallel and tangential to the spacecraft body. The free field of view of the two sensors is 15° x 360° (Figure 22).

In summary, by their unique features, the CIS instruments will provide fast measurements of the major plasma ion species with greatly improved accuracy and resolution. The inherent flexibility of the instrument control will allow a permanent optimisation of the scientific operation according to the various situations encountered all along the Cluster mission. The extensive on-board data processing will not only improve the time resolution of the measurements and significantly reduce data ground-processing costs, but will also make the plasma fundamental parameters quickly and directly available in a usable form to other investigators.

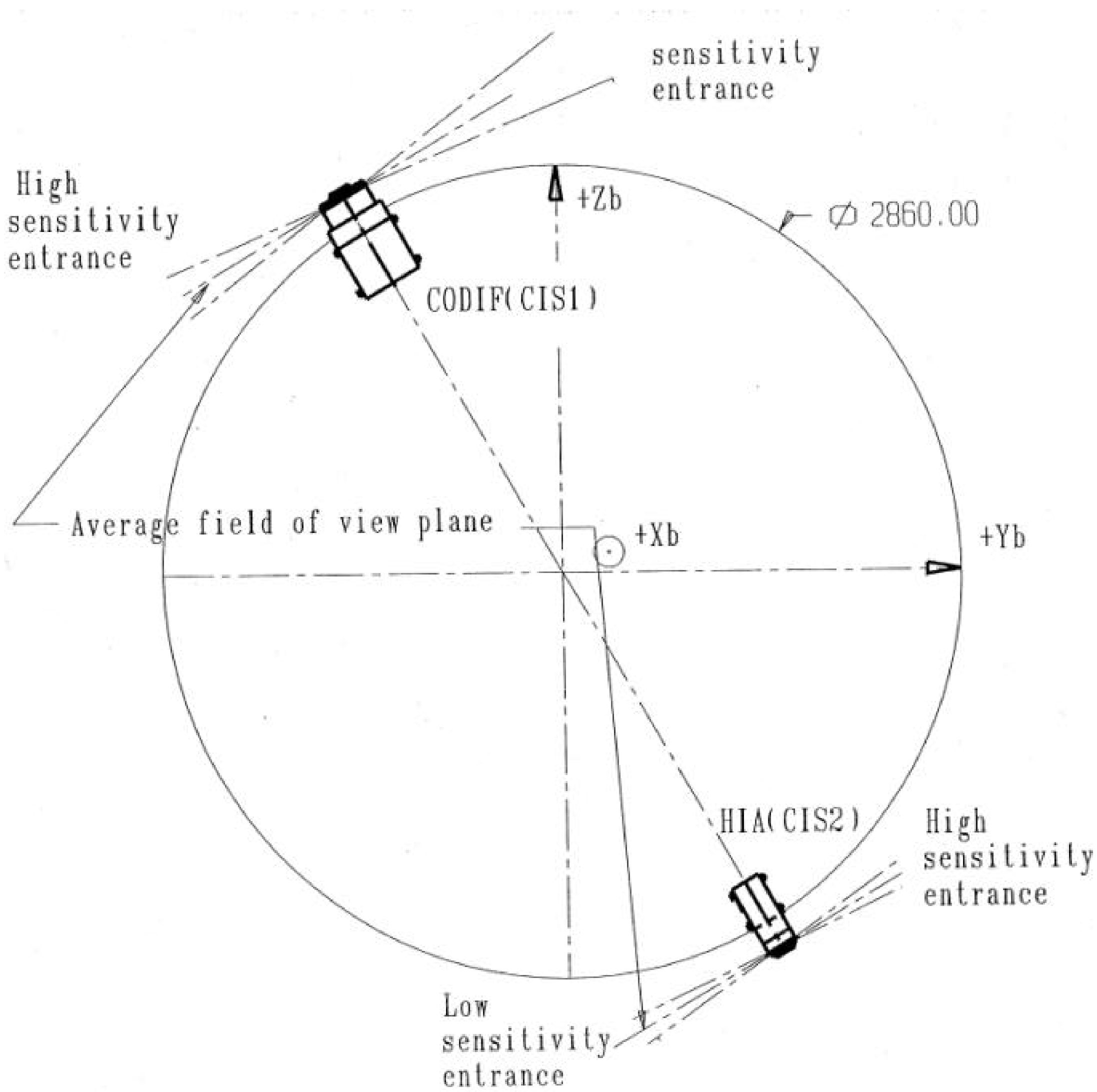


Figure 22. Position of the two sensors on the spacecraft and their fields of view.

6. References

Burgess D.: 1989, Cyclic Behaviour at Quasi-parallel Collisionless Shocks, *Geophys. Res. Lett.* **16**, 345.

Carlson C.W., *et al.*: 1982, An Instrument for Rapidly Measuring Plasma Distribution Functions with High Resolution, *Adv. Space Res.* **2**, 7, 67.

Escoubet P.C., and R. Schmidt: 1997, Cluster Science and Mission Overview, this issue.

Giacalone J., *et al.*: 1994, Artificial Spacecraft in Hybrid Simulations of the Quasi-parallel Earth's Bow Shock: Analysis of Time Series Versus Spatial Profiles and a Separation Strategy for Cluster, *Ann. Geophysicae* **12**, 591.

Gloeckler G., *et al.*: 1993, Detection of Interstellar Pick-up Hydrogen in the Solar System, *Science* **261**, 70.

Lin R.P., *et al.*:1995 , A Three-dimensional Plasma and Energetic Particle Investigation for the Wind Spacecraft, *Space Sci. Rev.* **71**, 125.

Martz C.: 1993, Spectrométrie Ionique dans la Magnétosphère et le Vent Solaire. Simulation et Précision des Mesures Coordonnées au Moyen des 4 Satellites de la Mission Cluster, Thesis, Paul Sabatier Toulouse University.

Martz C., and J.A. Sauvaud: 1995, Accuracy of Ion Distribution Measurements and Related Parameters Using Top-hat Ion Spectrometers; Application to the CIS Cluster Experiment, submitted to *Rev. Sci. Instruments*.

Möbius E., *et al.*: 1985, The Time-of-Flight Spectrometer SULEICA for Ions of the Energy Range 5-270 keV/charge on AMPTE IRM, *IEEE Trans. Geosc. Remote Sens.* GE-23, 274.

Möbius E., *et al.*: 1985, Direct Observation of He^+ Pick-up Ions of Interstellar Origin in the Solar Wind, *Nature* **318**, 426.

Möbius E., *et al.*: 1988, Interaction of Interstellar Pick-up Ions with the Solar Wind, *Astrophys. Space Sci.* **144**, 487.

Paschmann G., *et al.*: 1985, The Plasma Instrument for AMPTE IRM, *IEEE Trans. Geosc. Remote Sens.* GE-23, 262.

Paschmann G., *et al.*: 1986, The Magnetopause for Large Magnetic Shear: AMPTE/IRM Observations, *J. Geophys. Res.* **91**, 11099.

Quest K.B.: 1988, Theory and Simultion of Collisionless Parallel Shocks, *J. Geophys. Res.* **93**, 9649.

Rème H., *et al.*: 1987, The Giotto Electron Plasma Experiment, *J. Phys. E: Sci. Instrum.* **20**, 721-731.

Ritter H.: 1985, Sekundärelektronenemission von Kohlenstoffolien beim Durchgang von Ionen im Energiebereich von 40 bis 500 keV, MPE Report 190.

Scholer M. and Terasawa T.: 1990, Ion Reflection and Dissipation at Quasi-parallel Collisionless Shocks, *Geophys. Res. Lett.* **17**, 119.

Scholer M.: in press, Interaction of Upstream Diffuse Ions with the Solar Wind, *Adv. Space Sci.*

Sckopke N., *et al.*: 1990, Ion Thermalization in Quasi-perpendicular Shocks Involving Reflected Ions, *J. Geophys. Res.* **95**, 6337.

Trattner K., *et al.*: 1994, Statistical Analysis of Diffuse Ion Events Upstream at the Earth's Bow Shock, *J. Geophys. Res.* **99**, 13389.

Young D., *et al.*: 1988, 2π-radian field-of-view toroidal electrostatic analyzer, *Rev. Sci. Instr.*, **59**, 743.

Cluster - CIS

User Manual for CIS Flight Operations

2. TELEMETRY

2.1. MONITORING PHILOSOPHY

The main parameters of the experiment will be sent through the digital housekeeping channels in order to be able to monitor the correct and safe functioning of the experiment (low voltage control, HV ON/OFF, HV values, current, temperature).

No OBDH monitoring requirements.

Ground monitoring required (detailed ground monitoring requirements are given in Chapter 4).

Instrument science and housekeeping data are read out over a single serial interface; the two types are differentiated by separate word gates (see Cluster EID Part A, section 3.3). Telemetry is collected is a series of blocks, a fixed number per telemetry frame. Telemetry frames are always 5.152222 seconds in duration independent of telemetry mode, and are synchronized by a 'RESET' pulse that occurs at the beginning of each frame. Housekeeping data consists of 54 8-bit bytes per telemetry frame, (made up of one 54 byte block). Science can be collected in a variety of modes with different bit-rates; these modes are subdivided into 'Normal' and 'Burst' modes, differentiated by the number of blocks per frame (10 for normal and 62 for burst). The different bit rates for Normal mode are generated by changing the number of words per block.

Mode	BPS	Bytes/Blk	Blks /Frame	Bytes/ Frame
HKP	83,85	54	1	54
NM1	5 527,71	356	10	3 560
NM2	6 521,46	420	10	4 200
NM3	4 502,91	290	10	2 900
BM1	26 762,82	278	62	17 236
BM2	6 546,3	68	62	4 216
BM3	29 458,36	306	62	18 972

Science data include a number of data products from both HIA and CODIF in a flexible format. Data are time-tagged in such a way as to allow absolute timing of the data on the ground (the absolute time of the beginning of each telemetry frame is available). The format allows bit rate allocations to the various data products to be changed relatively easily with minimal impact on ground processing. Since data collection is spin-synchronous, there is some scheme for dynamically tuning the data collection rate to the telemetry rate to avoid using fill (undesirable).

2.2. HOUSEKEEPING TELEMETRY

The following describes the implementation for telemetry formatting for CIS. Note that for all data words, the bits are stored into the data fields with the Most Significant Bits (MSB) of the data word in the MSB of the data field. Where a data field covers more than one telemetry word, the MSBs of the data word are stored in the first telemetry word, and the Least Significant Bits (LSB) are stored in the second word. Data is shifted out of the instrument in 16 bit words, MSB first.

Housekeeping data are organized in a fixed telemetry format synchronized to the telemetry frame. Part of the data is sub-commutated by two (13 words/frame), while the rest will be the same every frame (13 words/frame). Sub-commutation is indexed by the Frame Counter (included in the housekeeping every frame). The configuration tables are read out slowly by further sub-comutating by 32 one field in the housekeeping (ECP1CONF, ECP2CONF).

2.2.1 H0 Housekeeping

The housekeeping words sent every frame are called H0, and include mostly processor status words, most of which are repeated in the science telemetry frame header to simplify data analysis. Field descriptions with equivalent AIV names are provided below.

H0 Housekeeping Parameters

Ofs	15 msb	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0 lsb
0	Frame Ctr								cq	Cmd Ctr						
1	Command															
2	Err Ctr 1				Err Spin 1						Err Type 1					
3	tbd	Tlm Rate			Op Mode				sp	pe	pb	bt	Burst Free			
4	s/w vers. 1								Tbl vers. 1							
5	eo1	tbd	cs	hp	cp	ca	cm	cc	Fix Mod 1				Op Mod 1			
6	Config 1															
7	s/w vers. 2								Tbl vers. 2							
8	eo2	tbd			ht	ha	hm	hc	Fix Mod 2				Op Mod 2			
9	Config 2															
10	Err Ctr 2				Err Spin 2						Err Type 2					
11	tbd				Current 1											
12	tbd				Current 2											
26	Stat. reg.															

The 27th (no. 26) of housekeeping is decommutated from the 3 least sig.bits of the frame counter.

Descrition

Frame Ctr	ECP1FCNT	Count of the telemetry frames used in decomutating channels
cq	ECP1CMDQ	Command verify queue status (0=empty, 1=not empty)
Cmd Ctr	ECP1CMDC	Command Counter (multi-word commands count as one).
Command	ECP1CMDW	Command Verification word. For multi-word commands, only the first word is echoed. Rejected cmds aren't verified, but do generate an error.
Err Ctr 1	ECP1ECNT	CIS1 Error Counter is the count of CIS1 errors
Err Spin 1	ECP1ESPN	CIS1 Error Spin Counter when error occurred
Err Type 1	ECP1ETYP	CIS1 Error Type is the type of the most recent CIS1 error
Tlm Rate	ECP1TLMR	Current Telemetry Rate (see Operational Modes document)
Op Mode	ECP1MODE	Current Operating Mode (see Operational Modes document)
sp	ECP1BPWR	Scratch Memory Power status (1=on,0=off)
pe	ECP1BPBE	Playback Enable bit status (1=enabled,0=disabled)
pb	ECP1BPBS	Indicates burst playback mode (1=playback,0=normal)
bt	ECP1BTRG	Indicates the burst memory triggered
Burst Free	ECP1BFRE	Number of free burst blocks.
s/w vers.1	ECP1SVER	CIS1 Software Version number.
Tbl Vers.1	ECP1TVER	CIS1 Table Version number (fixed,operational,telemetry).
eo1	ECP1EOVF	CIS1 Error Overflow bit
cs	ECCDSENS	CODIF Sensitivity (0=LS, 1=HS)
hp	ECL2PWRS	HIA Power status (1=off,0=on)
cp	ECCHACCS	CODIF Post Accel HV status (1=on,0=off)
ca	ECCHANLS	CODIF Analyzer HV status (1=on,0=off)
cm	ECCHMCPS	CODIF MCP HV status (1=on,0=off)
cc	ECCACVRS	CODIF Cover status (1=on, 0=off)
Fix Mod 1	ECP1FMOD	CIS1 Fixed Table Modification counter
Op Mod 1	ECP1OMOD	CIS1 Operational Table Modification counter
Config 1	ECP1CONF	CIS1 config table read-out subcomutated by 32 on the 5 lsb of the frame counter.
s/w vers.2	ECP2SVER	CIS2 Software Version number
Tbl vers.2	ECP2TVER	CIS2 Table Version number (fixed, operational, telemetry)
eo2	ECP2EOVF	CIS2 Error Overflow bit
ht	ECHATSTS	HIA Amplifier test status (1=on,0=off)
ha	ECHHANLS	HIA Analyzer HV status (1=on,0=off)
hm	ECHHMCPS	HIA MCP HV status (1=on,0=off)
hc	ECHACVRS	HIA Cover actuator status (1=on, 0=off)
Fix Mod 2	ECP2FMOD	CIS2 Fixed table modification counter
Config 2	ECP2CONF	CIS2 config table read-out subcomutated by 22, not synchronous of the frame counter. (13 words fix table + 9 words operative table)
Err Ctr 2	ECP2ECNT	CIS2 Error Counter is the count of CIS1 errors
Err Spin 2	ECP2ESPN	CIS2 Error Spin Counter when error occurred
Err Type 2	ECP2ETYP	CIS2 Error Type is the type of the most recent CIS1 error
Current 1	ECL1ITOT	Total CIS1 Current analog measurement (CIS1 AHKP 10)
Current 2	ECL2ITOT	Total CIS2 Current analog measurement (CIS2 AHKP 10)
Stat. Reg.	ECCSTREG	CODIF status registers subcomutated by 8 (index = 3 lsb of ECP1FCNT)

Add remarks / Validity / ESOC Mnemonic

2.2.2 H1 Housekeeping

The housekeeping words sent when the frame counter is even is called H1, and includes the CIS1 analog housekeeping (12 bit words) and 2 CODIF 8-bit analog housekeeping values (ms=most significant bits, ls=least significant bits). Note that field names are AIV standard.

<u>H1 Housekeeping Parameters:</u>

	msb															lsb
Ofs	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
13	ECL1VP5												ECL1VN5 (ms)			
14	ECL1VN5 (ls)								ECL1VP12 (ms)							
15	ECL1VP12 (ls)				ECL1VN12											
16	ECCHIANL												ECCACOVR (ms)			
17	ECCACOVR (ls)				ECCAVSCR (ms)											
18	ECCAVSCR (ls)				ECCHVANL											
19	ECCTANL												ECL1ITOT (ms)			
20	ECL1ITOT (ls)								ECCRN100 (ms)							
21	ECCRN100 (ls)				ECCRN247											
22	ECCRP220												ECCRVOUT (ms)			
23	ECCRVOUT (ls)								ECCHID (ms)							
24	ECCHID (ls)				ECCRN153											
25	ECCAVP5								ECCAVP12							

Description

ECL1VP5	CIS1 +5 Volt monitor (AHKP1)
ECL1VN5	CIS1 -5 Volt monitor (AHKP2)
ECL1VP12	CIS1 +12 Volt monitor (AHKP3)
ECL1VN12	CIS1 -12 Volt monitor (AHKP4)
ECCHIANL	CODIF Step HV current on 28V primary (AHKP5)
ECCAVSCR	Scratch Memory Voltage (AHKP7)
ECCHVANL	CODIF Maximum Step HV value (AHKP8)
ECCTANAL	CIS1 analog electronics temperature (AHKP9)
EC1LITOT	Total CIS1 current at primary side of low power converter (AHKP10)
ECCRN100	CODIF RPA -100V deflector voltage (AHKP11)
ECCRN247	CODIF RPA -247V deflector voltage (AHKP12)
ECCRP220	CODIF RPA +220V deflector voltage (AHKP13)
ECCRVOUT	CODIF RPA out voltage (AHKP14)
ECCHID	CODIF Step HV diode current (AHKP15)
ECCRN153	CODIF RPA -153V deflector voltage (AHKP16)
ECCAVP5	CODIF +5 volt monitor (CODIF 1)
ECCAVP12	CODIF +12 volt monitor (CODIF 2)

** Validity of housekeeping for RPA to be defined.*

2.2.3. H2 Housekeeping

The housekeeping words sent when the frame counter is odd is called H2, and includes the CIS2 12-bit analog housekeeping and the CODIF 8-bit analog housekeeping. Note that field names are AIV standard (ms=most significant bits, ls=least significant bits).

<u>H2 Housekeeping Parameters:</u>

	msb															lsb
Ofs	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
13	ECHHVANL												ECHHVMO (ms)			
14	ECHHVMO (ls)								ECHHVMI (ms)							
15	ECHHVMI (ls)				ECL2VP5											
16	ECL2VP12												ECL2VN12 (ms)			
17	ECL2VN12 (ls)								ECHHIANL (ms)							
18	ECHHIANL (ls)				ECHHIMCP											
19	ECHTELEC												ECHACOVR (ms)			
20	ECHAVOVR (ls)								ECHHID (ms)							
21	ECHHID (ls)				ECHADIS1											
22	ECHADIS2												tbd			
23	ECCHVACC								ECCHVMCP							
24	ECCTELEC								ECCHIACC							
25	ECCHIMCP								ECCAVN5							

Description

ECHHVANL	HIA Maximum step HV value (AHKP1)
ECHHVMO	HIA MCP high voltage actual (AHKP2)
ECHHVMI	HIA MCP high voltage control (AHKP3)
ECL2VP5	CIS2 +5 volt monitor (AHKP4)
ECL2VP12	CIS2 +12 volt monitor (AHKP5)
ECL2VN12	CIS2 -12 volt monitor (AHKP6)
ECHHIANL	HIA step HV current on the 28V primary (AHKP7)
ECHHIMCP	HIA MCP HV current on the 28V primary (AHKP8)
ECHTELEC	CIS2 analog electronics temperature (AHKP9)
ECHACOVR	HIA Cover actuator status (AHKP11)
ECHHID	HIA stepping HV diode current (AHKP12)
ECHADIS1	HIA Discriminator level 1 (AHKP13)
ECHADIS2	HIA Discriminator level 2 (AHKP14)
ECCHVACC	CODIF Acceleration HV (CODIF4)
ECCHVMCP	CODIF MCP HV monitor (CODIF6)
ECCTELEC	CODIF electronics temperature (CODIF8)
ECCHIACC	CODIF Acceleration HV current (CODIF5)
ECCHIMCP	CODIF MCP HV current (CODIF7)
ECCAVN5	CODIF -5 volt monitor (CODIF3)

See tables CIS HK parameters - Description
(3 pages)
file UMTMPARA.XLS

2.2.4. Calibration curves for CIS1

CAL_ID	DESCRIPTION	Params	X	Clu #5 F8	Clu #6 F5	Clu #7 F6	Clu #8 F7	Spare F4
ADC1RANG	Dynamique ADC CIS1	ECCACOVR	0	0	0	0	0	0
		ECCAVSCR	4 095	5,12	5,12	5,12	5,12	5,12
CHIANL	Current HV Analyser	ECCHIANL	0	-0,5	-0,5	-0,5	-0,5	-0,5
			4 095	9,74	9,74	9,74	9,74	9,74
CHIDAN	Current diods HV analyser	ECCHID_	0	0	0	0	0	0
			4 095	22,53	22,53	22,53	22,53	22,53
CHIMCP	Current HV MCPs	ECCHIMCP	0	0	0	0	0	3
			255	148	148	148	148	151,92
CHIPAC	Current HV Acceleration	ECCHIACC	0	0	0	0	0	3
			255	34	34	34	34	36,3
CHVANL	Voltage HV Analyser	ECCHVANL	0	0	0	0	0	0
			4 095	-5675	-5 613,3	-5 676	-5676	-5 613,3
CHVMCP	Voltage HV MCPs	ECCHVMCP	0	0	0	0	0	50
			255	4753	4 580	4 570	4889	4 565,03
CHVPAC	Voltage HV Acceleration	ECCHVACC	0	0	0	0	0	0
			255	-30329	-28968	-28968	-29001	-26 520
CRN153	RPA Deflection voltage -153V	ECCRN153	0	0	0	0	0	0
			4 095	-255.93	-255,53	-255,56	-257,57	-257,83
CRPAN100	RPA Acceleration voltage -100V	ECCRN100	0	0	0	0	0	0
			4 095	-104,01	-103,6	-104	-102,78	-104,6
CRPAN247	RPA Deflection voltage -247V	ECCRN247	0	0	0	0	0	0
			4 095	-282,55	-281,33	-281,33	-282,55	-282,4
CRPAP220	RPA Repeling voltage +220V	ECCRP220	0	0	0	0	0	0
			4 095	260,42	261,26	259,62	260,85	258,8
CRPAVOUT	RPA voltage	ECCRVOUT	0	0	0	0	0	0
			4 095	26.208	26,29	26,2	26.2	25,66
CTAELEC	Temperature LPC/RPA electronics	ECCTANAL	0	-41,7	-41,7	-41,7	-41,7	-41,7
			4 095	71,48	71,48	71,48	71,48	71,61
CTELEC	Temperature CODIF electronics	ECCTELEC	0	-63,91	-63,91	-63,91	-63,91	-129,5
			255	110,76	110,76	110,76	110,76	44,41
L1ITOT	Total current CIS1	EC1LITOT	0	22.538	27.23	32,659	32.66	22,2
		ECL1ITOT	4 095	484.454	513.71	503,17	503.17	592,84
L1VN5	LPC -5Volt	ECL1VN5_	0	-7,5	-7,5	-7,5	-7,5	-7,5
			4 095	5,072	5,3	5,07	5,39	-5,36
L1VN12	LPC -12Volt	ECL1VN12	0	-23,94	-23,94	-23,94	-23,94	-24
			4 095	-8,7885	-8,57	-8,79	-8,706	-8,62
L1VP5	LPC +5Volt	ECL1VP5_	0	0	0	0	0	0
			4 095	6,3882	6,42	6,42	6,445	6,44
L1VP12	LPC +12Volt	ECL1VP12	0	0	0	0	0	0
			4 095	15,438	15,45	15,45	15,48	15,46
VN12CALB	CODIF -5Volt	ECCAVN12	0	-6,9	-6,9	-6,9	-6,9	-6,9
			255	-3,00	-3,11	-3,11	-3,11	-3,11
VP5CALIB	CODIF+5Volt	ECCAVP5_	0	0	0	0	0	0
			255	9,64	9,64	9,64	9,64	9,64
VP12CALB	CODIF +12Volt	ECCAVP12	0	0	0	0	0	0
			255	22,56	22,34	22,34	22,56	22,17

2.2.5. Calibration curves for CIS2

CALIB_ID	DESCRIPTION	Params	X	Clu #5 F8	Clu #6 F5	Clu #7 F6	Clu #8 F7	Spare F4
ADC2RANG		ECHACOVR	0	0	0	0	0	0
		ECHADIS1	4 095	5,115	5,12	5,12	5,081	5,12
		ECHADIS2						
HHIANL		ECHIANL	0	-0,5	-0,5	-0,5	-0,5	-0,5
			4 095	9.74	9,74	9,74	9.74	9,74
HHID	HV diode current	ECHHID_	0	0	0	0	0	0
			4 095	22,53	22,53	22,53	22,53	22,53
HHIMCP		ECHHIMCP	0	0,8	0,8	0,8	0,8	0,8
			4 095	52	52	52	52	52
HHVANAL		ECHHVANAL	0	0	0	0	0	0
			4 095	-5159	-5 130,4	-4902	-5013	-5 130,4
HHVMI		ECHHVMI_	0	0	0	0	0	0
			4 095	-4958	-5 125,7	-5 125,7	-4958	-5 125,7
HHVMO		ECHHVMO_	0	0	0	0	0	0
			4 095	-4958	-5118	-5 118,75	-4958	-5 118,75
HTAELEC2		ECHTELEC	0	-46,89	-46,89	-46,89	-46,89	-45,4
			4 095	74,57	74,57	74,57	74,57	76,06
L2ITOT		ECL2ITOT	0	-3.3488	10,1	67,238	67.24	8,2
			4 095	231.7	205	153,64	153.64	212,95
L2VN12		ECL2VN12	0	-24.75	-24,75	-24,75	-24,75	-24,75
			4 095	-8.8614	-9.10	-9,19	-9,02	-8,67
L2VP5		ECL2VP5_	0	0	0	0	0	0
			4 095	6,3882	6,27	6,142	6,265	6,53
L2VP12		ECL2VP12	0	0	0	0	0	0
			4 095	15,8886	15,7	15,56	15,15	16,16

2.2.6. CIS1 Error Type (ECP1ETYP)

[low priority error codes]

00h........................ not a valid error code
01h........................ serial comm out of sync
02h........................ burst product lost (BM full)
03h........................ bad rx command
04h........................ parity error on rx data
05h........................ checksum error for received data
06h........................ no rx data buffer is available
07h........................ too many retries, bad message
08h........................ i/o read in progress
09h........................ low priority task sync error
0Ah....................... task time-out waiting for serial tx
0Bh....................... block request not ack'd
0Ch....................... sio message nack'd
0Dh....................... burst command queue overflow
0Eh....................... received NDMA command from CIS2

[medium priority error codes]

10h....................... operating table checksum error
11h....................... fixed table checksum error
12h....................... multi-word command timeout
13h....................... tx state change timeout
14h....................... rx state change timeout
15h....................... time-out waiting for product sent
16h....................... bad op mode command, ignored
17h....................... invalid telemetry event
18h....................... multiword cmd lost, task i/f not rdy
19h....................... multiword cmd checksum error
1Ah....................... burst memory test failed
1Bh....................... product memory allocation failure
1Ch....................... HIA cmd task busy, hia cmd lost
1Dh....................... tlm ring sent timeout
1Eh....................... multiword command count exceed max
1Fh....................... bad cmd in burst mem queue

[high priority error codes]

20h....................... serial error sending hia cmd
21h....................... tlm block count corrupted
22h....................... serial i/o queue overflow

23h....................... tlm packet queue overflow
24h....................... operating mode command queue overflow
25h....................... cmd verification queue overflow
26h....................... response buffer overflow
27h....................... command queue overflow
28h....................... sio dma channel is busy
29h....................... mcp high voltage hkp/cmd mismatch
2Ah....................... accel high voltage hkp/cmd mismatch
2Bh....................... no serial link with CIS2 (after ~10 seconds)
2Ch....................... tlm mode detect failed, mode unknow
2Dh....................... missed science block EOP
2Eh....................... product init failure; task killed

[critical priority error codes]
30h....................... telemetry event timeout (dma halted)
31h....................... spin sync timeout
32h....................... Timer A interval missed
33h....................... CPU built-in test failed
34h......................... spurious interrupt
35h......................... bad TOF DMA write address
36h......................... software watchdog timeout
3Eh....................... EEPROM checksum error /reserved for Partial mode
3Fh....................... RAM 0 R/W test error

2.2.7. CIS2 Error Type (ECP2ETYP)

As part of the telemetry data sent by CIS2, the housekeeping packet reports the health status both of the hardware and the running software. Emphasis is put here after on the expected values in the error field. Science packets should always be treated taking into account this information, as the quality of the science data will depend on which errors occured during sampling, formatting and transmission of the products.

The following tables list all the error codes for the current S/W version. A certain number of error codes is reserved to the monitoring of the CIS 1-2 interface activity. Although such errors reveal some loss of the interface synchronisation, they can be disregarded from the point of view of science product reliability.

Error sorting in the following three table (A, B and C) is arbitrary. It is just outlined, in case of 'C', that if any of such type of errors occurs, some critical malfunctioning of the operating system is appeared.

Type A errors

Error #	Related activity	Description
10h	I/F Protocol	Undefined Rx packet header word
11h	I/F-AIV Protocol	Undef. AIV command in Rx'ed command pkt
12h	I/F Protocol	Undefined I/F control word
13h	I/F-AIV Protocol	Rx'ed AIV packet checksum error
14h	I/F Protocol	Rx'ed packet checksum error
15h	I/F Protocol	I/F control word with bad parity bit
16h	I/F Protocol	DMA Rx bus not granted (unexpected DMA pkt)
17h	I/F Protocol	Ack precocious during Tx
18h	I/F Protocol	Nack during Tx
19h	I/F Protocol	Ack/Nack unexpected (Tx was off)
1Ah*	I/F Protocol	Burst waiting timeout for Tx channel free
1Bh*	Operating system	TLM product trashing (too low Cis-2 TLM bit-rate)
1Ch*	Operating system	Output TLM FIFOs full
1Dh*	Operating system	Spacecraft TLM rate not allowed (in Rx'ed experiment status packet)
1Eh*	Operating system	Experiment TLM sub-rate not allowed (Rx'ed experiment status pkt)
1Fh*	Operating system	Bad B field components (in Rx'ed status experiment packet)

** These errors (1Ah to 1Fh) are only supported by EEPROM software. The other ones are supported by both, EEPROM and PROM (partial operation mode) softwares.*

Type B errors

Error #	Related activity	Description
20h	I/F Protocol	2nd error in current Rx transmission
21h	I/F Protocol	2nd error in current Tx transmission
22h	I/F Protocol	Timeout in current Tx transmission (Active resync.)
23h	I/F Protocol	Timeout in current Rx transmission (Active resync.)
24h	I/F Protocol	Tmeout waiting for Tx/Rx channel free (Active resync.)
25h	I/F Protocol	Cis-2 answer timeout in Cis-1 Tx(Passive resync.)
26h	I/F Protocol	Cis-1 timeout in Cis-2 Tx (Passive resync.)

Type C (critical) errors

Error #	Related activity	Description
30h	Operating system	Experiment spin no. != Instrument spin no.
31h*	Operating system	Sectoring activity out of phase
32h*	Operating system	Sub-fix table (RAM parameters) checksum error
33h*	Operating system	Sub-operative table (RAM parameters) checksum error
34h*	Operating system	EEPROM page checksum error
35h*	Operating system	TLM FIFOs handling error
36h*	Operating system	Unknown memory sub-pool to release

** These errors (31h to 36h) are only supported by EEPROM software. The other ones are supported by both, EEPROM and PROM (partial operation mode) softwares.*

2.2.8. Boot Report Packet

When entering in the fail safe mode due to any error, CIS2 sends an alarm to CIS1. When this alarm is aknowledged, CIS2 sends a 6 words error report packet with the following structure:

Word #	Description	Comment
1	Header I.P. word	
2	CPU Built In Test report BAyyy	yyy is the Marconi BIT report A/B counter error
3	PROM error check report	0 -- no error 40 -- PROM error
4	EEPROM error check report	0 -- no error or address of the block in error
5	RAM error check report	0 -- no error or address + 1 of the error
6	checksum	

These 4 words (# 2 to 5) are stored in CIS1 RAM at address @ 1ECDh and can be retrieved by memory dump.

These words (#2 to 5) are also placed by CIS1 in the Config2 word of the H0 housekeeping. They are subcommutated by the three least significant bits of the frame counter as follow:

Frame counter (lsb)	Description
0	B005h - alarm status packet
1	CPU bit error report
2	Prom error check report
3	EEPROM error check report
4	Ram error check report
5	DEADh - CIS2 fail safe mode flag
6	CIS1 spin counter when alarm received
7	(unspecified)

2.2.9. Description of Config 1 (ECP1CONF)

Here is the description of the decommutation of Config 1 field in HK0 using the 5 least significant bits of the frame counter:

Frame counter (5 lsb)	***Description***	***source***
00h	CIS control bit flags	Fix tab.
01h	MCP/PACC HV control bit flags & tracking authorisation	Fix tab.
02h	MCP HV desired setting	Fix tab.
03h	MCP HV rate of change (+/-1 every n ms)	Fix tab.
04h	PACC HV desired setting	Fix tab.
05h	PACC HV rate of change (+/-1 every n ms)	Fix tab.
06h	Spin phase (1/1024ths of spin)	Fix tab.
07h	Sector Mode (shall be 1)	Fix tab.
08h	Telemetry rate/Operating mode after reset	Fix tab.
09h	Fixed table checksum	Fix tab.
0Ah	Energy Sweep parameter table A pointer	Oper. tab.
0Bh	NM1 Telemetry Allocation Table pointer	Oper. tab.
OCh	NM2,BM2 Telemetry Allocation Table pointer	Oper. tab.
0Dh	NM3 Telemetry Allocation Table pointer	Oper. tab.
0Eh	BM1 Telemetry Allocation Table pointer	Oper. tab.
0Fh	CODIF Proton Suppression and H/L Sensitivity bit flags	Fix tab.
10h	CODIF H&L Power Control bit flags	Fix tab.
11h	RPA -247V setting	Oper. tab.
12h	RPA -153V setting	Oper. tab.
13h	Operating Mode Table checksum (sum of 7 words above)	Oper. tab.
14h	MSword of 32 bit spin ctr	miscellaneous
15h	LSword of 32 bit soin counter	miscellaneous
16h	CODIF test mode flag	miscellaneous
17h	DPU counter data lost ctr	miscellaneous
18h	The test flag determines whether to use real ctr data (zero) or just post the test buffer (non-zero). flag = 1, use EEPROM test buffer	miscellaneous
19h	PACC and MCP HVs maximum authorised	Fix tab.
1Ah	MS byte = LS byte of reset counter LS byte = LS byte of reset counter negative	miscellaneous
1Bh	Task counter pointer after a watchdog reset	miscellaneous
1Ch	CIS model number	miscellaneous
1Dh	Mass numbers sent to Scratch	miscellaneous
1Eh	Spare word 3	miscellaneous
1Fh	Spare word 4	miscellaneous

2.2.10. Description of Config 2 (ECP2CONF)

The instrument configuration is slowly echoed to ground via the HK packet using a sub-commutated word in the HK packet, ECP2CONF. Both the current fixed (13 words) & current operative (9words) tables stored in RAM (22 words) are transmitted in this way.The first table is related to the current instrument set-up configuration, while the second corresponds to current operating sub-mode status.

Description of these tables is in section 6.4.5 and the offset of parameters relatively to the first word is indicated in the following table.

Description	** ECP2CONF offset =[##h]*
Fixed Table Ver. no.	0
Instrument Default Configuration	1
MCPs High Voltage Setting	2
MCPs rising delay	3
Discriminator 1 treshold (large GF)	4
Discriminator 2 treshold (small GF)	5
Default boot operational mode	6
Current azimuthal displacement phase (be carefull, the value in the table and echoed in ECP2CONF is not the value specified in the command)	7
Eclipse on/off mode flag	8
Auto change mode on/off flag	9
Synchro word #1 for hk word config2	10
Synchro word #2 for hk word config2	11
Fixed Table Checksum	12
MSB: mode group info LSB: Oper.table version number	13
Sweeping type (normal: 2ms)	14
Mechanical phase (26.367°)	15
Max counter count for hot side moments(G)	16
Max counter count for cold side moments(G)	17
Normal tlm allocation table indx	18
Default 'k1' compression factor	19
Default 'k12' compression factor	20
Checksum for op. table	21

2.2.11. Description of Stat. Reg. (ECCSTREG)

The values provide status information about the CODIF instrument and can be interpreted as follows:

Index*	Mnemonic	Description
0	LSctrl	LS control register
1	LSstim	LS stimulation register
2	HSctrl	HS control register
3	HSstim	HS stimulation register
4	Amode	ASIC mode control register (of selected half)
5	Asampl	ASIC sampling register (of selected half)
6	MCPACC	8 msbits = last MCP HV commanded
		8 lsbits = last PAC HV commanded
7	HVstat	8 msbits = HV status
		8 lsbits = ASIC Mode control register (of unselected half)

* Index : the 3 least significant bits of the frame counter

2.2.12. Monitoring of Housekeeping Parameters

2.2.12.1. Telemetry hick-ups

In partial mode of operations the housekeeping telemetry frames could be corrupted about once every two days. This forms the subject of CL-DOR-NC-1966 (28/07/94).

Due to this situation, during the experiment survey by ESOC, any housekeeping parameter will be declared wrong only if it is found at a false value for more than two successive frames.

2.3. INITAL SETTING ACCORDING TO THE MODE

Partial mode (PROM mode)

Initial status of CIS1 at switch ON

Parameters	Initial Status	Meaning
CIS1		
ECCACVRS	0	OFF
ECCDSENS	0	LS selected
ECCHACCS	0	PACC HV OFF
ECCHANLS	0	ANAL HV OFF
ECCHMCPS	0	MCP HV OFF
ECL2PWRS	1	CIS2 OFF
ECP1BPWR	0	SCRATCH MEMORY OFF

of CIS2 at CIS2 switch ON

Parameters	Initial Status	Meaning
CIS2		
ECHHANLS	0	ANAL HV OFF
ECHHMCPS	0	MCP HV OFF
ECHATSTS	0	TEST GENERATOR OFF

Nominal mode (EEPROM mode)

Initial conditions depend on the content of the fixed and operating mode tables (See Chapter 6)

2.4. SCIENCE DATA

Science data format and description are provided in annex.

Science telemetry products from CIS1 and CI2 are summarized in tables 2.1. and 2.2.

2.4.1. Telemetry Products Overview

The following describes the telemetry products that the instruments generate. These product numbers are reported in the packet headers, and are also used in the telemetry allocation table (see CIS Operational Mode document). The telemetry allocation table also includes the time resolution for each data product, normally in spins. The product should be collected at this rate unless the buffers are full (if full, then skip one spin and check again). Some products are averaged for the interval, while others are sampled.

The order of the products in the Telemetry Allocation table determines which product is read out fastest. Typically the telemetry allocation table will be designed to give a slightly higher bit rate than nominal, so that there is always something available to transmit. The lowest priority product will take up the slack, sometimes having a longer interval between readouts than is programmed.

2.4.2. Diagnostic Telemetry Products

The following telemetry products are for processor diagnostics. They are identical for Main and HIA (other than the Main/HIA ID bit in the header)

Name	Description
63. Fill	Filler data when no other telemetry is available.
62. Memory Dump	Start memory address followed by 256 words of memory contents.
61. I/O Read	Selected I/O address followed by data word read in I/O instruction.

2.4.3. CIS1 PROM Telemetry Products

These products are used for the CIS1 PROM software and may be selected for diagnostic purposes.

Name	Description
0. Sweep Diag	This data comes from the housekeeping ADC, and consists of the measured values of the sweeping parameters over a nominal sweep of their range. The packet contains 32 values for each selected CODIF A/D housekeeping value: AHKP8 — analyzer high voltage AHKP5 — analyzer high voltage current AHKP11 — RPA-100 AHKP12 — RPA-247 AHKP13 — RPA+220 AHKP14 — RPA OUT AHKP15 — RPA IN AHKP16 — RPA-153 Each value is a 12 bit ADC value coded into a 16 bit word, for a total of 256 word packet.
1. Raw Counts	Output of the CODIF event counters for one energy sweep; organized as 32 energy samples, each containing the 48 event counters. This is a total of 1536 counters. Each counter shall be log-compressed to 8 bits (see compression scheme below), resulting in a packet length of 768 data words.
2. Raw Rates	Output of the CODIF rate counters for one energy sweep; organized as 32 energy samples, each containing the 24 HS rate counters, followed by the 24 LS rate counters. This is a total of 1536 counters. Each counter shall be log-compressed to 8 bits (see compression scheme below), resulting in a packet length of 768 data words.
3. Raw Events	This is a raw event stream read by the main processor DMA port. It includes the first 1024 event words from the start of the accumulation interval. If 1024 events have not been read by the end of the interval, a short packet is generated. Note that the data stream includes energy step markers so that the energy and spin sector can be reconstructed from the data stream (these markers will fill up the stream in about 1/4 spin if no events are present). Each event or marker is contained in a 16 bit word, so this data product fits in one 1024 word packet.
4. Full Events	(also Live Pulse Height data) This is similar to the Raw Events data product, except that the events are read from the CODIF digital board rather than the event board, This means that the events contain more information, but fewer of them can be collected (maximum one per sector interval, typically 1024 per spin). Full events consist of 32 bits each, and a maximum of 512 will be collected in an accumulation

interval (so that only one packet is made).

5. WEC Dump — This product consists of 32 consecutive 16-bit WEC data words.

6. FGM Dump — This product consists of 256 consecutive 16-bit FGM data words.

2.4.4. CIS2 PROM Telemetry Products

These products are used for the HIA PROM software and may be selected for diagnostic purposes.

Name	Description
0. Sweep Diag	This data comes from the housekeeping ADC, and consists of the measured values of the sweeping parameters over a nominal sweep of their range. The packet contains 32 values for each of HIA AHKP1 (analyzer high voltage), and AHKP7 (analyzer high voltage current), Each value is a 12 bit ADC value coded into a 16 bit word, for a total of 64 words.
1. Raw Counts	Output of all HIA counters for one energy sweep; organized as 32 energy samples, each containing the 48 event counters. This is a total of 1536 counters. Each counter shall be log-compressed to 8 bits (see compression scheme below), giving a packet size of 768 words.

2.4.5. CIS1 Telemetry Products

Most of these products are be double-buffered (memory space permitting) so that a new accumulation can be started before the previous one's transmission is complete.

Name	Description
7. Moments	13 Moments of the distribution for each of 4 masses (from the event board counters) for 3 energy ranges, compressed to 12 bits each, making a 117 word block. Multiple moment blocks may be packed into a packet for efficiency.
8. Heat Flux Tensor	not existing.
9. Cold Moments	same as 7 but computed using only data from the solar wind direction with the best angular and energy resolution.
10. Cold Heat Flux	not existing.
11. 3D Mass	Detailed mass distribution read-out (binned events); 64 masses for 6 angles and 8 energy bins, compressed to 8 bits. This makes 1536 words

(2 packets).

12. 3D Proton, 16E Distribution data from the event counters lowest mass (typically protons), compressed to 88 angles and 16 energies each, with each counter compressed to 8 bits. This gives a packet size of 704 words. Typically this data will be transmitted at lowest priority so that it can fill any remaining available telemetry.

13. 3D Proton, 31E Same as 12 but with 31 energies. This makes 1364 words (2 packets).

14. 3D Proton, 24A Same as 13 but with only 24 angles and 31 energies. This makes 372 words.

15. 3D Alphas, 16E Same as type 12 but for the second mass bin (typically Alphas). Note that these products are packeted separately so that they can have different time resolution appropriate to their counting statistics (protons fastest, then alphas, and finally the last 2 masses)

16. 3D Alphas, 31E Same as type 15 but with 31 energies. This makes 1364 words (2 packets).

17. 3D High Mass, 16E Same as type 12 but for the last 2 masses (2 packets).

18. 3D High Mass, 31E Same as type 17 but with 31 energies. This makes 2728 words (3 packets).

19. 2D Mass, 31E, 4M A compressed version of the 3D distribution onto one axis. Generates 16 spin phase angles for 31 energies for 4 masses, 8 bit log-compressed, for a 992 word packet.

20. 2D Mass, 16E, 4M Same as type 19 except with 16 energies and 8 spin phase angles (45 resolution) and 4 masses, for a 256 word packet.

21. 2D Mass, 16E, 2M Same as type 19 except with 16 energies and 16 spin phase angles, but for 2 masses, for a 256 word packet.

22. 2D Mass, 31E, 1M Same as type 19 except with 31 energies and 32 spin phase angles and 1 mass, giving a 496 word packet.

23. Pitch Angle Cut, 16E Snapshot sweep of 16 Energies for 4 masses and 8 polar angles, taken when the instrument FOV includes the magnetic field direction. 256 word packets (counts log compressed to 8 bits). Can produce two such distributions per spin.

24. Pitch Angle Cut, 31E Same as type 23, but for 31 energies (492 words/packet)

25. Remote Sensing not existing.

26. Solar Wind Helium not existing

27. Rates CODIF Rate counters, similar to EM type 2, but organized as 18 counters (for currently selected analyzer half), for 16 energies and 16 spin phase sectors. Data will be log compressed to 8 bits per sample. 2 spin phases are sent per spin.

28. Selected Events CODIF events (16 bit events from the CODIF digital board) selected by some criterion which attempts to evenly sample all of phase space, giving priority to high-mass particles. This data is similar to EM type 4 (Full Events), except for the selection algorithm.

29. RPA diagnostic Product CODIF RPA data for 4 masses, 16 energies and 88 angles. The RPA grid bias is swept with linear energy steps.

30. RPA Science Product not existing .

31. RPA Moments not existing.

32. 3D He+, 16E Same as type 12 but for the He+.

33. 3D O+, 16E Same as type 12 but for the O+.

34. 3D He+, 31E Same as type 32 but with 31 energies. This makes 1364 words (2 packets).

35. 3D O+, 31E Same as type 33 but with 31 energies. This makes 1364 words (2 packets).

36. Burst counters 16 bit raw counters, 2 masses, 8 anodes, 32 energies, 16 sweeps per spin.

37. Burst status 16 bit spin_msw + 10 words from most recent frame header.

38. Burst trigger 182 16 bit words of the burst trigger table.

39. 3D Proton, 16E Compressed version of type 12

40. 3D Proton, 31E Compressed version of type 13

41. 3D Proton, 24A Compressed version of type 14

42. 3D Alphas, 16E Compressed version of type 15

43. 3D Alphas, 31E Compressed version of type 16

44. 3D High Mass, 16E Compressed version of type 17

45. 3D High Mass, 31E Compressed version of type 18

46. 3D He+, 16E Compressed version of type 32

47. 3D O+, 16E Compressed version of type 33

48. 3D He+, 31E Compressed version of type 34

49. 3D O+, 31E Compressed version of type 35

A more detailed description of the CIS1 telemetry products is provided in annex.

2.4.6. CIS2 Telemetry Products

Name	Description
2. Moments	13 moments of the measured ion distribution for each of 3 energy bands at 12 bits per moment, giving a total of 29 1/4 words per spin. 16 spins of data are combined to generate a packet.
3.	Deleted.
4. Cold Moments	13 moments computed from a limited section of the analyzer with high energy and angle resolution, for 2 species (protons and alphas, separated by energy), compressed to 12 bits each. This gives 19 1/2 words per sample, which should be accumulated for at least 16 samples per packet.
5. 3D, 62E	Ion distribution compressed to 8 polar bins and 16 azimuthal (spin-phase) bins for 62 energies, compressed to 8 bits, giving 3968 words. This will take 3 packets to transmit. (there may be some difficulty supporting this product due to memory limitations; it may be possible only as a burst product).
6. 3D, 31E, 88A	Ion distribution data compressed to 88 solid angles (22.5 resolution) and 31 energies compressed to 8 bits each, gives 1364 words, which takes 2 packets to transmit. Uses Large geometric factor half of analyzer.
7. 3D, 31E, 42A	Same as type 5, but compressed to 42 angles.
8. Cold 3D	Ion distribution with high energy and angle resolution over a small region

of phase space; 8x8 angles by 31 energies by 8 log-compressed bits gives 992 words per packet.

9. 1D (Spectra) Distribution data summed over all angles for up to 62 energy bins, compressed to 8 bits. This generates 31 words per spin, and should be transmitted over 16 spins.

10. 2D Azimuthal 3D ion distribution summed over polar angle (for one half of the detector or the other, low or high sensitivity) to give 16 angles by 31 energies log compressed to 8 bits per sample, 248 words per packet.

11. 2D Polar Same as above, but summed over azimuthal angle (for both halves of the analyzer) with 22.5 resolution, to give 16 angles by 31 energies log compressed to 8 bits per sample, for 248 words per packet.

12. Pitch Angle Cut Snapshot sweep of 31 Energies and 16 polar angles, taken when the instrument FOV includes the magnetic field direction. 248 word packets (counts log compressed to 8 bits). Can produce two such distributions per spin.

13. Cold 2D Polar Like the Cold 3D distribution, summed over azimuth angle to give high-resolution 8 polar angles by 31 energies, 8 bit log compressed per sample, to give 124 words per spin; combine 8 samples per packet.

14. Cold 2D Azimuth Same as above, but summed over polar angle to give 8 high-resolution azimuthal angles.

15. Hot 3D 16Ex88Ω The sampling sphere is sliced by planes perpendicular to the anodes plane breaking down 8 slices. Data are all formatted into one packet. Enenergy index ranges from 0 to 15.

16. Hot 3D 30Ex88Ω The sampling sphere is sliced by planes perpendicular to the anodes plane breaking down 8 slices. Data are all formatted into two packets. Enenergy index ranges from 0 to 29.

17. Hot 3D 62Ex88Ω The sampling sphere is sliced by planes perpendicular to the anodes plane breaking down 8 slices. Data are all formatted into 3 packets. Enenergy index ranges from 0 to 61.

21. Hot 3D 31Ex8qx16ϕ compressed Same as 5 but with compression and for 31E only.

22. Cold 3D 31Ex8θx16ϕ compressed Same as 8 but with compression.

Cluster - CIS

User Manual for CIS Flight Operations

3. CONTROL

3.1. CONTROL PHILOSOPHY

The experiment commanding philosophy is to use block commands for memory loads as described in 3.2.4 and memory load commands to set the different modes, voltage settings, etc. of the experiment. There will be typically up to 10 commands to set up a specific mode.

3.1.1 Scope

The CIS instrument has 6 'Low Power Commands' (LPC - digital discrete pulses) and a 'Memory Load Command' interface (serial digital). The LPC lines are used to reset the system in various ways (Hot Reset, HIA Reset, and Cold Reset). These signals are controlled by a command format determined by the spacecraft. The Memory Load commands are used for all other functions, such as mode changes, parameter updates, and code or table modifications. The format of this serial stream is described in the following section.

3.1.2 Memory load commands

Commands to the CIS1 and CIS2 use the same format for simplicity. CIS1 receives all commands, and passes on commands for the CIS2 processor via the inter-processor serial interface.

3.2. EXTERNAL TELECOMMAND IMPLEMENTATION

The following describes the implementation for command handling for CIS:

3.2.1 Memory Load Command Types and Allocated Channels

Memory Load commands are received by the instrument 16 bits at a time. An interrupt prompts the processor to read and decode each command word. The specified command rate for the Cluster spacecraft is 10-20 commands/second for all instruments (although commands may be received at the instrument at a higher rate if they are buffered in the spacecraft time-tagged command or macro command memories). Due to this bandwidth limitation, the commands are coded efficiently.

There is two basic memory load command types: single word commands, consisting of a single 16 bit word, and multiple word commands.

Two channels are allocated to CIS for memory load commands, the main and the redundant channel. The allocated RTU addresses are indicated below.

RTU Addresses for CIS Memory Load Commands

Main Channel	2
Redundant Channel	12

3.2.2 Single Word Memory Load Commands

Most commonly used commands would be single word commands, such as Instrument mode setting, HV enable, MCP voltage setting, etc. Their format is:

Command Format

msb															lsb
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
d	t	Opcode						Parm							

d .... command destination (0=CIS1 Main, 1=CIS2 HIA)

t .... command type (0=single word, 1=multiword)

Opcode .... command op-code (0 to 63)

Parm .... 8-bit command parameter

Single word commands only affect the current operating mode of the instrument. On processor reset (by command or power-up) all parameters return to their default values. Default settings can only be modified by a multi-word command EEPROM memory load as described in section 3.2.4., or by the 'Save Current Configuration' commands (ZEC1SAVS and ZEC2SAVS described in Section 3.2.3.1 and 3.2.2.2)..

3.2.3. Single Word Command Opcodes

The following is a listing of single word commands with their bit patterns and parameter definitions, divided by the processor effected (CIS1 Main or CIS2 HIA). Command bit patterns are specified in terms of 'usefld' (usable bits), 'fixfld' (fixed bits mask), 'fixval' (fixed bit values), and 'prohbt' (prohibited bits, set to zero). For all CIS commands, 'usefld' is 0xFFFF and 'prohbt' is 0. The 'D' field is as described in section 3.2.2. above; an 'M' stands for the CIS-1 or Main processor (value 0), and a 'H' stands for the CIS-2 or HIA processor (value 1). The second letter under 'D' indicates the table (if any) effected by the command: 'F' for fixed parameters table, 'O' for Operational mode table (see Operational Modes document for description of tables).

Some commands affect both processors (such as telemetry rate and mode). These are directed to the CIS1 processor; the information gets to the CIS2 processor via the mode/status exchange between the processors that occurs once a spin.

Those bits which are not fixed (typically the 8 LSB) contain one or more parameters as described in the command description.

The first 7 commands set the current instrument telemetry rate, and are those sent automatically by the spacecraft to CIS on telemetry rate changes.

3.2.3.1. Telecommands to CIS1:

Name	D	Fixfld	Fixval	Description
ZEC1THOS	M	FFFF	0000	Set telemetry rate HKP
ZEC1TN1S	M	FFFF	0001	Set telemetry rate NM1
ZEC1TN2S	M	FFFF	0002	Set telemetry rate NM2
ZEC1TN3S	M	FFFF	0003	Set telemetry rate NM3
ZEC1TB1S	M	FFFF	0004	Set telemetry rate BM1
ZEC1TB2S	M	FFFF	0005	Set telemetry rate BM2
ZEC1TB3S	M	FFFF	0006	Set telemetry rate BM3
ZEC1MODS	MF	FFF0	0100	CIS Instrument operational mode setting (parameter value 0 to 15, indicating the mode number; mode definitions defined in CIS Operational Modes document; default 0)
ZEC1SAVS	M	FF00	0200	CIS1 Configuration save. Copies current Fixed table (parameter 1) or current Operational Mode table (parameter 0) from RAM to EEPROM, where it becomes the new default value at subsequent processor resets. The full EEPROM checksum is not updated. It is necessary to send the command ZEC1EECS to restart in Nominal operation mode after a reset or a switch on. No commands should be sent for 10 seconds following this command. Command is ignored if the OpMode or Fixed Table checksum in RAM is invalid. The Table Version number in EEPROM is incremented.If the Default OpMode Table, Default Fixed Table, or Telemetry Allocation tables in EEPROM are written to directly using a memory load command, the checksum and Table Version number must be manually updated.
ZEC1CVRN	MF	FFFF	0301	CIS1 Cover Open ON
ZEC1CVRF	MF	FFFF	0300	CIS1 Cover Open OFF
ZEC1MCPN	MF	FFFF	0311	CIS1 MCP HV ON
ZEC1MCPF	MF	FFFF	0310	CIS1 MCP HV OFF
ZEC1ANLN	MF	FFFF	0321	CIS1 Analyzer HV ON
ZEC1ANLF	MF	FFFF	0320	CIS1 Analyzer HV OFF
ZEC1ACCN	MF	FFFF	0331	CIS1 Acceleration HV ON
ZEC1ACCF	MF	FFFF	0330	CIS1 Acceleration HV OFF
ZEC1SCRN	MF	FFFF	0341	CIS1 Scratch memory power ON
ZEC1SCRF	MF	FFFF	0340	CIS1 Scratch memory power OFF
ZEC1PWRN	MF	FFFF	0351	CIS1 HIA LPC Switch ON
ZEC1PWRF	MF	FFFF	0350	CIS1 HIA LPC Switch OFF
ZEC1SPAS	MF	FF00	0400	Set CIS1 spin phase adjustment between start of measurement and spin pulse. Parm = 0-255 (1/1024ths spin), default = 75.
ZEC1MCPS	MF	FF00	0500	MCP HV setting. Parm = 0-255 (DAC steps) default = 0

ZEC1ACCS	MF	FF00	0600	Accel HV setting. Parm = 0-255 DAC steps, default = 0
ZEC1RA1S	MF	FF00	0700	RPA -247V adjust. Parm = 0-255 DAC steps, default = 0
ZEC1RA2S	MF	FF00	0800	RPA -153V adjust. Parm = 0-255 DAC steps, default = 0
*ZEC1RRAS	MO	FF00	0900	RPA range. Parameter = 1-16 DAC steps/sample, default = 1
*ZEC1ROFS	MO	FF00	0A00	RPA offset. Parameter = 0-255 = first DAC step of RPA sweep, default = 0
ZEC1SHLS	MO	FF00	0B00	Analyzer sensitivity select (0=Low sensitivity, 1=High sensitivity)
ZEC1PARS	M	C000	0000	Generic CIS1 parameter set; 6 MSB of parameter is the Opcode, and 8 LSB of the parameter is the value, as described in section 3.2.2. above.
ZEC1RPAF		FFFF	0360	CIS1 RPA OFF
ZEC1RPAN		FFFF	0361	CIS1 RPA ON

* *Not implemented in EEPROM software nor in PROM.*

3.2.3.2. Commands to CIS2:

Name	D	fixfld	fixval	Description
ZEC2SAVS	H	FF00	8200	CIS2 Configuration save (copies current Fixed parameter and Operational Mode tables from RAM to EEPROM, where they become the new default value at subsequent processor resets. Since this command writes to the EEPROM, it is followed by a processor reset to restart normal operations. No commands should be sent for 10 seconds following this command. Table version is automatically incremented. In partial operation, restart from the default PROM tables and recompute the EEPROM checksum. (no CIS2 reset).
*ZEC2CVRN	HF	FFFF	8301	CIS2 Cover Open ON
*ZEC2CVRF	HF	FFFF	8300	CIS2 Cover Open OFF
ZEC2MCPN	HF	FFFF	8311	CIS2 MCP HV ON
ZEC2MCPF	HF	FFFF	8310	CIS2 MCP HV OFF
ZEC2ANLN	HF	FFFF	8321	CIS2 Analyzer HV ON
ZEC2ANLF	HF	FFFF	8320	CIS2 Analyzer HV OFF
ZEC2TSTN	HO	FFFF	8331	CIS2 Amplifier Test ON
ZEC2TSTF	HO	FFFF	8330	CIS2 Amplifier Test OFF
ZEC2SPAS	HF	FF00	8400	Set CIS2 spin phase adjustment between start of measurement and spin pulse. Parameter = 0-255 1/1024ths spin, default = 75
ZEC2MCPS	HF	FF00	8500	MCP HV setting. Parm = 0-255 DAC steps, default = 0
ZEC2DL1S	HF	FF00	8600	Discriminator Level 1 setting. Parm = 0-255 DAC steps
ZEC2DL2S	HF	FF00	8700	Discriminator Level 2 setting. Parm = 0-255 DAC steps
ZEC2PARS	H	C000	8000	Generic CIS2 parameter set; 6 MSB of parameter is the OPCODE, and 8 LSB of the parameter is the value, as described in section 3.2.2. above.

* no more useful because CIS2 has no cover !

3.2.3.3. Diagnostic Commands

The following normal memory load commands are for diagnostics. They are recognized in normal and bootstrap modes (except for ZEC1MDUS in bootstrap mode). Only these commands and multi-word memory load commands are recognized while in bootstrap mode.

- to CIS 1:

Name	D	fixfld	fixval	Description
ZEC1MEMS	M	FF00	3700	CIS1 memory write to RAM using the 8 lsbits in this command word and the msb in the diagnostic data word set by ZEC1DAMS. The address written to is the diagnostic address set via ZEC1ADLS and ZEC1ADMS commands
ZEC1ADLS	M	FF00	3800	CIS1 address LSB set (parameter is the address 8 LSB)
ZEC1ADMS	M	FF00	3900	CIS1 address MSB set (parameter is the address 8 MSB)

ZEC1MDUS	M	FF00	3A00	CIS1 memory dump request (starting at the location indicated by the CIS1 address register, programmed with ZEC1ADLS and ZEC1ADMS, continuing for the number of pages indicated in parameter, plus 1 (0 to 255). A page is 256 words. The memory dump will be formatted as normal telemetry packets, one page per packet; see CIS Telemetry Format document). Echo of the command will be issued when the requested number of pages wil be dumped.
ZEC1MLAS	M	FFFF	3B00	CIS1 memory load buffer address set (set address of RAM buffer used for memory load to the CIS address register set with ZEC1ADLS and ZEC1ADMS above. Default is FFh. Used only in case of a problem with the RAM buffer)
ZEC1IORS	M	FF00	3C00	CIS1 I/O channel read (from location indicated by the CIS1 address register. Parameter word is unused).
ZEC1DAMS	M	FF00	3D00	CIS1 data word MSB set (parameter is 8 MSB of CIS1 data word; used for ZEC1IOWS and ZEC1MEMS)
ZEC1IOWS	M	FF00	3E00	CIS1 I/O channel write (to address specified by the CIS1 Address register, write the data word composed of the 8 MSB set by ZEC1DAMS and the 8 LSB being the parameter to this command).
ZEC1JMPS	M	FF00	3F00	CIS1 processor jump (to address specified in the CIS1 address register, with register R1 set to the parameter value).

- to CIS2:

Name	D	fixfld	fixval	Description
ZEC2ADLS	H	FF00	B800	CIS2 address LSB set (used for diagnostics; parameter is the address register 8 LSB)
ZEC2ADMS	H	FF00	B900	CIS2 address MSB set (parameter is address 8 MSB)
ZEC2MDUS	H	FF00	BA00	CIS2 memory dump request (starting at the location indicated by the CIS2 address register, programmed with ZEC2ADLS and ZEC2ADMS, continuing for the number of pages indicated in parameter, plus 1 (0 to 255). A page is 256 words. The memory dump will be formatted as normal telemetry packets, one page per packet; see CIS Telemetry Format document).
ZEC2MLAS	H	FFFF	BB00	CIS2 memory load buffer address set (set address of RAM buffer used for memory load to the CIS address register set with ZEC1ADLS and ZEC1ADMS above. Default is FFh. Used only in case of a problem with the RAM buffer)
ZEC2IORS	H	FF00	BC00	CIS2 I/O channel read (from location indicated by the CIS2 address register. Parameter word is unused).
ZEC2DAMS	H	FF00	BD00	CIS2 data word MSB set (parameter is 8 MSB of data word; used for ZEC2IOWS and ZEC2MEMS)
ZEC2IOWS	H	FF00	BE00	CIS2 I/O channel write (to address specified by the CIS2 Address register, write the data word composed of the 8 MSB set by ZEC2DAMS and the 8 LSB being the parameter to this command).

ZEC2JMPS	H	FF00	BF00	CIS2 processor jump (to address specified in the CIS2 address register, with register R1 set to the parameter value).

3.2.3.4. Test Commands

The following memory load commands are for use during testing. They are included in the EEPROM software and in the partial operation mode which is implementated in PROM - see the *Cluster CIS DPU Software Description* document).

CIS1:

Name	D	fixfld	fixval	Description
ZEC1SWPS	M	FF00	0C00	Generate and use a new sweep table (the table parameters may be modified via multi-word commands previously specified or via the test interface monitor). Not available in EEPROM.
ZEC1EECS	M	FFFF	0F00	This command re-computes and updates the checksum table in EEPROM. Since EEPROM cannot be read during the interval that it is being programmed (this takes about 10 msec per 64 words) the normal operations are stopped during EEPROM reprogramming. CIS1 will restart normal operations as soon as the execution of the block command is finished.
ZEC1SCRS	M	FFFF	0345	Initiates a Scratch Memory test. The test takes approximately 120 seconds to complete. Not available in PROM software (partial or survival modes). The scratch memory is swtched on. Various pattern are writen into the memory and checked by reading operations. Then the scratch memory is switched off. The command is echoed only if the test is successful. Otherwise an error 1A is reported.

3.2.4. Multiple Word Commands

Multiple word commands are used for memory load, consisting of a memory load op-code, the number of words to load, the address to load, the data to load, and a check-sum. The check-sum is used to verify that all words in the memory load were received successfully before the load is implemented.

Multiple Word Command Format

Word	Description
1st	Op-code & # words N (up to 77) - see Single Word command format.
2nd	Address to load (16 bits)
3rd..N+3	Data Words (N+1 of them)

N+4th	Checksum (two's complement of arithmetic sum of words 1.. N+3)

As indicated above, the first word of a multiple word command is a special kind of single word command. The PARM field is used to indicate the number of words in the load minus one (excluding the opcode, address, and checksum words; e.g. a value of 0 for PARM indicates a 4 word command sequence for a 1 word data load). The OPCODE field is an identifier of the memory load; it is not used on-board, but is useful for ground processing and command verification.

Multiple Word commands shall be sent as block commands. No additional measures need be taken to differentiate commands from data words. The size of a multiple word command is limited to 77 data words per block (longer loads must be blocked into groups not exceeding 77 data words each before transmission).

An internal delay is implemented. So a maximum delay of 1 second between 2 consecutive commands of a multiple word block is assumed (by default). This delay can be modified by writting a new value at address @=mwc_to (1B60h for version 2.33); 0->disable (no timeout); 1-32767 (0001h-7FFFh) -> milliseconds per word.

Data words are loaded into memory starting at the given Address, with subsequent data words loaded into the following locations sequentially. Multiple word command blocks will be pre-assembled into a scratch buffer before being loaded into the destination; they will only be transferred if the checksum test passes.

Memory load commands typically will address EEPROM to change code or table values.

3.2.4.1 Block commands for CIS2 (EEPROM)

When CIS2 is in Nominal (EEPROM) mode, it is possible to send a block command to write in EEPROM, for exemple to modify some tables (fix, operating, ...). In that case, after execution of the block command, EEPROM table checksum is not computed, CIS2 is reseted and restart in PROM partial mode (because EEPROM checksums are wrong).

3.2.4.1 Block commands for CIS2 (PROM)

When CIS2 is in Partial operation (PROM) mode, every words of a block command shall belong to the same page of 32 words. The 11 most significant bits of the address shall stay identical for data contained in a block command. This is due to the way the EEPROM is reprogrammed. EEPROM block command software has been upgraded in order to take care of this particularity and to accept any address for block command.

3.2.5. ON/OFF Commands (Low Power Commands)

They are used to reset the CIS1 and CIS2 processors in different way:

- CIS1 hot reset ,

- CIS2 reset only,

- CIS reboot (cold reset for CIS1 and CIS2)

Two of the six Lower Power commands are also used to select the CIS main or redundant Low Power command interface.

Six Low Power commands are devoted to CIS. Each of them has a specific RTU address defined in the table below:

Telecommand name	RTU address	Description
ZECLPC1A	0	CIS1 hot reset (primary) After a hot reset CIS1 normally restart in "nominal operation mode". To be used only when the CIS **primary** low power command interface is selected.
ZECLPC1B	80	CIS1 hot reset (redundant). After a hot reset CIS normally restart in "nominal operation mode". To be used only when the CIS **redundant** low power command interface is selected.
ZECLPC2A	1	CIS2 reset (primary). CIS2 restart according to the sequence described in fig.3.2. Used also to select the CIS primary low power command interface.
ZECLPC2B	81	CIS2 reset(redundant). CIS2 restart according to the sequence described in fig.3.2. Used also to select the CIS redundant low power command interface.
ZECLPC3A	2	CIS1 cold reset (reboot) and CIS2 reset (primary) After a cold reset CIS normally restart in "survival mode", waiting for commands. No scientific products transmitted. After a jump to address 0 (ZEC1JMPS,0), CIS1 will start in "Partial Operation Mode". To be used only when the CIS **primary** low power command interface is selected.
ZECLPC3B	82	CIS1 cold reset (reboot) and CIS2 reset (redundant) After a cold reset CIS normally restart in "survival mode", waiting for commands. No scientific products transmitted. After a jump to address 0 (ZEC1JMPS,0), CIS1 will start in "Partial Operation Mode". To be used only when the CIS **redundant** low power command interface is selected.

CIS1 high voltage status and CIS2 status according to the mode of operation reached after CIS switch ON or after a low power command (hot or cold reset).

	CIS1 HV Analyser	CIS1 HV MCP	CIS1 HV Acceleration	CIS2
Nominal Operation modes (EEPROM): commissioning	OFF & control volt. sweeping	OFF & set = 0	OFF & set = 0	OFF
Nominal Operation modes (EEPROM)	See CIS1 fix tables			
Partial Operation mode (PROM)	OFF & control volt. sweeping	OFF & set = 0	OFF & set = 0	OFF
Survival mode (PROM)	OFF	OFF & set = 0	OFF & set = 0	ON

CIS2 high voltage status according to the mode of operation reached after CIS2 switch ON or after a reset

	CIS2 HV Analyser	CIS2 HV MCP	Remarks
Nominal operation modes (EEPROM): commissioning	OFF & no sweep of control voltage (max value)	OFF & set = 0	Restart in EEPROM if RAM ok and if Chksum ok
Nominal operation modes (EEPROM): flight modes	See CIS2 fix tables		
Partial operation modes (PROM)	OFF & no sweep of control voltage	OFF & set = 0	
Survival mode (PROM)	OFF & no sweep of control voltage (max value)	OFF & set = 0	

See table "Telecommand description for CIS" (3 pages)
file UMTCLIST.XLS

Figure 3.1a. : CIS1 PROM Boot Sequence (1)

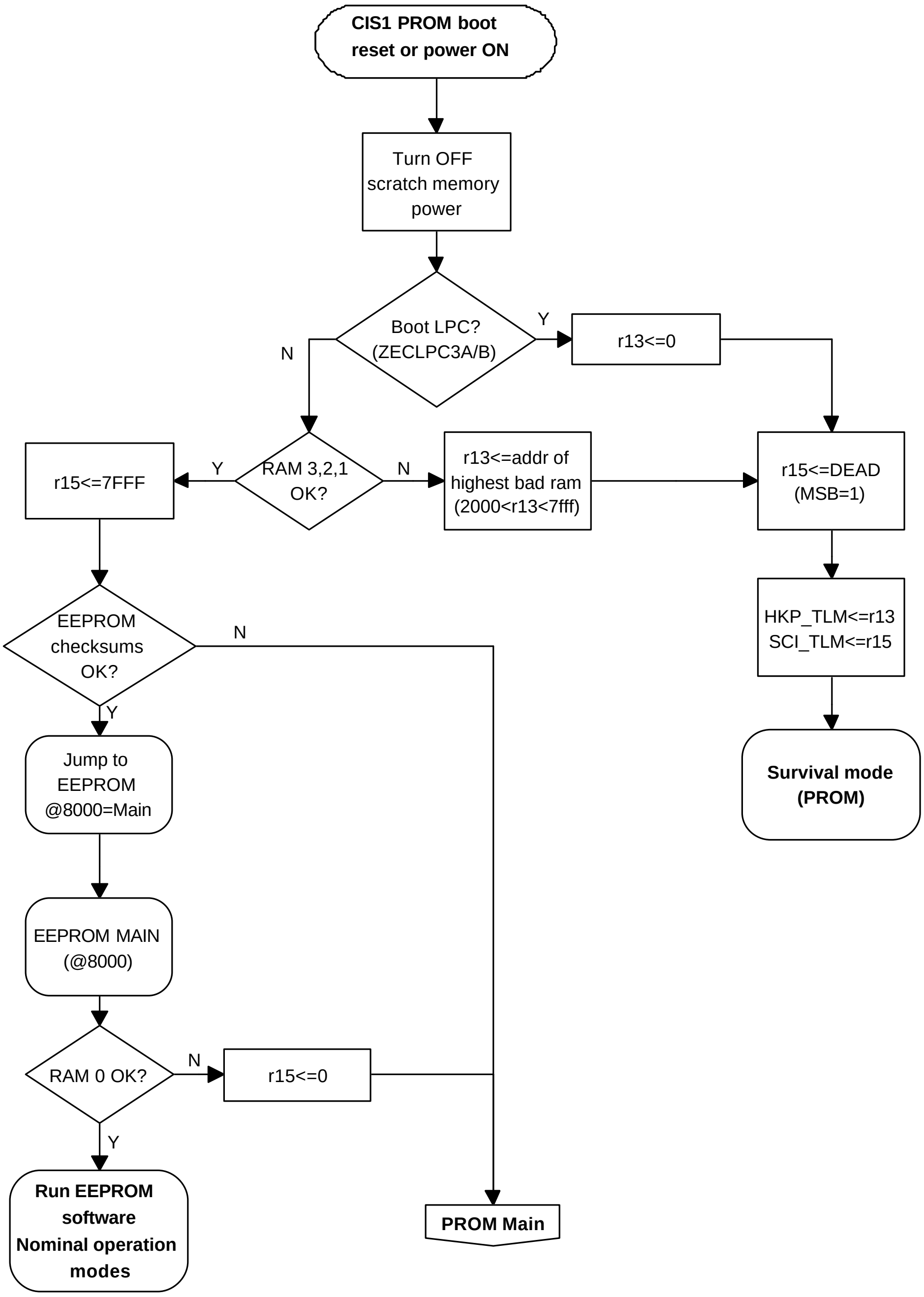


Figure 3.1b. : CIS1 PROM Boot Sequence (2)

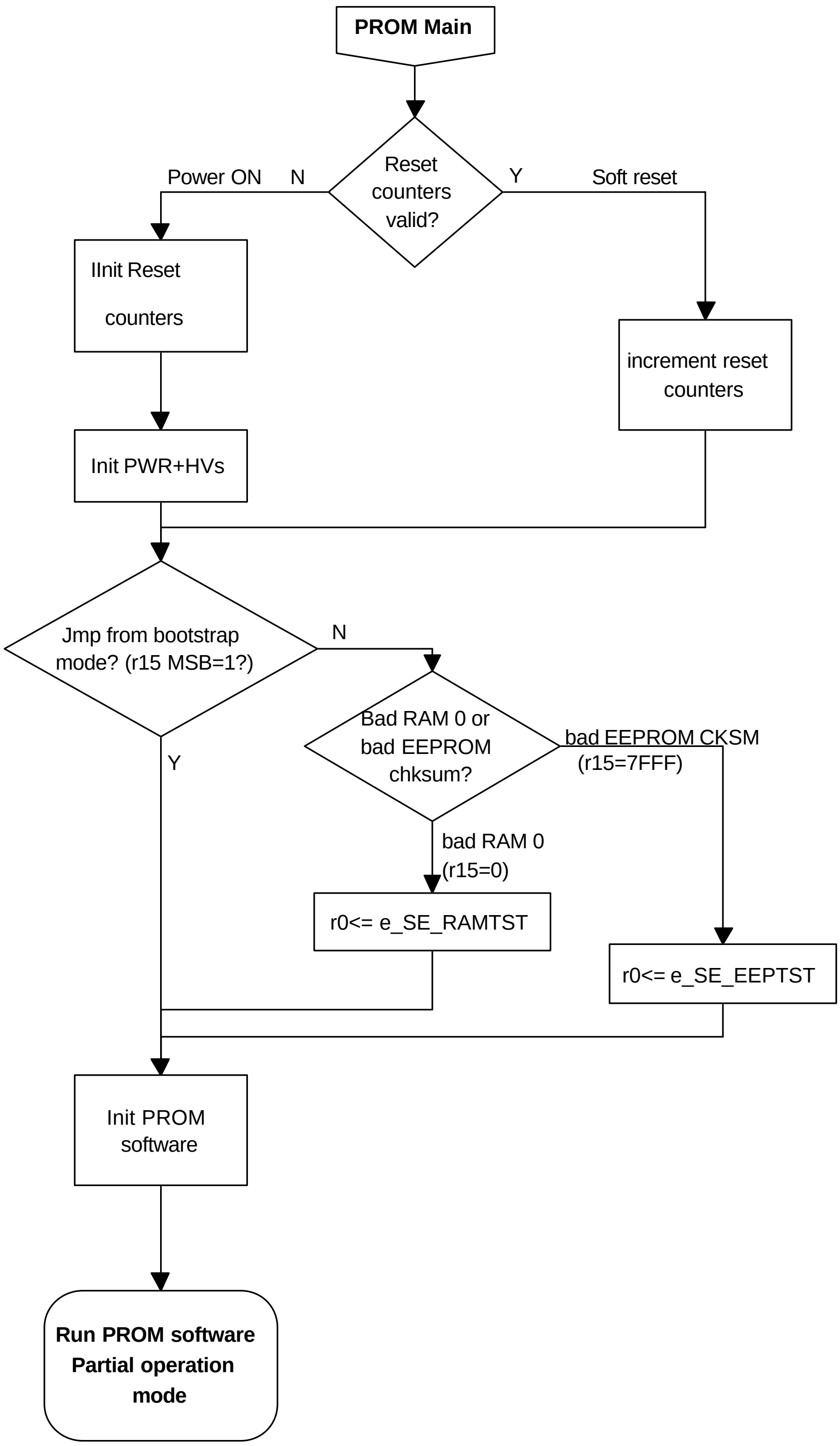
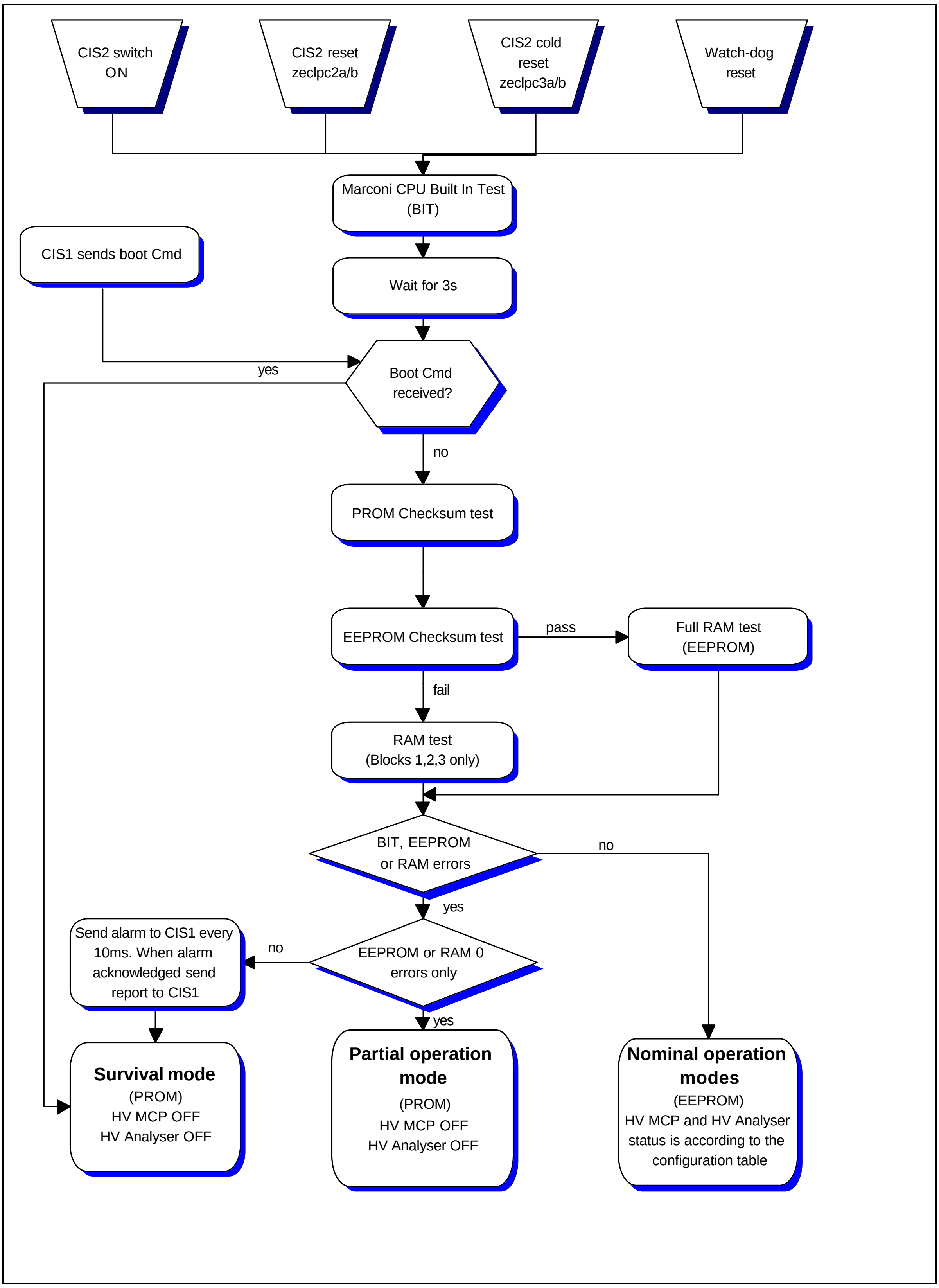


Fig. 3.2. : CIS2 Survival Mode Sequence and Basic Modes of Operations



3.2.6. Critical Telecommands

The telecommands affecting the HV are critical !

Before sending them it is necessary to take into account the pressure level as well as the duration of staying at this level.

After launch it is necessary to wait for 4 days after opening the cover to set the levels at the nominal values.

The analyser HV could be switchon at high value if the pressure is better than 3*10e-6 torr.

Hereafter are defined the nominal and maximum values for the different models. The software of CIS1 itself is checking if the command parameter is lower than the maximum value authorised. If yes, the command is executed else the command is refused.

CIS1 :

Model number	HV type	Max value at air	Max value P<3*10e-6	Nominal value	Max value
FM5	PACC	3394 V param = 20 hex	15340 V param = 90 hex		20033 V param = BC hex
	MCP	260 V param = 10 hex		2308 V param = 8E hex	2406 V param = 94 hex
FM6	PACC	3401 V param = 20 hex	15359 V param = 90 hex		20056 V param = BC hex
	MCP	286.75 V param = 10 hex		2651 V param = 94 hex	2793 V param = 9C hex
FM7	PACC	3348 V param = 20 hex	15156 V param = 90 hex		19795 V param = BC hex
	MCP	287.42 V param = 10 hex		2519 V param = 8C hex	2626 V param = 92 hex
FM8	PACC	3348 V param = 20 hex	15066 V param = 90 hex		19787V param = BC hex
	MCP	267 V param = 10 hex		2341V param = 8C hex	2441V param = 92 hex
FM4 (spare)	PACC	3401 V param = 20 hex	15359V param = 90 hex		18772 V param = BC hex
	MCP	286.75 V param = 10 hex		857 V Param = hex	2857 V param = hex

CIS2 :

Model number	HV type	Max value at air	Max value P<3*10e-6	Nominal value	Max value
FM5	MCP	218.8 V param = 10 hex	N/A	2297 V param = A8 hex	2407 V param = B0 hex
FM6	MCP	218.8 V param = 10 hex	N/A	2297 V param = A8 hex	2407 V param = B0 hex
FM7	MCP	218.8 V param = 10 hex	N/A	2297 V param = A8 hex	2407 V param = B0 hex
FM8	MCP	218.8V param = 10 hex	N/A	2352 V param = AC hex	2462V param = B4 hex
FM4 (spare)	MCP	218.8 V param = 10 hex	N/A	2292V param = hex	2407V param = hex

3.3. REFLECTION OF TELECOMMANDS ON TM (Cross Correlation Matrix TC-TM)

The instrument command verification consists of a command counter and a most recent command word identifier in the instrument housekeeping. If more than one command word is received between read-outs of the housekeeping channel (about 5 seconds), the command identifiers will be queued up in a short FIFO (approximately 32 commands deep). Command identifiers will be removed from the queue as they are read out, once per telemetry frame. If the queue is filled, an error flag will be sent. A bit in the housekeeping will indicate the status of the command verification FIFO.

Multiple Word commands will be verified by a single word (the first word of the command, which include the load identifier field). If further verification is required, a memory dump of the system memory can be commanded (this is made via the science data channel, and so must be verified by the investigator team).

CIS2 command verification will be done by the CIS1 processor, but CIS1 will only verify the command when it is successfully transmitted to and acknowledged by the HIA processor. So, if a command is not acknoledged by CIS2, it is not echoed. Same thing when CIS2 is OFF.

3.4. ON-BOARD CALIBRATION TABLES MODIFICATION

See Section 3.2.4. (Multiple Word Commands).

3.5. ON-BOARD SOFTWARE MODIFICATION

See Section 3.2.4. (Multiple Word Commands)

3.6. INTERNAL CONTROL AND COMMANDS

3.6.1. Autonomous Operations

3.6.1.1. Recovery Procedure used by the DPU in case of discharge of PACC or MCP HV

This procedure will be used in the following configuration :

MCP High Voltage and ACC High Voltage respectively enabled during flight.

The flight DPU software will track the value of the HKP for MCP high voltage and for PACC high voltage.

Some discharge could occur during flight. In this case, these High voltages will drop down to 0.

The following procedure is used in case of HV enabled.

The informations available are :

* Command value sent by the DPU to the CODIF command register for the high voltages.

The desired set value is written in memory. The command value is sent to Codif and kept in memory. The command is incremented or decremented till it will reached the desired set value (target).

* HKP value read inside CODIF register

The algorithm to track and recover the High Voltage will be the following :

For PACC :

```
IF ACC command value is less than 10 THEN

        Nothing to check

ELSE

        IF HKP ACC value less than 4 THEN

            Disable PACC

            Wait some seconds

            Start again to send the comand value starting from 0

            to reach the nominal value

        ENDIF

ENDIF
```

For MCP :

IF MCP command value is less than 10 THEN

    Nothing to check

ELSE

    IF HKP MCP value less than 4 THEN

        Disable MCP HV

        Wait some seconds

        Start again to send the comand value starting from 0

        to reach the nominal value

    ENDIF

ENDIF

3.7 Redundancy concept for S/C interfaces and how to select main or redundant branch

The CIS instrument consists of the 2 non-redundant units CODIF (CIS1) and HIA (CIS2). Most of the interfaces to the satellite have primary and redundant branches.

The interfaces described briefly below are:

- Power supply,
- Low Power Command interface,
- OBDH/RTU interface for commanding,
- RTU telemetry output, and
- Inter Experiment Link (IEL)

<u>1. The Power Interface</u>

Purpose & Design

To receive electrical power from the switchable power bus (28V). This bus is redundant and has two LCLs, CIS LCL-A and CIS LCL-B.

On CIS side these power lines are merged (via diodes) together. The CIS1 and CIS2 power converters are connected to these merged power lines by a single line each.

Operational Consequences

To provide power to the instrument LCL-A **or** LCL-B has to be on. CIS does not recognise which one of the power line is active. No further selection on CIS level is necessary. Concerning the redundancy, a 'mixed' configuration of power and commanding interfaces is possible, e.g. powering CIS via the LCL-B and commanding CIS through the primary interface (commands of the type XCIS3xxx) is possible.

<u>2. The Low Power Command (LPC) interface</u>

Purpose & Design

This interface is used to start and reset the CIS processors (CIS1 and CIS2).

CIS1 can start from EEPROM or PROM (CIS1 hot or CIS1 cold reset).

CIS2 can start from EEPROM (CIS2 reset). The 'CIS1 hot reset' includes the CIS2 reset as well.

Note: The LCL 'ON' command (CIS LCL-A or LCL-B) will start the CIS1 processor to boot.

This interface has a primary and redundant branch. The selection of a branch is done by sending the 'CIS2 reset' command ('ZECLPC2**A**' or 'ZECLPC2**B**') for the <u>**first**</u> time after power on. The primary command 'ZECLPC2**A**' will select the primary branch and the redundant command 'ZECLPC2**B**' will select the redundant branch.

Operational Consequences

1. The 3 different reset commands (CIS1 hot reset, CIS1 cold reset and CIS2 reset) exist, as primary and redundant commands each (therefore, there are 6 commands in total).

2. The 'CIS2 reset' command has two different functions, which depend on the command history:

- The selection of the interface branch (as described above) and

- To reset the CIS2 processor. This second function is activated always when the command is send except **for the first time if the interface branch selected was not already active !**

3. OBDH/RTU interface for commanding and timing

Purpose & Design

This interface handles the memory load commands and timing signals from the OBDH/RTU incl. the Sun Reference Pulse signal.

This interface has a primary and redundant branch. No dedicated command exists to select the primary or redundant branch. The internal command gate makes the selection between primary and redundant interfaces: the first command arriving will select the channel. Any CIS memory load command could be used. Example: a command (‘XCIS3xxx’ command) arrives through the primary channel (CMDGATE1), it selects the primary interface. If a command (‘XCIS6xxx’ command) arrives through the redundant channel (CMDGATE2), it selects the redundant interface.

Operational Consequences

Any command which was used to select or change the interface branch will have no other effect than this selection (**if the interface branch selected was not already active ! Otherwise it will have effect that could be bad !)**; e.g. a ‘telemetry mode’ command or a ‘HV on’ command will select the channel only but not set the telemetry mode or the HV.

Warning: Critical commands, e.g. ‘HV on’, **shall not be used** for this redundancy selection. Because **if this command is sent a second time or if the interface branch was already selected**, it will switch on the HV.

Recommendation: Send twice a telemetry mode CMD (ZEC1TN1S for NM1) or twice an address CMD (ZEC1ADLS). Those commands can be repeated without any problems.

Constraint: Always the same branch type (primary or redundant) has to be selected for the OBDH/RTU interface and the Low Power Command interface, i.e. either both on ‘primary’ or both on ‘redundant’.

4. Telemetry output Interface

Purpose & Design

This I/F provides the housekeeping and science telemetry to the RTU. It has a primary and redundant branch. Both outputs are active permanently (hot redundancy). So, the OBDH can get data from primary or redundant interface. By selecting the OBDH/RTU interface the corresponding TLM interface is configured automatically; i.e. if commanding via the redundant RTU interface the redundant CIS TLM interface is used.

Operational Consequences

No selection for the TLM I/F is required. For commanding and telemetry always the same type of interface branch is used, i.e. either both are on ‘primary’ or both are on ‘redundant’.

5. Inter Experiment Link (IEL)

Purpose & Design

This interface receives signals from FGM and WEC-DWP . It is not redundant.

Operational Consequences

No selection is possible

Summary of Redundancy Selection

1. The Low Power Command Interface has to be selected first if needed. If no reset are needed it is preferable to configure the OBDH/RTU I/F first and after having checked the telemetry, just configure the Low Power Command Interface by sending ‘ZECLPC2**A**’ or ‘ZECLPC2**B**’.

2. Always the same branch type has to be selected for LPC I/F and OBDH/RTU I/F, i.e. both on 'primary' or both on 'redundant'.

3. Switching from primary to redundant interfaces or vice versa, could be done at any time, leaving the CIS on.

   Note: It is necessary to configure the interface within some seconds after the reconfiguration of the spacecraft in order not to miss the spin and telemetry signals. (If the SRP is supplied in hot redundancy by the RTU this constraint does not apply – ESOC to check). If the experiment has to wait for the sun reference pulse for more than 8 seconds the CIS internal watchdog will trigger a processor reset.

Cluster - CIS

User Manual for CIS Flight Operations

4. ENVIRONMENT

4.1. THERMAL DESIGN DESCRIPTION

The 2 boxes (CIS1 and CIS2) are thermally coupled with the S/C platform. Due to the use of dampers at the feet of the CIS1 box, the conductive thermal path to the S/C platform is reduced.

4.1.1. Conditions

For normal operations, the temperature shall lie within the nominal range for CIS (-10°, + 40°) that is the range for platform mounted units.
The prefered temperature is around 20°.
To open the retractable covers of CIS1 and CIS2, the prefered temperature range is between +10° and +40°.

4.1.2. Monitoring

There are five temperature sensors in the 2 units (3 CIS powered temperature sensors and 2 S/C powered thermistors). Two extra S/C powered thermistors are located close to the CIS1 and CIS2 temperature reference feets (TRP).

Internal temperature sensors

ESOC Code	Parameter name	Type	Unit	Location
C_059	ECCTANAL	CIS1 powered temp. sensor	CIS1 (DPU)	DPU section - Low power converter and analog electronic board
C_073	ECCTELEC	CIS1 powered temp. sensor	CIS1 (CODIF)	CODIF - Digital electronic board
C_060	ECHTELEC	CIS2 powered temp. sensor	CIS2	Analog electronic board
	ECIS1__T	S/C powered	CIS1	Base plate, DPU section
	ECIS2__TT	S/C powered	CIS2	Base plate, close to amplifier board

The HK parameters are described in sections 2.2.2. and 2.2.3. and calibration curves are provided in section 2.2.4. for CIS1 and 2.2.5. for CIS2.

For S/C powered thermistors, use calibration curves provided by Dornier.

The S/C powered thermistors shall be used to monitor CIS1 and CIS2 temperatures when CIS is OFF and particularly during eclipses.

The experiment powered temperature sensors give internal temperature of each unit and should be monitored when CIS1 and CIS2 are ON.

4.1.3. Control

CIS has no active thermal control hardware. The only means for temperature control is to switch ON or OFF some sections of the instrument.

For CIS1, CODIF electronics can be switched ON or OFF (high sensitivity section, low sensitivity section, or both).

High voltages can be switched OFF in case of over heating or set to a reduced level. Normally acceleration high voltage stay ON, at the nominal level.

For CIS2, only MCP and analysers HV can be switched ON or OFF to modulate dissipated power.

For power dissipated in the different configurations, see section 4.2.

4.1.4. Procedures

Standard procedures will be used to configure the instrument in different modes.

4.1.4.1. Conditions for switch ON

CIS1 temperature shall be lower than 50°.
CIS2 temperature shall be lower than 50°.

Switch ON CIS when temperature is above than -20°.

4.1.4.2. Condition for switch OFF

Some sections of CIS shall be switched OFF when temperature is above 45°.

4.2. POWER

Each box has its own low voltage power converter.

There is no CIS internal switching of 28 V main bus power. The main and redundant lines are routed from CIS-1 to CIS-2 and separately decoupled by diodes in each unit.

CIS2 can be switched ON or OFF by memory load command.

4.2.1. Power profiles

The power dissipated in CIS depends of the configuration (high voltages ON or OFF, high-voltages setting, CODIF configuration, number of particules counted).

The following tables give a raw idea of the dissipated power in different cases.

4.2.1.1. CIS1 power profile

CIS1

FM5	HS/LS OFF	HS or LS ON	HS/LS ON
Nominal	5.31 W	6.31 W	7.31 W
Partial/Survival	6.82 W	7.82 W	8.82 W
FM6	HS/LS OFF	HS or LS ON	HS/LS ON
Nominal	5.18 W	6.18 W	7.18 W
Partial/Survival	6.60 W	7.60 W	8.60 W
FM7	HS/LS OFF	HS or LS ON	HS/LS ON
Nominal	4.62 W	5.62 W	6.62W
Partial/Survival	5.84 W	6.84 W	7.84W
FM8	HS/LS OFF	HS or LS ON	HS/LS ON
Nominal	4.72 W	5.72 W	6.72W
Partial/Survival	6.12 W	7.12 W	8.12W
FM4 (Spare)	HS/LS OFF	HS or LS ON	HS/LS ON
Nominal	4.84 W	5.84 W	6.84 W
Partial/Survival	5.92 W	6.92 W	7.92 W

4.2.1.2. CIS2 power profile

Model	Nominal	Partial	Survival
FM5	2.87 W	3.70 W	3.70 W
FM6	3.00 W	3.84 W	3.84 W
FM7	2.72 W	3.78 W	3.78 W
FM8	2.69 W	3.72 W	3.72 W
FM4(Spare)	2.64 W	3.62 W	3.62 W

4.2.2. High voltages

4.2.3. Conditions

4.2.4. Monitoring

4.2.4.1. Primary power current

The power dissipated in CIS can be monitored through 2 CIS parameters and 2 S/C parameters. The status of CIS (ON/OFF) can be monitored through 2 S/C parameters (LCL status).

CIS2 status (ON or OFF) is monitored with ECL2PWRS parameter.

ESOC Code	Parameter name	Type	Description
1J_228	PCLCISA_C	S/C parameter	CIS total current monitored at primary LCL
1J_229	PCLCISB_C	S/C parameter	CIS total current monitored at redundant LCL
1C_041	ECL1ITOT	CIS1 parameter	CIS1 total current monitored at primary side of CIS1 low power converter
1C_042	ECL2ITOT	CIS2 parameter	CIS2 total current monitored at primary side of CIS2 low power converter
1J_641		S/C parameter	LCL_A status
1J_642		S/C parameter	LCL_B status
1C_021	ECL2PWRS	CIS parameter	CIS2 powered status

4.2.4.2. CIS1/CIS2 secondary voltages

CIS1 secondary voltages are monitored in the CIS housekeepings. Detailed description of these parameters are provided in sections 2.2.2. and 2.2.3. and calibration curves in sections 2.2.4. for CIS1 and 2.2.5. for CIS2.

These parameters are:

for **CIS1-DPU section:**

ESOC Code	Parameter name		Limits
1C_043	**ECL1VP5_**	**+ 5V**	+4 to +6 V
1C_045	**ECL1VN5_**	**- 5V**	-6 to -4 V
1C_047	**ECL1VP12**	**+ 12V**	+11 to +13 V
1C_049	**ECL1VN12**	**- 12V**	-13 to -11 V

for **CIS1-CODIF electronics:**

ESOC Code	Parameter name		Limits
1C_076	**ECCAVP5_**	**+ 5V**	+3.2 to +5 V
1C_078	**ECCAVN12**	**- 5V**	-6 to -4 V
1C_079	**ECCAVP12**	**+ 12V**	+11 to +13 V

for **CIS2:**

ESOC Code	Parameter name		Limits
1C_050	**ECL1VP5_**	**+ 5V**	+4 to +6 V
1C_052	**ECL1VP12**	**+ 12V**	+11 to +13 V
1C_054	**ECL1VN12**	**- 12V**	-13 to -11 V

4.3. COMMUNICATIONS

4.3.1. Bit Rate Requirements

	block size	exact bit rate
NM1	356	5527.71 bps
NM2	420	6521.46 bps
NM3	290	4502.91 bps
BM1	278	26762.82 bps
BM2	68	6546.30 bps
BM3	306	29458.36 bps
HK	54	83.85 bps

Operational Considerations

In the nominal mode, NM1 prevails (about 80 % of time) but there are 2 other modes:

NM2 (Ion Mode - 6.521 kbits/s about 10% of time) and NM3 (Electron Mode - 4.50 kbits/s about 10 % of time).

In the special WEC/WBD TR Mode (BM2) CIS bit rate is 6.521 kbits/s as in NM2.

Same mode on all 4 S/C at a given time is considered as baselined.

Special requirements:
high speed data transmission for a defined period (TBD).

The expected time delay between transmission of a full block of housekeeping parameter is below 16s.

Preliminary operational timeline as below:

4.4. TIMING

a) Time Tagging Concept

Principle of measurement synchronisation:

All the measurements made by the detectors are spin synchronised and relative to the Sun Reference Pulse (with a fixed delay named ***phase*** = 74/1024 spin period). So, from the datation of the Sun Reference Pulse it is easy to date any event occurring during one spin period.

In addition, the delay between the Reset Pulse and the Sun Reference Pulse will be measured by the experiment and transmitted in the experiment data block.

b) Specific On-board Timing Requirement

In order to be able to have a good relation with the UT we require that the Sun Reference Pulse be dated on board with a good precision (+/- 2 ms) and that this information be transmitted to the ground in the data stream.

This information is expected to be available as auxiliary data via the ground segment.

4.5. INTERFACE TO OTHER EXPERIMENTS

Link with DWP for Reception of EFW Spacecraft Potential and Whisper Synchronisation

Purpose

CIS receives informations on the spacecraft potential from the EFW instrument. This potential can be as high as + 50 V for spacecraft in the magnetosphere and can disturb low energy plasma measurements.

CIS needs to know the spacecraft potential when making low energy ions measurements. The knowledge of this potential is very important to correct, on-board, moment computations. When the RPA mode of CODIF is used, in an option, the RPA voltages could be adapted in function of the s/c potential.

The WHISPER instrument in its investigation of plasma electron densities employs the established technique of Resonance Sounding. This requires the transmission of a radio wave over a limited time period at a fixed frequency. Eventually, natural resonances of the plasma in that frequency range will be triggered.

A Spacecraft Potential value will be transmitted one per spacecraft spin by DWP (top bit of the word set to 1). The format of the potential value (12 bits) is TBD.

Before and after each burst of WHISPER rf transmission, a word will be transmitted across the interface. The WHISPER instrument has three synchronization modes. These are Gliding, Synchronous and Continuous. These methods of synchronization are described below.

The Gliding synchronization mode divides the spin of the spacecraft into a number of equal period spin segments. Spin segment 0 starts at the Sun Reference pulse. Each spin of the spacecraft, WHISPER will only be allowed to transmit during one spin segment (the WHISPER segment). WHISPER may transmit more than one rf pulse during the WHISPER segment. The first rf pulse will be preceded by the Start Glide command, and the last rf pulse will be followed by the Stop Glide command. On the next spin of the spacecraft, the new WHISPER segment will be the segment immediately following the WHISPER segment in the last spin.

The Synchronous mode synchronizes the WHISPER rf transmissions to the voltage flyback period of the electron plate detectors. Voltage flyback occurs once, twice of four times per spin of the spacecraft. WHISPER will only transmit a single rf pulse once, twice of four times per spin, synchronised to the voltage flyback period. A Start Sychronous command is sent before the single rf pulse, and a Stop Synchronous command immediately after.

In the Continuous mode WHISPER is not synchronized with the spin of the spacecraft, and transmits rf pulses at intervals of multiples of 13.3 ms. A Start Continuous command is sent by DWP before every rf pulse, and a Stop Continuous command afterwards.

DWP will send the appropriate Start command for the mode at least 1.11 ms (TBC) before the start of the first rf pulse, and the Stop command for the mode no sooner than 1 ms (TBC) after the end of the last rf pulse.

DWP will ensure that there is an interval of at least 2 ms between the transmission of any two words to allow the receiving instrument time to recognise and read the first word.

Cluster - CIS

User Manual for CIS Flight Operations

5. COMMISSIONING

5.1. TEST EQUIPMENT AT ESOC

Two sets of equipment will be installed at ESOC in order that the CIS team be able to monitor simultaneously, data coming from 2 spacecrafts. Each set will be:

Parts description	Interface	Note
One work station, UNIX O.S.	Ethernet	
GSE - Based on a PC	RS232 38200 bauds + Ethernet	Same GSE than the one used for CIS integration/ground operations
1 colour printer		tbd
1 laser printer		tbd

5.2. INITIALIZATION OF CIS

The first turn-on of the instrument will be short and used to open the cover.
The second turn-on of the instrument will occur about some days after opening of the retractable covers to allow for adequate outgassing of the detector system. At turn-on, availability of real-time science data, to be analysed by the instrument EGSE, is mandatory. The microchannel plate counts must initially be monitored to avoid serious damage. In the first phase of the turn-on of the MCP,HVs will be slowly (i.e., over several hours) raised to operational levels. This sequence will be used also after major reconfiguration and needs on-line attendance.

The switch on sequence is the following:

5.2.1 Verification of CIS1 electronics

CIS1 power ON
At initial turn ON, CIS1 used the EEPROM software. Verification of housekeepings, mainly low power voltages and current, nominal status of CIS1 high voltages, and various status.
Switch to PROM software (diagnostic software) and repeat previous step.
Dump of PROM, EEPROM, check sum and of various tables (fix and adjustable) to get the status of the software.
Verification of DPU electronics: Check High/Low sentivity selection, Burst memory ON/OFF, RPA deflection commanding to Low/Medium/High value, RPA stepping.
Verification of Stepping high voltage commanding (Various stepping)
CODIF verification
Switch ON High sensitivity section
Initialize CODIF registers

Run a full test sequence for High Sensitivity section
Switch OFF High sensitivity section and ON Low sensitivity section
Run a full test sequence for Low Sensitivity section
Switch ON High and Low sensitivity sections
Verification of the High voltage commanding with high voltages OFF for ACC and MCPs. (DAC setting)

5.2.2. Verification of CIS2 electronics

Switch ON CIS2
At initial turn ON, CIS2 used the EEPROM software. Verification of housekeepings, mainly low power voltages and current, nominal status of CIS2 high voltages, and various status.
Switch to PROM software (diagnostic software) and repeat previous step.
Dump of PROM, EEPROM, check sum and of various tables (fix and adjustable) to get the status of the software.
Verification of CIS2 electronics: Adjust discriminator levels to the nominal value and run an amplifier test.
Verification of the MCP High voltage commanding with high voltages OFF (DAC setting).
Verification of Stepping high voltage commanding (Various stepping)

5.3. MECHANISMS - RETRACTABLE COVER

This will be done at the beginning of the operations of CIS1, after a short verification of the electronics of CIS1
Conditions:
* CIS2 OFF
* CODIF HS/LS OFF
* CIS1 operation in EEPROM
* CIS temperature higher than 0°C.

5.4. HIGH-VOLTAGES SWITCH-ON

The Hv switch on will be performed at least one week after opening the cover. It will be done after a full verification of the instrument (see 5.2.1). It will be performed using Partial Operation mode (PROM). This is described in 5.7.

5.5. TELEMETRY MODES - TESTING

After verification of the electronics of CIS in NM1, the other telemetry mode can be exercised, according to the telemetry status of the spacecraft.

5.6. IEL TESTING

For this test, the magnetometer and DWP + EFW shall be operational and so fully tested previouly

CIS will verify that data sent by these 2 units are read correctly and transmited to ground by CIS.

5.7. PROM OPERATION OF CIS1, CIS1 ALONE OR WITH CIS2

High-voltages switch ON. CIS1 and CIS2 HV activities could be done in parallele.

CIS1 :

Quasi real time monitoring is required at this level. To monitor the impact of the other HV settings, the MCP Bias Voltage is the first to be turned on. This requires though a setting of the Postacceleretion HV to 4kV to accelerate the electrons from the MCP to the signal plate. In this setting just the MCP background rates + penetrating cosmic rays should be seen when monitoring the rates.

Postacceleration (PACC) switch on,
PACC set to 4kV : monitor rates during 5 mn,
MCP set to nominal value * 0.5 : monitor rates during 5 mn,
MCP set to nominal value * 0.6 : monitor rates during 5 mn,
MCP set to nominal value * 0.7 : monitor rates during 5 mn,
MCP set to nominal value * 0.8 : monitor rates during 5 mn,
MCP set to nominal value * 0.85 : monitor rates during 1 hour,
MCP set to nominal value * 0.9 : monitor background rates wait 5 hours
MCP set to nominal value * 0.95 : monitor background rates wait 1 hour,
Sweep Hv switch on in nominal mode : monitor rates ; wait 1 day,
Sweep Hv switch off : watch for background,
MCP set to nominal value : monitor background rates wait 1 hour,
Sweep Hv switch on in nominal mode : monitor rates during 30 minutes,
Sweep Hv switch off : watch for background,
PACC set to 6kV : monitor rates during 5 mn,
PACC set to 8kV : monitor rates during 5 mn,
PACC set to 10kV : monitor rates during 5 mn,
PACC set to 12kV : monitor rates during 5 mn,
PACC set to 14kV : monitor rates during 5 mn,
PACC set to 15kV : monitor rates during 5 mn,
Sweep Hv switch on in nominal mode : monitor rates during 30 minutes,
Sweep Hv switch off ,
MCP HV to nominal value * 0.5
PACC HV to 4kV,
MCP HV to 0,

PACC HV to 0,
MCP HV OFF
PACC HV OFF

CIS2 :
PROM mode running. Discri level set to 3.00 volt.
CIS2 high-voltages switch ON
MCPs high-voltage
Set high voltage MCP to the lower value (O volt)
Switch ON MCP
Increase high-voltage slowly up to 500 volts by step of 100 volts every 5 minutes
monitor background rates.
Increase high-voltage slowly up to 1500 volts by step of 100 volts every 15 minutes.
monitor background rates. Wait for 1 hour
After 1 orbit, increase high voltage up to 2000 volts by steps of 100 volts every 15 minutes.
monitor background rates.
After 1 orbit, increase high voltage up to its nominal value by steps of 100 volts every 15 minutes.
monitor background rates
Stepping high-voltage switched ON.
Verification of steps, and currents (28V and diod).

Adjust the discri level according to the performances of MCPs and to the noise level.

5.8. CIS TESTS WITH THE OTHER CLUSTER INSTRUMENTS

For each spacecraft:

This phase will be operated after the individual commissioning of all Cluster instruments.

The CIS experiment will be on, in normal configuration, in order to look for possible effects of the other instruments, put on and off individualy and succesively. Then more scientific comparisons will be made with:

5.8.1. PEACE experiment (+ CIS)

Comparison between electron density and velocity given by PEACE and ion densities and velocities given by CIS in 3 different regions (Which ones)of the orbits of the commissioning phase.

Duration: 3 x 30 minutes/satellite on 1 orbit.

5.8.2. MAG FGM experiment (+ CIS)

Use of the MAG data, through IEL, in order to determine Pitch Angle Distribution Cuts when B field vector is in the field of view of the CODIF and HIA spectrometers and to determine CODIF remote sensing distributions.

Transmission, twice a spin, of the PAD cuts and, one a spin, of CODIF remote sensing distributions and of the MAG data used to calculate these PAD cuts and remote sensing Distributions.

Transmission of full distribution of ions to validate calculations of PADs and remote sensing Ds.

Durate: 3 x 15 minutes/satellite on 1 orbit.

5.8.3. EFW experiment (+ CIS)

Use of potential information to see the effects on CIS ion spectra.

Duration: 3 x 30 minutes/satellite on 1 orbit.

5.8.4. ASPOC experiment (+ CIS)

Search for possible effects of ASPOC on CIS ion measurements.

Duration: 3 x 30 minutes/satellite on 1 orbit.

In addition tests with maximum ASPOC emission are requested.

5.8.5. EFW + ASPOC (+ CIS)

Duration: 3 x 30 minutes/satellite on 1 orbit.

5.8.6. WHISPER (+ CIS)

Search for possible effects when WHISPER is in active operation. Tests also are requested in passive mode and if possible in permanent active mode.

Duration: 3 x (10 + 10 + 10) minutes/satellite on 1 orbit.

5.8.7. WHISPER + PEACE (+ CIS)

Comparison of electron and ion densities.

Duration: 3 x 30 minutes/satellite on 1 orbit.

5.8.8. EDI (+ CIS)

Tests with max current of EDI.

Duration: 15 minutes/satellite.

5.8.9. RAPID (+ CIS)

Intercalibration between the 2 experiments in 3 different regions of the orbits of the commissioning phase.

Duration: 3 x 30 minutes/satellite on 1 orbit.

5.9. PROCEDURES

5.9.1. GENERAL PROCEDURES

No.	Procedure	Purpose
5.9.1.1.	**CISON**	Switch CIS ON, configure interfaces according to the one selected (primary or redundant), configure CIS according to the telemetry rate at switch ON time, and verify that the status reached is the correct one
5.9.1.2.	**CISOFF**	Switches CIS OFF
5.9.1.3.	**1CVR OPEN**	CIS1 cover actuator switch ON to open the retractable cover. Normaly be used only once, during the commissioning phase
5.9.1.4.	**CIS2ON_C**	To switch CIS2 ON
5.9.1.5	**CIS2OFF**	Switches CIS2 OFF
5.9.1.6	**CIS_OFF_EMER**	Switches CIS1 and CIS2 quickly in case of emergency

5.9.2. HV OPERATIONS PROCEDURES

No.	Procedure	Purpose
5.9.2.1.	**1ANLON**	CIS1 analyser high voltage switch ON
5.9.2.2	**1ANLOF**	CIS1 analyser high voltage switch OFF
5.9.2.3.	**2ANLON**	CIS2 analyser high voltage switch ON
5.9.2.4	**2ANLOF**	CIS2 analyser high voltage switch OFF
5.9.2.5.	**1ACCON**	Switch CIS1 acceleration HV ON
5.9.2.6.	**1ACCOFF**	Switch CIS1 acceleration HV OFF
5.9.2.7.	**1MCPON**	Switch CIS1 MCP HV ON
5.9.2.8.	**1MCPOFF**	Switch CIS1 MCP HV OFF
5.9.2.9.	**2MCPON**	Switch CIS1 analyser HV ON
5.9.2.10.	**2MCPOFF**	Switch CIS2 MCP HV OFF
5.9.2.11	**1ACCSET**	CIS1 acceleration HV setting.
5.9.2.12	**1MCPSET**	CIS1 MCP HV setting
5.9.2.13	**2MCPSET**	CIS2 MCP HV setting
5.9.2.14.	**CIS1 MCPGAIN CALIB**	Verification of the gain of CODIF MCPs and of the correct setting of MCP high voltage
5.9.2.15.	**CIS2 MCPGAIN CALIB**	Verification of the gain of CIS2 MCPs and of the correct setting of MCP high voltage

5.9.3. CODIF OPERATIONS		
No.	**Procedure**	**Purpose**
5.9.3.1	**CODIF_HS_ON**	Switch ON of the high sensitivity section of the electronics of CODIF
5.9.3.2.	**CODIF_LS_ON**	Switch ON of the low sensitivity section of the electronics of CODIF
5.9.3.3.	**CODIF_HSLS_ON**	Switch ON of the low and high sensitivity sections of the elctronics of CODIF
5.9.3.4.	**CODIF_HSLS_OFF**	Switch OFF of the low and high sensitivity sections of the electronics of CODIF
5.9.3.5.	**CIS1_HS_STIMULI_SHORT**	Short test of the electronics of CODIF (CIS1 sensor), high sensitivity section
5.9.3.6.	**CIS1_LS_STIMULI_SHORT**	Short test of the low sensitivity section of the electronics of CODIF (CIS1 sensor)
5.9.3.7.	**RPA_M247S**	RPA -247V setting
5.9.3.8.	**RPA_M153S**	RPA -153V setting
5.9.3.9.	**CIS1_HS_STIMULI_LONG**	Detailed and long test of the electronics of CODIF (CIS1 sensor), high sensitivity section
5.9.3.10.	**CIS1_LS_STIMULI_LONG**	Detailed and long test of the electronics of CODIF (CIS1 sensor), low sensitivity section
5.9.3.11	**RPA_ON**	RPA voltages switched ON
5.9.3.12	**RPA_OFF**	RPA voltages switched OFF
5.9.3.13	**RPA_SET**	RPA cut-off voltage setting

5.9.4. VARIOUS		
No.	**Procedure**	**Purpose**
5.9.4.1.	**CIS2_SURVIVAL**	CIS2 software will go from nominal or partial mode to survival mode - CIS1 mode not affected
5.9.4.2.	**CIS12_SURVIVAL**	CIS1 and CIS2 softwares will go from nominal or partial mode to survival mode (prom)
5.9.4.3.	**CIS2_TO_NOMINAL**	CIS2 software will go from partial or survival mode to nominal mode.
5.9.4.4.	**CIS1_TO-NOMINAL**	CIS1 software will go from Partial or Survival modes to nominal mode
5.9.4.5.	**2SURV_TO_PART**	CIS2 software will go from Survival mode to PARTIAL mode
5.9.4.6.	**1EEPPART**	CIS1 software will go from survival to partial mode
5.9.4.7.	**1SURV_TO_PART**	CIS1 EEPROM checksum updated
5.9.4.8.	**2EEPCHK**	CIS2 EEPROM checksum update
5.9.4.9.	**1TIMEOUT**	Modify default time-out used by CIS1 for maximum delay between 2 consecutive commands of a block command (1s), in partial operation mode to increase it to 10s (default value in nominal mode)

Note: The procedures defined for nominal operations will also be used (tested) during commissioning

5.9.1. General Procedures

5.9.1.1. Procedure: CISON

Purpose: The purpose of this procedure is to switch CIS ON, to configure interfaces according to the one selected (primary or redundant), to initialise correctly configuration words, to configure CIS according to the telemetry rate at switch ON time, and to verify that the status reached is the correct one.

Description:

Initial conditons: CIS is OFF

Final Conditions: CIS is ON, interfaces correctly configured and working with the current telemetry format.

```
 ** Select which LCL will be used, and switch CIS ON
If LCL-A selected then
        send ZCISAONN                -- CIS LCL-A ON
        send ZEXEMLCZ                -- Execute Ml cmd
        wait 20 seconds
        verify LCL-A status PLCISA_A = ON
else
        send ZCISBONN                -- CIS LCL-B ON
        send ZEXEMLCZ                -- Execute Ml cmd
        wait 20 seconds
        verify LCL-B status PLCISA_A = ON
endif

** Select primary or redundant interface for low power commands
If primary lpc interface chosen then
        send ZECLPC2A        -- select primary I/F and reset CIS2
        wait 1s
        send ZECLPC1A        -- CIS1 hot reset
        record that primary lpc I/F is selected
else
        send ZECLPC2B        -- select redundant I/F and reset CIS2
        wait 1s
        send ZECLPC1B        -- CIS1 hot reset
        record that redundant lpc I/F is selected
endif
        wait 4 frames
** Select primary/redundant CIS I/F with the OBDH
send ZEC1ADMS,0

** Initialise configuration words
wait 1s
send ZEC1ADMS,0              -- Adress 0x0041
```

```
wait 1s
send ZEC1ADLS,0x41
wait 1s
send ZEC1DAMS,0             -- Data= 0x0000 -> @0x0041
wait 1s
send ZEC1MEMS,0
wait 1s
send ZEC1ADLS,0x40          -- Adress 0x0040
wait 1s
send ZEC1MEMS,0x55          -- Data= 0x0055 -> @0x0040
wait 1s
send ZEC1MDUS,0             -- Verification: Dump 1 page starting at @0040
wait 20     s                       -- Wait for transmission of dump product

** Reset CIS1 processor
If primary lpc interface selected then
        send ZECLPC1A       -- CIS1 hot reset
else
        send ZECLPC1B       -- CIS1 hot reset
endif

wait 10s

** Configure CIS according to the telemetry rate
select Tlm_rate=HKP, NM1, NM2, NM3, BM1, BM2, BM3

case "HKP"
        send ZEC1TH0S       -- configure CIS for telemetry rate HKP
case "NM1"
        send ZEC1TN1S       -- configure CIS for telemetry rate NM1
case "NM2"
        send ZEC1TN2S       -- configure CIS for telemetry rate NM2
case "NM3"
send ZEC1TN3S       -- configure CIS for telemetry rate NM3
case "BM1"
        send ZEC1TB1S       -- configure CIS for telemetry rate BM1
case "BM2"
        send ZEC1TB2S       -- configure CIS for telemetry rate BM2
case "BM3"
        send ZEC1TB3S       -- configure CIS for telemetry rate BM3
wait 20 seconds
        verify correct setting of CIS telemetry rate: ECP1TLMR
```

**** Verification of CIS status after switch ON**

```
** Verification of low power voltages and currents
+4.9V <ECL1VP5_< +5.1V              -- CIS1 DPU +5V
-5.1V <ECL1VN5_< -4.9V              -- CIS1 DPU -5V
```

+11.8V <ECL1VP12< +12.2V -- CIS1 DPU +12V
-12.2V <ECL1VN12< -11.8V -- CIS1 DPU -12V

+4.1V <ECCAVP5_< +4.4V -- CIS1 CODIF +5V
+11.8V <ECCAVP12< +12.2V -- CIS1 CODIF +12V
-5.1V <ECCAVN12< -4.9V -- CIS1 CODIF -5V

130A <EC<160mA -- CIS LCL current (total)
130mA <ECL1ITOT< 160mA -- CIS1 total current

** Verification of CIS1 status after switch ON
ECCHACCS= OFF -- acceleration HV OFF
ECCHMCPS= OFF -- MCP HV OFF
ECCHANLS= OFF -- Analyser HV OFF
-- Cover actuator status OFFECCACVRS=OFF

-- RPA voltages
ECCRN100<1volt
ECCRN153<1.5volt
ECCRN247<1volt
ECCRP220<1volt
ECCRVOUT<0.2volt

5.9.1.2. Procedure CISOFF

Purpose: Switches CIS OFF.
Description: This procedure configure CIS in order to have a correct status after the next switch ON, and finally remove power.
Constraints: This procedure can be used in **survival mode**. In case of emergency use procedure CIS_OFF_EMER.
Initial conditions: CIS is in Survival mode.
Final conditions: CIS OFF.

** In case of a watch-dog reset, CIS1 distinguishes a watch-dog reset or a hot reset from a normal switch ON, by testing the status of 2 memory addresses that are incremented and decremented in order to have always the same sommation. The addresses of these 2 words are different for nominal mode (EEPROM->@0040, @0041) and for partial operations (PROM->@2000, @2001). Normally, when CIS is OFF, these addresses are cleared and at power ON CIS knows that it is a switch ON and initialisation is different than for a watch-dog or hot reset. However we noted during the AIV phase that these 2 memory words are not always cleared when CIS is OFF, due to a residual voltage existing because CIS is still receiving the S/C signals. So, in order to have a good configuration at switch ON, it is necessary to clear these 4 memory words. It is the purpose of the following commands. **

```
wait 1s
send ZEC1ADLS,0x41              -- Adress 0x0041
wait 1s
send ZEC1ADMS,0
wait 1s
send ZEC1DAMS,0         -- Data= 0x0000 -> @0x0041
wait 1s
send ZEC1MEMS,0
wait 1s
send ZEC1ADLS,0x40      -- Adress 0x0040
wait 1s
send ZEC1MEMS,0x55      -- Data= 0x0055 -> @0x0040
wait 1s
send ZEC1MDUS,0                 -- Verification: Dump 1 page starting at @0040

wait 30s

send ZEC1ADLS,1         -- Adress 0x2001
wait 1s
send ZEC1ADMS,0x20
wait 1s
send ZEC1DAMS,0         -- Data= 0x0000 -> @0x2001
wait 1s
send ZEC1MEMS,0
wait 1s
send ZEC1ADLS,0         -- Adress 0x2000
wait 1s
```

```
send ZEC1MEMS,0x55          -- Data= 0x0055 -> @0x2000
wait 1s
send ZEC1MDUS,0                        -- Verification: Dump 1 page starting at @2000

wait 10s

** Switch OFF LCL A and B
send ZEC1AFFN, ZEXEMLCZ          -- LCL_A OFF
send YCISBFFN, ZEXEMLCY          -- LCL_B OFF
wait 20s

** Verify LCL_A et LCL_B  status
verify PLCISA_S=OFF
verify PLCISB_S=OFF
```

5.9.1.3. 1CVR_OPEN

Purpose: CIS1 cover actuator switch ON to open the retractable cover. This procedure will normaly be used only once, during the commissioning phase.
Description : This procedure will switch CIS1 cover actuator ON. After that procedure, the retractable cover shall be opened.
Constraints: The temperature of CIS1 shall be greater than 0°. Check this temperature before execution of this procedure.
Initial conditions: CIS1 cover actuator OFF (ECCACVRS = OFF)
Final conditions: CIS1 cover actuator OFF (ECCACVRS = OFF). Affected parameters are: ECCACVRS, ECCACOVR and ECL1ITOT.

** Verify initial status
ECCACVRS=OFF
ECCACOVR<50mvolt
record ECL1ITOT

** CIS1 cover actuator ON
send ZEC1CVRN
monitor ECCACOVR and ECL1ITOT
After 2 or 3 formats ECCACOVR increase to about 250mV and ECL1ITOT increase by about 40mA.
These 2 parameters go back to their initial values after 2 or 3 formats.

Wait 4 formats

** Verify intermediate status
ECCACVRS=ON
ECCACOVR<50mvolt
ECL1ITOT returned to initial value

** CIS1 cover actuator OFF
send ZEC1CVRF
wait 4 formats

** Verify final status
ECCACVRS=OFF
ECCACOVR<50mvolt
ECL1ITOT returned to initial value

In case of error execute emergency procedure : send ZEC1CVRF

5.9.1.4. Procedure: CIS2ON_C

Purpose: The purpose of this procedure is to switch CIS2 ON, and to verify that the status reached is the correct one.
Description:
Initial conditons: CIS1 should be ON - CIS2 is OFF
Final Conditions: CIS2 is ON in nominal mode with the dialog established with CIS1

**** CIS2 ON**
send ZEC1PWRN
wait 4s
**** Reset CIS2 processor after CIS2 powered ON**
If primary lpc interface selected then
send ZECLPC2A -- CIS2 reset
else
send ZECLPC2B -- CIS2 reset
endif
wait 4 formats

**** Verification of CIS2 status after switch ON**

** Verification of low power voltages and current
+4.8V <ECL2VP5_< +5.2V -- CIS2 LPC +5V
+11.7V <ECL2VP12< +12.3V -- CIS2 LPC +12V
-12.3V <ECL2VN12< -11.7V -- CIS2 LPC -12V

75mA <ECL2ITOT< 95mA -- CIS2 total current (nominal 85mA)

** Verification of digital parameter status
ECL2PWRS= ON-- CIS2 POWER ON
ECHHMCPS= OFF -- MCP HV OFF
ECHHANLS= OFF -- Analyser HV OFF
ECHACVRS=OFF -- Cover actuator status OFF
ECHATSTS=OFF --Amplifier test status OFF

** Verification of discriminators set value
4.65volt<ECHADIS1<4.9volt
4.65volt<ECHADIS2<4.9volt

5.9.1.5. Procedure: CIS2OFF

Purpose: The purpose of this procedure is to switch CIS2 OFF, and to verify that the status reached is the correct one.

Description:

Initial conditons: CIS2 is ON **in survival mode**

Final Conditions: CIS2 is OFF

**** CIS2 OFF**

send ZEC1PWRF

wait 4 formats

**** Verification of CIS2 status after switch OFF**

ECL2PWRS= OFF -- CIS2 POWER OFF

5.9.1.6. Procedure CIS_OFF_EMER

Purpose: Switches CIS OFF in case of emergency.
Description: This procedure removes simply the power by the way of the LCL A and B.
Constraints: This procedure can be used in nominal, partial or survival modes.
Initial conditions: Any
Final conditions: CIS OFF.

```
** Switch OFF LCL A and B
send ZEC1AFFN, ZEXEMLCZ        -- LCL_A OFF
send YCISBFFN, ZEXEMLCY        -- LCL_B OFF
wait 20s

** Verify LCL_A et LCL_B  status
verify PLCISA_S=OFF
verify PLCISB_S=OFF
```

5.9.2. HV Operations Procedures

5.9.2. HV OPERATIONS PROCEDURES		
No.	**Procedure**	**Purpose**
5.9.2.1.	**1ANLON**	CIS1 analyser high voltage switch ON
5.9.2.2	**1ANLOF**	CIS1 analyser high voltage switch OFF
5.9.2.3.	**2ANLON**	CIS2 analyser high voltage switch ON
5.9.2.4	**2ANLOF**	CIS2 analyser high voltage switch OFF
5.9.2.5.	**1ACCON**	Switch CIS1 acceleration HV ON
5.9.2.6.	**1ACCOFF**	Switch CIS1 acceleration HV OFF
5.9.2.7.	**1MCPON**	Switch CIS1 MCP HV ON
5.9.2.8.	**1MCPOFF**	Switch CIS1 MCP HV OFF
5.9.2.9.	**2MCPON**	Switch CIS1 analyser HV ON
5.9.2.10.	**2MCPOFF**	Switch CIS2 MCP HV OFF
5.9.2.11	**1ACCSET**	CIS1 acceleration HV setting
5.9.2.12	**1MCPSET**	CIS1 MCP HV setting
5.9.2.13	**2MCPSET**	CIS2 MCP HV setting
5.9.2.14.	**CIS1 MCPGAIN CALIB**	Verification of the gain of CODIF MCPs and of the correct setting of MCP high voltage
5.9.2.15.	**CIS2 MCPGAIN CALIB**	Verification of the gain of CIS2 MCPs and of the correct setting of MCP high voltage

5.9.2.1. Procedure: 1ANLON

Purpose : CIS1 Analyser high voltage switch ON

Description : This procedure will switch CIS1 analyser HV ON. After that, this HV will sweep.

Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".

Initial conditions: CIS1 Analyser voltage OFF (ECCHANLS = OFF).

Final conditions: CIS1 Analyser high voltage ON and sweeping according to the mode selected (ECCHANLS = ON). Affected parameters are: ECCHANLS, ECCHVANL, ECCHIANL, ECCHID_, and ECL1ITOT

** Verify initial status
ECCHANLS=OFF
ECCHVANL=-5260volt +/- 3%
ECCHIANL~= 9,6mA (this,value reflect the fact that analyser high voltage is OFF but do not reflect a real power consumption by the high voltage)
ECCHID_<0.1mA
record ECL1ITOT

** CIS1 analyser HV switch ON
send ZEC1ANLN
Wait 4 formats

** Verify HV status
verify ECCHANLS= ON
verify ECCHVANL= init_voltage +/- 10%
verify ECCHIANL= init_current +/- 10%
verify ECCHID__= init_idiod +/- 10%

In case of error execute emergency procedure: send ZEC1ANLF

Final value of high voltage parameters

Model /Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
init_voltage (V)	-5675	-5613	-5676	-5676	-5 220
init_current (mA)	1,5	1,5	1,5	1,5	1,2
init_idiod (mA)	1	1	1	1	1,2

5.9.2.2. 1ANLOF

Purpose: Switch CIS1 Analyser HV OFF
Description: This procedure switches Analyser HV OFF
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: Analyser high voltage ON, and sweeping according to the mode selected.
Final conditions: CIS1 Analyser high voltage OFF (ECCHANLS = OFF). Affected parameters are: ECCHANLS, ECCHVANL, ECCHIANL, ECCHID_, and ECL1ITOT.

** Verify initial status
ECCHANLS=ON
ECCHVANL~= -5260volt +/- 3%
ECCHIANL~=1.5mA +/- 10% (valid: this value refect the real power consumption by the analyser high voltage)
ECCHID_~=1mA +/- 10%
record ECL1ITOT

** CIS1 analyser HV switch OFF
send ZEC1ANLF
Wait 4 formats

** Verify final status
ECCHANLS=OFF
ECCHVANL: no change (-5260 volt - This housekeeping reflect the value of the control of the high voltage, not the feed back)
ECCHIANL~= 9,6mA (this value reflect the fact that analyser high voltage is OFF but do not reflect a real power consumption by the high voltage)
ECCHID_<0.1mA

In case of error execute emergency procedure : CIS_OFF_EMER

5.9.2.3. Procedure: **2ANLON**

Purpose : CIS2 Analyser high voltage switch ON

Description: This procedure will switch CIS2 analyser HV ON. After that, this HV will sweep.

Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes". HIA shall be ON.

Initial conditions: CIS2 Analyser voltage OFF (ECHHANLS = OFF).

Final conditions: CIS2 Analyser high voltage ON and sweeping according to the mode selected (ECHHANLS = ON). Affected parameters are: ECHHANLS, ECHHVANL, ECHHIANL, ECHHID_, and ECL2ITOT

** Verify initial status
ECHHANLS=OFF
ECHHVANL>-150volt
ECHHIANL~= 9,6mA (this,value reflect the fact that analyser high voltage is OFF but do not reflect a real power consumption by the high voltage)
ECHHID_<0.1mA
record ECL2ITOT

** CIS2 analyser HV switch ON
send ZEC2ANLN
Wait 6 formats

** Verify HV status
verify ECHHANLS= ON
verify ECHHVANL= init_voltage +/- 3%
verify ECHHIANL= init_current +/-10%
verify ECHHID__= init_idiod +/-10%

** In case of error execute emergency procedure: send ZEC2ANLF

Final value of high voltage parameters

Model / Parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS2-F6 clu #7	CIS2-F7 clu #8	CIS2-F4
init_voltage (V)	-5159	-5130	-4902	-5013	-4800
init_current (mA)	2,2	2,2	2,2	2,2	1,2
init_idiod (mA)	1,7	1,7	1,7	1,7	1,2

5.9.2.4. ECIST_2ANLOF

Purpose: Switch CIS2 Analyser HV OF
Description: This procedure switches Analyser HV OFF
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: Analyser high voltage ON, and sweeping according to the mode selected.
Final conditions: CIS2 Analyser high voltage OFF (ECHHANLS = OFF). Affected parameters are: ECHHANLS, ECHHVANL, ECHHIANL, ECHHID_, and ECL2ITOT.

** Verify initial status
ECHHANLS=ON
ECHHVANL~= -4900 volt +/- 3%
ECHHIANL~=2.2mA +/- 10% (valid: this value refect the real power consumption by the analyser high voltage)
ECHHID_~=1mA +/- 10%
record ECL2ITOT

** CIS2 analyser HV switch OFF
send ZEC2ANLF
Wait 6 formats

** Verify final status
ECHHANLS=OFF
ECHHIANL~= 9,6mA (this,value reflect the fact that analyser high voltage is OFF but do not reflect a real power consumption by the high voltage)
ECHHID_<0.1mA

** In case of error execute emergency procedure : send ZEC1PWRF

5.9.2.5. Procedure: 1ACCON

Purpose: Switch CIS1 acceleration HV ON
Description: This procedure initialises acceleration HV to 0 and switches it ON
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: Acceleration high voltage OFF
Final conditions: At the end, acceleration high voltage ON, at the lower value.

** Verify that acceleration HV is OFF
verify ECCHACCS= OFF
record ECL1ITOT

** Set commanded value to 0
send ZEC1ACCS,0

** Switch HV ON
send ZEC1ACCN

** Verify HV status
verify ECCHACCS= ON
verify ECCHVACC= init_voltage +/- 10%
verify ECCHIACC= init_current +/- 10%

In case of error execute emergency procedure: send ZEC1ACCF

Final value of high voltage parameters

Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
init_voltage	-1600	-1600	-1600	-1600	
init_current	1.6	1.6	1.6	1.6	

5.9.2.6. Procedure: 1ACCOFF

Purpose: Switch CIS1 acceleration HV OFF
Description:
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: Acceleration high voltage ON, at the lower value.
Final conditions: At the end, acceleration high voltage OFF.

** Verify that acceleration HV is ON
verify ECCHACCS= ON
verify ECCHVACC> -2000 Volt
record ECL1ITOT

** Switch HV OFF
send ZEC1ACCF

** Verify HV status
verify ECCHACCS= OFF

In case of error execute emergency procedure: CIS_OFF_EMER

5.9.2.7. Procedure: 1MCPON

Purpose: Switch CIS1 MCP HV ON
Description: This procedure initialises MCP HV to 0 and switches it ON
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: MCP high voltage OFF
Final conditions: At the end, MCP high voltage ON, at a low value.

** Verify that MCP HV is OFF
verify ECCHMCPS= OFF
record ECL1ITOT

** Set commanded value to 0
send ZEC1MCPS,0
wait 5s

** Switch HV ON
send ZEC1MCPN

** Verify HV status
verify ECCHMCPS= ON
verify ECCHVMCP= init_voltage +/- 10%
verify ECCHIMCP= init_current +/- 10%

In case of error execute emergency procedure: send ZEC1MCPF

Final value of high voltage parameters

Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
init_voltage	-208	-208	-208	-208	
init_current	5.2	5.2	5.2	5.2	

5.9.2.8. Procedure: 1MCPOFF

Purpose: Switch CIS1 MCP HV OFF
Description: This procedure switches MCP HV OFF
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: MCP high voltage ON at the lower value.
Final conditions: At the end, MCP high voltage OFF.

** Verify that MCP HV is ON
verify ECCHMCPS= ON
verify ECCHVMCP>-300 volt
verify ECCHIMCP< 10 mA
record ECL1ITOT

** Switch HV OFF
send ZEC1MCPF

** Verify HV status
record ECL1ITOT
verify ECCHMCPS= OFF

In case of error execute emergency procedure: CIS_OFF_EMER

5.9.2.9. Procedure: 2MCPON

Purpose: Switch CIS2 MCP HV ON
Description: This procedure initialises MCP HV to 0 and switches it ON
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes". HIA shall be ON.
Initial conditions: MCP high voltage OFF
Final conditions: At the end, MCP high voltage ON, at a low value.

** Verify that MCP HV is OFF
verify ECHHMCPS= OFF
record ECL2ITOT

** Set commanded value to 0
send ZEC2MCPS,0
wait 5s

** Switch HV ON
send ZEC2MCPN

** Verify HV status
record ECL2ITOT
verify ECHHMCPS= ON
verify ECHHVMO_= init_voltage +/- 10%
verify ECHHIMCP= init_current +/- 10%

In case of error execute emergency procedure: send ZEC2MCPF

Initial value of high voltage parameters

Model / Parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
init_voltage	-10	-10	-10	-10	-10
init_current	0.8	0.8	0.8	0.8	0.8

5.9.2.10. Procedure: 2MCPOFF

Purpose: Switch CIS2 MCP HV OFF
Description: This procedure initialise MCP HV to 0 and switch it OFF
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: MCP high voltage ON, at the lower value.
Final conditions: At the end, MCP high voltage OFF.

** Verify that MCP HV is ON
verify ECHHMCPS= ON
verify ECHHVMO_> -50volt
verify ECHHIMCP< 2 mA

record ECL2ITOT

** Switch HV OFF
send ZEC2MCPF

** Verify HV status
record ECL2ITOT
verify ECHHMCPS= OFF

In case of error execute emergency procedure: send ZEC1PWRF

5.9.2.11. Procedure: 1ACCSET

Purpose: CIS1 acceleration HV setting.
Description: This procedure modify the current setting of CIS1 acceleration HV .
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: CIS1 acceleration high voltage is set to a defined level
Final conditions: At the end, CIS1 acceleration high voltage is set at a new value.

** Verify that CIS1 acceleration HV is ON.
verify ECCHACCS = ON -- C_022
record ECL1ITOT -- C_041
record current setting:
ECCHVACC -- C_070
ECCHIACC -- C_075

** Set value to requested value
send ZEC1ACCS, $setacc -- XCIS3134

** If acceleration HV is ON, it increases or decreases slowly. So the time to reach the specified value can varie according to the difference between initial setting and final setting. So, wait for final setting.
wait delay_for_settings

** Verify HV status
record ECL1ITOT -- C_041
verify ECCHVACC= $setacc * acc-coeff +/-3% -- C_070
record ECCHIACCMCP -- C_075

Value of parameters used for this procedure

Model/ Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
acc-coeff	104.63	103.25	104.82	105,28	

5.9.2.12. Procedure: 1MCPSET

Purpose: CIS1 MCP HV setting.
Description: This procedure modify the current setting of CIS1 MCP HV .
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: CIS1 MCP high voltage is ON.????
Final conditions: At the end, CIS1 MCP high voltage is still ON, at set the new value.

** Verify that CIS1 MCP HV is ON
verify ECCHMCPS = ON
record ECL1ITOT
record current setting:
ECCHVMCP
ECCHIMCP

** Set value to requested value
send ZEC1MCPS, $setmcp1

** HV increase or decrease slowly. So the time to reach the specified value can varie according to the difference between initial setting and final setting. So, wait for final setting.
wait delay_for_settings

** Verify HV status
record ECL1ITOT
verify ECCHVMCP= $setmcp1 * mcp1-coeff +/- 3%
record ECCHIMCP

Value of parameters used for this procedure

Model/ Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
mcp1-coeff	16.722	16.259	17.922	17,964	

5.9.2.13. Procedure: 2MCPSET

Purpose: CIS2 MCP HV setting.
Description: This procedure modify the current setting of CIS2 MCP HV.
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used in "Nominal operation modes", to set CIS1 HV to the safe level.
Initial conditions: MCP high voltage ON.
Final conditions: At the end, MCP high voltage is ON, at the setting level .

** Verify thatMCP HV is ON
verify ECHHMCPS= ON
record ECL2ITOT

** Set value to requested value
send ZEC2MCPS, $setmcp2

** HV increase slowly. So the time to reach the specified value can varie according to the difference between initial setting and final setting. So, wait for final setting.
wait delay_for_settings

** Verify HV status
record ECL2ITOT -- CIS2 total current on the primary 28volt
verify ECHHVMO=$setmcp2 * mcp2-coeff+/- 3% -- HV MCP output voltage
verify ECHHVMI= $setmcp2 * mcp2-coeff +/- 3% -- HV MCP command voltage
record ECHHIMCP= mcp2_current -- HV MCP current on the 28volt

Value of parameters used for this procedure

Model/ Parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS2-F6 clu #7	CIS2-F7 clu #8	CIS2-F4
mcp2-coeff	13.675	13.67	13.678	13,675	

5.9.2.14. Procedure: CIS1_MCPGAIN_CALIB

Purpose :	Verification of the gain of CODIF MCPs and of the correct setting of MCP high voltage.
Description:	This procedure commands CODIF MCP high voltage at 5 levels around the nominal setting value
Constraints:	This procedure can be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, on a routine basis (about once per month), in "Nominal operation modes", to verify that the gain of CODIF MCPs has not decrease and that the setting of MCP high voltage is still correct.
Initial conditions:	CODIF high sensitivity and low sensitivity sections are ON. MCP high voltage is set to the nominal level and Acceleration high voltage too. CIS is in Nominal mode 15 (Calibration mode)
Final conditions:	At the end, CODIF MCP high voltage return to its nominal value.

```
** Record CIS1 current
record ECL1ITOT

**Save current setting of MCP high voltage

** Set MCP high voltage to val1 (lower value)
send ZEC1MCPS,val1
monitor ECL1ITOT    -- monitor CIS1 current (decrease)
monitor ECCHVMCP -- monitor MCP voltage
monitor ECCHIMCP   -- monitor MCP current
wait 1mn

** Set MCP high voltage to val 2
send ZEC1MCPS,val2
monitor ECL1ITOT    -- monitor CIS1 current (decrease)
monitor ECCHVMCP -- monitor MCP voltage
monitor ECCHIMCP   -- monitor MCP current
wait 1mn

** Set MCP high voltage to val 3
send ZEC1MCPS,val3
monitor ECL1ITOT    -- monitor CIS1 current (decrease)
monitor ECCHVMCP -- monitor MCP voltage
monitor ECCHIMCP   -- monitor MCP current
wait 1mn

** Set MCP high voltage to val 4 (nominal value)
send ZEC1MCPS,val4
monitor ECL1ITOT    -- monitor CIS1 current (decrease)
monitor ECCHVMCP-- monitor MCP voltage
monitor ECCHIMCP   -- monitor MCP current
wait 1mn
```

** Set MCP high voltage to val5 (higher value)
send ZEC1MCPS,val5
monitor ECL1ITOT -- monitor CIS1 current (decrease)
monitor ECCHVMCP -- monitor MCP voltage
monitor ECCHIMCP -- monitor MCP current
wait 1mn

** Set MCP high voltage to val 4 (return to nominal value)
send ZEC1MCPS,val4
monitor ECL1ITOT -- monitor CIS1 current (decrease)
monitor ECCHVMCP -- monitor MCP voltage
monitor ECCHIMCP -- monitor MCP current
wait 1mn

Value of the paramater used for commanding, according to CIS1 model #

Model/ Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
val1	80h=128d	82h=130	88h=136d	80h=128d	
val2	84h=132d	86h=134d	8Ch=140d	84h=132d	
val3	88h=136d	8Ah=138d	90h=144d	88h=136d	
val4 (nominal value)	8Ch=140d	8Eh=142d	94h=148d	8Ch=140d	
val5	90h=144d	92h=146d	98h=152d	90h=144d	

5.9.2.15. Procedure: CIS2_MCPGAIN_CALIB

Purpose:	Verification of the gain of CIS2 MCPs and of the correct setting of MCP high voltage.
Description :	This procedure command CIS2 MCP high voltage at 5 levels around the nominal setting values. For each value, the discriminator level is set to 10 value around 3.2 volts.
Constraints:	This procedure can be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, on a routine basis (about once per month), in "Nominal operation modes", to verify that the gain of CODIF MCPs has not decrease and that the setting of MCP high voltage is still correct.
Initial conditions:	HIA MCP high voltage is set to the nominal level. Analyser high voltage is ON, and sweeping. CIS is in Nominal mode 15 (Calibration mode)
Final conditions:	At the end, HIA MCP high voltage return to its nominal value.

```
** Record CIS2 current
record ECL1ITOT

**Save current setting of MCP high voltage

** Set MCP high voltage to val1 (lower value)
send ZEC2MCPS,val1
monitor ECL2ITOT          -- monitor CIS1 current (decrease)
monitor ECHHVMO_          -- monitor MCP voltage
monitor ECHHVMI_          -- monitor VH MCP control voltage
monitor ECHHIMCP          -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155        -- 2,9 volt
send ZEC2DL2S, 155        -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160        -- 3,0 volt
send ZEC2DL2S, 160        -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165        -- 3,1 volt
send ZEC2DL2S, 165        -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171        -- 3,2 volt
send ZEC2DL2S, 171        -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176         -- 3,3 volt
send ZEC2DL2S, 176        -- 3,3 volt
wait 1mn
```

```
** Set discriminator level dl6
send ZEC2DL1S, 181          -- 3,4 volt
send ZEC2DL2S, 181          -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187          -- 3,5 volt
send ZEC2DL2S, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192          -- 3,6 volt
send ZEC2DL2S, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197          -- 3,7 volt
send ZEC2DL2S, 197          -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203          -- 3,8 volt
send ZEC2DL2S, 203          -- 3,8 volt
wait 1mn

** Set MCP high voltage to val 2
send ZEC2MCPS,val2
monitor ECL2ITOT            -- monitor CIS1 current (decrease)
monitor ECHHVMO_            -- monitor MCP voltage
monitor ECHHVMI_            -- monitor VH MCP control voltage
monitor ECHHIMCP            -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155          -- 2,9 volt
send ZEC2DL2S, 155          -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160          -- 3,0 volt
send ZEC2DL2S, 160          -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165          -- 3,1 volt
send ZEC2DL2S, 165          -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171          -- 3,2 volt
send ZEC2DL2S, 171          -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176           -- 3,3 volt
send ZEC2DL2S, 176          -- 3,3 volt
wait 1mn
** Set discriminator level dl6
```

```
send ZEC2DL1S, 181          -- 3,4 volt
send ZEC2DL2S, 181          -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187          -- 3,5 volt
send ZEC2DL2S, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192          -- 3,6 volt
send ZEC2DL2S, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197          -- 3,7 volt
send ZEC2DL2S, 197          -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203          -- 3,8 volt
send ZEC2DL2S, 203          -- 3,8 volt
wait 1mn

** Set MCP high voltage to val 3
send ZEC2MCPS,val3
monitor ECL2ITOT            -- monitor CIS1 current (decrease)
monitor ECHHVMO_            -- monitor MCP voltage
monitor ECHHVMI_            -- monitor VH MCP control voltage
monitor ECHHIMCP            -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155          -- 2,9 volt
send ZEC2DL2S, 155          -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160          -- 3,0 volt
send ZEC2DL2S, 160          -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165          -- 3,1 volt
send ZEC2DL2S, 165          -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171          -- 3,2 volt
send ZEC2DL2S, 171          -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176           -- 3,3 volt
send ZEC2DL2S, 176          -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181          -- 3,4 volt
```

```
send ZEC2DL2S, 181            -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187            -- 3,5 volt
send ZEC2DL2S, 187            -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192            -- 3,6 volt
send ZEC2DL2S, 192            -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197            -- 3,7 volt
send ZEC2DL2S, 197            -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203            -- 3,8 volt
send ZEC2DL2S, 203            -- 3,8 volt
wait 1mn

** Set MCP high voltage to val 4 (nominal value)
send ZEC2MCPS,val4
monitor ECL1ITOT              -- monitor CIS1 current (decrease)
monitor ECHHVMO_              -- monitor MCP voltage
monitor ECHHVMI_              -- monitor VH MCP control voltage
monitor ECHHIMCP              -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155            -- 2,9 volt
send ZEC2DL2S, 155            -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160            -- 3,0 volt
send ZEC2DL2S, 160            -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165            -- 3,1 volt
send ZEC2DL2S, 165            -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171            -- 3,2 volt
send ZEC2DL2S, 171            -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176             -- 3,3 volt
send ZEC2DL2S, 176            -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181            -- 3,4 volt
send ZEC2DL2S, 181            -- 3,4 volt
```

```
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187          -- 3,5 volt
send ZEC2DL2S, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192          -- 3,6 volt
send ZEC2DL2S, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197          -- 3,7 volt
send ZEC2DL2S, 197          -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203          -- 3,8 volt
send ZEC2DL2S, 203          -- 3,8 volt
wait 1mn

** Set MCP high voltage to val5 (higher value)
send ZEC2MCPS,val5
monitor ECL2ITOT            -- monitor CIS1 current (decrease)
monitor ECHHVMO_            -- monitor MCP voltage
monitor ECHHVMI_            -- monitor VH MCP control voltage
monitor ECHHIMCP            -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155          - 2,9 volt
send ZEC2DL2S, 155          -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160          -- 3,0 volt
send ZEC2DL2S, 160          -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165          -- 3,1 volt
send ZEC2DL2S, 165          -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171          -- 3,2 volt
send ZEC2DL2S, 171          -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176           -- 3,3 volt
send ZEC2DL2S, 176          -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181          -- 3,4 volt
send ZEC2DL2S, 181          -- 3,4 volt
wait 1mn
```

```
** Set discriminator level dl7
send ZEC2DL1S, 187          -- 3,5 volt
send ZEC2DL2S, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192          -- 3,6 volt
send ZEC2DL2S, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197          -- 3,7 volt
send ZEC2DL2S, 197          -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203          -- 3,8 volt
send ZEC2DL2S, 203          -- 3,8 volt
wait 1mn

** Set MCP high voltage to val 4 (nominal value)
send ZEC2MCPS,val4
monitor ECL2ITOT            -- monitor CIS1 current (decrease)
monitor ECHHVMO_            -- monitor MCP voltage
monitor ECHHVMI_            -- monitor VH MCP control voltage
monitor ECHHIMCP            -- monitor MCP current
** Set discriminator level dl2 (nominal value)
send ZEC2DL1S, 160          -- 3,0 volt
send ZEC2DL2S, 160          -- 3,0 volt
```

Value of the parameter used for commanding, according to CIS2 model #

Model/ Parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS2-F6 clu #7	CIS2-F7 clu #8	CIS2-F4
val1	160 (2188v)	156 (2134v)	156 (2134v)	156 (2134v)	
val2	164 (2243v)	160 (2188v)	160 (2188v)	160 (2188v)	
val3	168 (2300v)	164 (2243v)	164 (2243v)	164 (2243v)	
val4(nominal value)	172 (2353v)	168 (2300v)	168 (2300v)	168 (2300v)	
val5	176 (2406v)	172 (2353v)	172 (2353v)	172 (2353v)	

5.9.3. CODIF Operations

5.9.3.1. Procedure: CODIF_HS_ON

Purpose : Switch ON of the high sensitivity section of the electronics of CODIF.
Description : This procedure command CODIF high sensitivity electronics ON by writing a 1 at the right address.
Constraints: This procedure is normaly used only during the commissioning phase with the PROM software (Partial operation mode), but it can also be used in "Nominal operation modes" for some specific test.
Initial conditions: CODIF high sensitivity section is normaly OFF.
Final conditions: At the end, CODIF high sensitivity section is ON. Monitor the CIS1 current increase by about 20mA.

```
** Record CIS1 current
record ECL1ITOT

** I** Switch high sensitivity section electronics ON
send ZEC1ADMS,0x02          -- Select MSB address
wait 1s
send ZEC1ADLS,0x90          -- Select LSB address
wait 1s
send ZEC1DAMS,0x00          -- Data MSB=0
wait 1s
send ZEC1IOWS,0x02          -- Data LSB=1 and write
wait 1s

** Monitor CIS1 current increase by about 35mA
verify that ECL1ITOT  increases by 35mA
verify that ECCAVP5 increases from ~4.2 volts to 4.7 volts
```

5.9.3.2. Procedure: CODIF_LS_ON

Purpose:	Switch ON of the low sensitivity section of the electronics of CODIF.
Description :	This procedure command CODIF low sensitivity electronics ON by writing a 2 at the right address.
Constraints:	This procedure is normaly used only during the commissioning phase with the PROM software (Partial operation mode), but it can also be used in "Nominal operation modes" for some specific test.
Initial conditions:	CODIF low sensitivity section is OFF.
Final conditions:	At the end, CODIF low sensitivity section is normaly ON. Monitor the CIS1 current increase by about 20mA.

```
** Record CIS1 current
record ECL1ITOT

** Switch low sentivity section electronics ON
send ZEC1ADMS,0x02      -- Select MSB address
wait 1s
send ZEC1ADLS,0x90      -- Select LSB address
wait 1s
send ZEC1DAMS,0x00      -- Data MSB=0
wait 1s
send ZEC1IOWS,0x01      -- Data LSB=2 and write
wait 1s

** Monitor CIS1 current increase by about 35mA
verify that ECL1ITOT  increases by 35mA
verify that ECCAVP5 increases from ~4.2 volts to 4.7 volts
```

5.9.3.3. Procedure: CODIF_HSLS_ON

Purpose : Switch ON of the low and high sensitivity sections of the electronics of CODIF.

Description: This procedure command CODIF low sensitivity and high sensitivity electronics ON by writing a 3 at the right address.

Constraints: This procedure is normaly used only during the commissioning phase with the PROM software (Partial operation mode), but it can also be used in "Nominal operation modes" for some specific test.

Initial conditions: CODIF low sensitivity and high sensitivity sections are normaly OFF.

Final conditions: At the end, CODIF low sensitivity and high sensitivity sections are normaly ON. Monitor the CIS1 current increase by about 40mA.

```
** Record CIS1 current
record ECL1ITOT

** Switch low sentivity and high sensitivity section electronics ON
send ZEC1ADMS,0x02        -- Select MSB address
wait 1s
send ZEC1ADLS,0x90        -- Select LSB address
wait 1s
send ZEC1DAMS,0x00        -- Data MSB=0
wait 1s
send ZEC1IOWS,0x03        -- Data LSB=3 and write
wait 1s

** Monitor CIS1 current increase by about 70mA
verify that ECL1ITOT  increases by 70mA
verify that ECCAVP5 increases from ~4.2 volts to 4.7 volts
```

5.9.3.4. Procedure: CODIF_HSLS_OFF

Purpose:	Switch OFF of the low and high sensitivity sections of the electronics of CODIF.
Description:	This procedure command CODIF low sensitivity and high sensitivity electronics OFF by writing a 0 at the right address.
Constraints:	This procedure is normaly used only during the commissioning phase with the PROM software (Partial operation mode), but it can also be used in "Nominal operation modes" for some specific test.
Initial conditions:	CODIF low sensitivity or high sensitivity section, or both are normaly ON.
Final conditions:	At the end, CODIF low sensitivity and high sensitivity sections are OFF. Monitor the CIS1 current decrease by about 20 or 40mA, depending of the case (1 or both sections ON at the begining).

```
** Record CIS1 current
record ECL1ITOT

** Switch low sentivity and high sensitivity section electronics ON
send ZEC1ADMS,0x02          -- Select MSB address
wait 1s
send ZEC1ADLS,0x90          -- Select LSB address
wait 1s
send ZEC1DAMS,0x00          -- Data MSB=0
wait 1s
send ZEC1IOWS,0x00          -- Data LSB=0 and write
wait 1s

** Monitor CIS1 current decrease
verify that ECL1ITOT  decreases by 35 or 70mA
verify that ECCAVP5 decreases from ~4.7 volts to 4.2 volts
```

5.9.3.5. Procedure: CIS1_HS_STIMULI_SHORT

Purpose: Short test of the electronic of CODIF (CIS1 sensor), high sensitivity section.

Description: This procedure will send stimulis to the input of the electronic boards at various places and various levels. This simulate particles pulses. The result is transmited to ground in the science data and indicate if the electronics is working correctly.

Constraints: This procedure willl be used during the commissioning phase in "Nominal or Partial operation modes".
This procedure shall not be used when the telemetry mode is housekeeping because verification necessitate science data.

Initial conditions: CODIF high sensitivity sections shall be ON. CIS1 shall be in "Calibration" mode (Nominal operation mode 15) or in "Partial operation" mode (#7). This gives the better telemetry products to evaluate results of this test

Final conditions: At the end, stimulis are stopped. Normal data acquisition can continue.

****Test description - short test**

```
  LONG TEST:
REGISTER DATA   OUTPUTS
                (IMMD)  (POLLED)           LOGIC MODES
                (HEX)   (DEC)    PIXEL     PIXEL DMA  POLCAL
STEP STIM CTRL  DMA     TOF POS  STIM      ADDED EVT  EVT
--- ----  ----  ---     --- ---  ----      ----  ---  ------
Init0000  0000  -       -   -    -         -     0    0  01
/* BASIC PIXEL TESTING : POLL=2 , IMMED=0
1   001F  A000  *       -   -    -         -     0    2  01
2   100C  A800  80C     012 101  PF1/PR1   -     0    2  01
3   1110  A800  91C     028 102  PF2/PR1   -     0    2  01
4   1220  A800  A62     098 104  PF3/PR1   -     0    2  01
5   1316  A800  B33     051 108  PF4/PR1   -     0    2  01
6   2419  A800  43F     063 210  PF5/PR2   -     0    2  01
7   251F  A800  55D     093 220  PF6/PR2   -     0    2  01
8   2627  A800  685     133 240  PF7/PR2   -     0    2  01
9   272F  A800  7AD     173 280  PF8/PR2   -     0    2  01
10  071F  A800  *       *   *    PF1/-     -     0    2  01
/* MODE TESTING:
11  3121  A000  *       103 302  PF2/PR1,2 -     0    0  01
12  1A23  C000  *771    113 146  PF3/PR1   PF2,7 0    0  10
13  2212  B400  *       *   *    PF3/PR2   -     1    1  01
14  3222  B400  *A6C    *108*304 PF3/PR1,2 -     1    1  01
15  1A28  C800  *78A    *139*104 PF3/PR1   PF2,7 2    0  10
16  111C  CC00  *       078 103  PF2/PR1   PF1   3    0  10
17  242A  CC00  *794    *   *    PF5/PR2   PF4   3    0  10
18  153A  CC00  *       228 130  PF6/PR1   PF5   3    0  10
19  0000  0000  *       *   *    -  /-     -     0    0  00
EXIT /* END OF SHORT TEST

* = Invalid or no data available (NUMBERS ARE FOR REV 17 ACTELS)
```

** **Initialisation HS section registers**
** Step0H - Stimuli: 0000 - Control: 0000
wait 1s send ZEC1ADMS, x02 -- Select MSB address
wait 1s send ZEC1ADLS, x4C -- Select LSB address
wait 1s send ZEC1DAMS, x00 -- Select MSB data
wait 1s send ZEC1IOWS, x00 -- Write MS_stimulation value
wait 1s send ZEC1ADLS, x4D -- Select LSB address
wait 1s send ZEC1IOWS, x00 -- Write MS_control register

**** Basic pixel testing**
** Step 1H - Stimuli: 001F - Control: A000
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00
** Step 2H - Stimuli: 100C - Control: A800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x10
wait 1s send ZEC1IOWS, x0C
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA8
wait 1s send ZEC1IOWS, x00
** Step 3H - Stimuli: 1110 - Control: A800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x10
** Step 4H - Stimuli: 1220 - Control: A800
wait 30s send ZEC1DAMS, x12
wait 1s send ZEC1IOWS, x20
** Step 5H - Stimuli: 1316 - Control: A800
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x16
** Step 6H - Stimuli: 2419 - Control: A800
wait 30s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x19
** Step 7H - Stimuli: 251F - Control: A800
wait 30s send ZEC1DAMS, x25
wait 1s send ZEC1IOWS, x1F
** Step 8H - Stimuli: 2627 - Control: A800
wait 30s send ZEC1DAMS, x26
wait 1s send ZEC1IOWS, x27
** Step 9H - Stimuli: 272F - Control: A800
wait 30s send ZEC1DAMS, x27
wait 1s send ZEC1IOWS, x2F
** Step 10H - Stimuli: 071F - Control: A800
wait 30s send ZEC1DAMS, x07

wait 1s send ZEC1IOWS, x1F

**** Mode testing**
** Step 11H - Stimuli: 3121 - Control: A000
wait 30s send ZEC1DAMS, x31
wait 1s send ZEC1IOWS, x21
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00
** Step 12H - Stimuli: 1A23 - Control: C000
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x23
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xC0
wait 1s send ZEC1IOWS, x00
** Step 13H - Stimuli: 2212 - Control: B400
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x22
wait 1s send ZEC1IOWS, x12
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xB4
wait 1s send ZEC1IOWS, x00
** Step 14H - Stimuli: 3222 - Control: B400
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x32
wait 1s send ZEC1IOWS, x22
** Step 15 H - Stimuli: 1A28 - Control: C800
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x28
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xC8
wait 1s send ZEC1IOWS, x00
** Step 16H - Stimuli: 111C - Control: CC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x1C
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xCC
wait 1s send ZEC1IOWS, x00
** Step 17H - Stimuli: 242A - Control: CC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x2A
** Step 18H - Stimuli: 153A - Control: CC00
wait 30s send ZEC1DAMS, x15
wait 1s send ZEC1IOWS, x3A

**** Return to normal operations - Stimulis OFF**
** Step 19H - Stimuli: 0000 - Control: 0000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1IOWS, x00

total duration ~10:26'
wait ~ 30s

5.9.3.6. Procedure: CIS1_LS_STIMULI_SHORT

Purpose: Short test of the low sensitivity section of the electronic of CODIF (CIS1 sensor).

Description: This procedure will send stimulis to the input of the electronic boards at various places and various levels. This simulate particles pulses. The result is transmited to ground in the science data and indicate if the electronics is working correctly.

Constraints: This procedure willl be used during the commissioning phase in "Nominal or Partial operation modes".

This procedure shall not be used when the telemetry mode is housekeeping because verification necessitate science data.

Initial conditions: CODIF low sensitivity section shall be ON. CIS1 shall be in "Calibration" mode (Nominal operation mode 15) or in "Partial operation" mode (#7). This gives the better telemetry products to evaluate results of this test

Final conditions: At the end, stimulis are stopped. Normal data acquisition can continue.

****Test description - short test:**

```
 REGISTER DATA   OUTPUTS
               (IMMD)  (POLLED)          LOGIC MODES
               (HEX)   (DEC)    PIXEL      PIXEL DMA  POLCAL
STEP STIM CTRL DMA     TOF POS  STIM       ADDED EVT  EVT
--- ----  ---- ---     --- ---  ----       ----  ---  ------
Init0000  0000 -       -   -    -          -     0    0  01
/* BASIC PIXEL TESTING : POLL=2 , IMMED=0
1   001F  A000 *       -   -    -          -     0    2  01
2   100C  A800 80C     012 101  PF1/PR1    -     0    2  01
3   1110  A800 91C     028 102  PF2/PR1    -     0    2  01
4   1220  A800 A62     098 104  PF3/PR1    -     0    2  01
5   1316  A800 B33     051 108  PF4/PR1    -     0    2  01
6   2419  A800 43F     063 210  PF5/PR2    -     0    2  01
7   251F  A800 55D     093 220  PF6/PR2    -     0    2  01
8   2627  A800 685     133 240  PF7/PR2    -     0    2  01
9   272F  A800 7AD     173 280  PF8/PR2    -     0    2  01
10  071F  A800 *       *   *    PF1/-      -     0    2  01
/* MODE TESTING:
11  3121  A000 *       103 302  PF2/PR1,2  -     0    0  01
12  1A23  C000 *771    113 146  PF3/PR1    PF2,7 0    0  10
13  2212  B400 *       *   *    PF3/PR2    -     1    1  01
14  3222  B400 *A6C    *108*304 PF3/PR1,2  -     1    1  01
15  1A28  C800 *78A    *139*104 PF3/PR1    PF2,7 2    0  10
16  111C  CC00 *       078 103  PF2/PR1    PF1   3    0  10
17  242A  CC00 *794    *   *    PF5/PR2    PF4   3    0  10
18  153A  CC00 *       228 130  PF6/PR1    PF5   3    0  10
19  0000  0000 *       *   *    -  /-      -     0    0  00
EXIT /* END OF SHORT TEST

* = Invalid or no data available (NUMBERS ARE FOR REV 17 ACTELS)
```

**** Initialisation LS section registers**
** Step0L - Stimuli: 0000 - Control: 0000
wait 1s send ZEC1ADMS, x02 -- Select MSB address
wait 1s send ZEC1ADLS, x48 -- Select LSB address
wait 1s send ZEC1DAMS, x00 -- Select MSB data
wait 1s send ZEC1IOWS, x00 -- Write LS_stimulation value
wait 1s send ZEC1ADLS, x49 -- Select LSB address
wait 1s send ZEC1IOWS, x00 -- Write LS_control register

**** Basic pixel testing**
** Step 1L - Stimuli: 001F - Control: A000
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00
** Step 2L - Stimuli: 100C - Control: A800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x10
wait 1s send ZEC1IOWS, x0C
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA8
wait 1s send ZEC1IOWS, x00
** Step 3L - Stimuli: 1110 - Control: A800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x10
** Step 4L - Stimuli: 1220 - Control: A800
wait 30s send ZEC1DAMS, x12
wait 1s send ZEC1IOWS, x20
** Step 5L - Stimuli: 1316 - Control: A800
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x16
** Step 6L - Stimuli: 2419 - Control: A800
wait 30s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x19
** Step 7L - Stimuli: 251F - Control: A800
wait 30s send ZEC1DAMS, x25
wait 1s send ZEC1IOWS, x1F
** Step 8L - Stimuli: 2627 - Control: A800
wait 30s send ZEC1DAMS, x26
wait 1s send ZEC1IOWS, x27
** Step 9L - Stimuli: 272F - Control: A800
wait 30s send ZEC1DAMS, x27
wait 1s send ZEC1IOWS, x2F
** Step 10L - Stimuli: 071F - Control: A800

wait 30s send ZEC1DAMS, x07
wait 1s send ZEC1IOWS, x1F

**** Mode testing**
** Step 11L - Stimuli: 3121 - Control: A000
wait 30s send ZEC1DAMS, x31
wait 1s send ZEC1IOWS, x21
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00
** Step 12L - Stimuli: 1A23 - Control: C000
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x23
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xC0
wait 1s send ZEC1IOWS, x00
** Step 13L - Stimuli: 2212 - Control: B400
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x22
wait 1s send ZEC1IOWS, x12
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xB4
wait 1s send ZEC1IOWS, x00
** Step 14L - Stimuli: 3222 - Control: B400
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x32
wait 1s send ZEC1IOWS, x22
** Step 15L - Stimuli: 1A28 - Control: C800
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x28
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xC8
wait 1s send ZEC1IOWS, x00
** Step 16L - Stimuli: 111C - Control: CC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x1C
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xCC
wait 1s send ZEC1IOWS, x00
** Step 17L - Stimuli: 242A - Control: CC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x2A
** Step 18L - Stimuli: 153A - Control: CC00
wait 30s send ZEC1DAMS, x15
wait 1s send ZEC1IOWS, x3A

**** Return to normal operations - Stimulis OFF**

** Step 19L - Stimuli: 0000 - Control: 0000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1IOWS, x00

total duration ~10:26'
wait ~ 30s

5.9.3.7. Procedure: RPA_M247S

Purpose: RPA -247V setting
Description: This procedure adjusts the value of deflection plate voltage N°1 (-247 volt) of the RPA section.
Parameter: It needs the value to which the deflection plate is set.
Constraints: This procedure wilL be used during the commissioning phase with the PROM software (Partial operation mode). It can also be used, in "Nominal operation modes".
Initial conditions: No particular condition required
Final conditions: At the end, CIS1 continue to operate in the same mode.

**** Variable** c_m247

** Adjust RPA deflection plate voltage N°1 (-247 volt) to the required level
send ZEC1RA1S, c_m247 -- 0 < c_m247 < 255d
wait 30s

** When RPA is ON, verify parameter ECCRN247
verify that ECCRN247 = c_m247 * p_m247 + o_m247 + ECCRVOUT +/- 3%

Nominal value of the parameter for commanding, according to CIS1 model #

Model/ Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
c_m247	121 (-245.75v)	139 (-250.43v)	118 (-244.54v)	187 (-264v)	110 (-243v)
p_m247 (volt/bit)	-0,2773	-0,27547	-0,2758	-0,2773	-0,276
o_m247 (volt)	-212,2	-211,74	-212	-212,31	-212,536

5.9.3.8. Procedure: RPA_M153S

Purpose: RPA -153V setting
Description: This procedure adjust the value of deflection plate voltage N°2 (-153 volt) of the RPA section.
Parameter: It needs the value to which the deflection plate is set.
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It can also be used, in "Nominal operation modes".
Initial conditions: No particular condition required
Final conditions: At the end, CIS1 continue to operate in the same mode.

**** Variable** c_m153, range 0-255

** Adjust RPA deflection plate voltage N°2 (-153 volt) to the required level
send ZEC1RA2S, c_m153

** When RPA is ON, verify parameter ECCRN153
verify that ECCRN153 = c_m153 * p_m153 + o_m153 + ECCRVOUT +/- 3%

Nominal value of the parameter for commanding, according to CIS1 model #

Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4
c_m153 (bit)	188 (-163,6)	169 (-160.22v)	174 (-159.52v)	202 (-166v)	120 (-152v)
p_m153 (volt/bit)	-0.1706	-0,172600	-0,158800	-0,1706	-0,170729
o_m153 (volt)	-131,520	-131,300	-131,89	-131,520	-131,524

5.9.3.9. Procedure: CIS1_HS_STIMULI_LONG

Purpose: Detailed and long test of the electronics of CODIF (CIS1 sensor), high sensitivity section.

Description: This procedure will send stimulis to the input of the electronic boards at various places and various levels. This simulate particles pulses. The result is transmited to ground in the science data and indicate if the electronics is working correctly.

Constraints: This procedure willl be used during the commissioning phase in "Nominal or Partial operation modes".

These procedure shall not be used when the telemetry mode is housekeeping because verification necessitate science data.

Initial conditions: CODIF high sensitivity sections shall be ON. CIS1 shall be in "Calibration" mode (Nominal operation mode 15). This gives the better telemetry products to evaluate results of this test

Final conditions: At the end, stimulis are stopped. Normal data acquisition can continue.

****Test description - long test:**

```
LONG TEST:
REGISTER DATA   OUTPUTS
                (IMMD)  (POLLED)             LOGIC MODES
                (HEX)   (DEC)    PIXEL       PIXEL DMA  POLCAL
STEPSTIM  CTRL  DMA     TOF POS  STIM        ADDED EVT  EVT
--- ----  ----  ---     --- ---  ----        ----  ---  ------
Init0000  0000  -       -   -    -           -     0    0  01
/* BASIC PIXEL TESTING : POLL=2 , IMMED=0
1   001F  A000  *       -   -    -           -     0    2  01
2   100C  A800  80C     012 101  PF1/PR1     -     0    2  01
3   1110  A800  91C     028 102  PF2/PR1     -     0    2  01
4   1220  A800  A62     098 104  PF3/PR1     -     0    2  01
5   1316  A800  B33     051 108  PF4/PR1     -     0    2  01
6   2419  A800  43F     063 210  PF5/PR2     -     0    2  01
7   251F  A800  55D     093 220  PF6/PR2     -     0    2  01
8   2627  A800  685     133 240  PF7/PR2     -     0    2  01
9   272F  A800  7AD     173 280  PF8/PR2     -     0    2  01
10  071F  A800  *       *   *    PF1/-       -     0    2  01
11  0000  A000  *       *   *    -  /-       -     0    0  01
/* MODE TESTING: POLL=0 , IMMED=0
12  011F  A000  *       *   *    PF2/-       -     0    0  01
13  110D  A000  910     016 102  PF2/PR1     -     0    0  01
14  2111  A000  11F     031 202  PF2/PR2     -     0    0  01
15  3121  A000  *       103 302  PF2/PR1,2   -     0    0  01
16  0517  A000  *       *   *    PF6/-       -     0    0  01
17  151A  A000  D44     068 120  PF6/PR1     -     0    0  01
18  2528  A000  58A     138 220  PF6/PR2     -     0    0  01
19  3530  A000  *       178 320  PF6/PR1,2   -     0    0  01
20  1B3E  A000  *       248 188  PF4/PR1     PF8   0    0  01
21  2C2A  A000  *794    148 218  PF5/PR2     PF4   0    0  01
22  181C  A000  *       078 111  PF1/PR1     PF5   0    0  01
23  1A38  A000  *       218 144  PF3/PR1     PF7   0    0  01
```

```
24  1314  C000  *       043 18C  PF4/PR1    PF3   0    0  10
25  1A23  C000  *771    113 146  PF3/PR1    PF2,7 0    0  10
26  1A1D  E000  *753    083 14C  PF3/PR1    PF4,7 0    0  11
27  2C34  E000  *7C6    198 138  PF5/PR2    PF4,6 0    0  11
28  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=1 , IMMED=1
29  021F  B400  *       *   *    PF3/-      -     1    1  01
30  120E  B400  A14     020 104  PF3/PR1    -     1    1  01
31  2212  B400  *       *   *    PF3/PR2    -     1    1  01
32  3222  B400  *A6C    *108*304 PF3/PR1,2  -     1    1  01
33  1618  B400  *       *   *    PF7/PR1    -     1    1  01
34  261B  B400  649     073 240  PF7/PR2    -     1    1  01
35  1329  D400  *       *   *    PF4/PR1    PF3   1    1  10
36  2431  D400  *7B7    *182*218 PF5/PR2    PF4   1    1  10
37  1A3F  D400  *       *   *    PF3/PR1    PF2,7 1    1  10
38  192B  F400  *       *   *    PF2/PR1    PF3,6 1    1  11
39  2A1D  F400  *753    *083*24C PF3/PR2    PF4,7 1    1  11
40  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=2 , IMMED=0
41  1024  A800  876     118 101  PF1/PR1    -     2    0  01
42  2034  A800  0C6     198 201  PF1/PR2    -     2    0  01
43  3018  A800  *       *   *    PF1/PR1,2  -     2    0  01
44  1426  A800  C80     128 110  PF5/PR1    -     2    0  01
45  3436  A800  *       *   *    PF5/PR1,2  -     2    0  01
46  241A  C800  *444    *073*218 PF5/PR2    PF4   2    0  10
47  1A28  C800  *78A    *139*146 PF3/PR1    PF2,7 2    0  10
48  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=3 , IMMED=0
49  1138  AC00  9DA     218 102  PF2/PR1    -     3    0  01
50  111C  CC00  *       078 103  PF2/PR1    PF1   3    0  10
51  242A  CC00  *794    *   *    PF5/PR2    PF4   3    0  10
52  153A  CC00  *       228 130  PF6/PR1    PF5   3    0  10
53  361E  AC00  *       *   *    PF7/PR1,2  -     3    0  01
54  2D2C  CC00  *79E    *158*234 PF6/PR2    PF3,5 3    0  10
55  0000  0000  *       *   *    -  /-      -     0    0  00
EXIT  /* END OF LONG TEST
* = Invalid or no data available-NUMBERS ARE FOR REV 17 ACTEL
- Logic Added Pixels will NOT show up in the Monitor Rates (from
 Rate Counters).
```

** **Initialisation HS section registers**
** Step0H - Stimuli: 0000 - Control: 0000

wait 1s	send ZEC1ADMS, x02	-- Select MSB address
wait 1s	send ZEC1ADLS, x4C	-- Select LSB address
wait 1s	send ZEC1DAMS, x00	-- Select MSB data
wait 1s	send ZEC1IOWS, x00	-- Write MS_stimulation value
wait 1s	send ZEC1ADLS, x4D	-- Select LSB address
wait 1s	send ZEC1IOWS, x00	-- Write MS_control register

**** Basic pixel testing**
** Step 1H - Stimuli: 001F - Control: A000

wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00
** Step 2H - Stimuli: 100C - Control: A800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x10
wait 1s send ZEC1IOWS, x0C
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA8
wait 1s send ZEC1IOWS, x00
** Step 3H - Stimuli: 1110 - Control: A800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x10
** Step 4H - Stimuli: 1220 - Control: A800
wait 30s send ZEC1DAMS, x12
wait 1s send ZEC1IOWS, x20
** Step 5H - Stimuli: 1316 - Control: A800
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x16
** Step 6H - Stimuli: 2419 - Control: A800
wait 30s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x19
** Step 7H - Stimuli: 251F - Control: A800
wait 30s send ZEC1DAMS, x25
wait 1s send ZEC1IOWS, x1F
** Step 8H - Stimuli: 2627 - Control: A800
wait 30s send ZEC1DAMS, x26
wait 1s send ZEC1IOWS, x27
** Step 9H - Stimuli: 272F - Control: A800
wait 30s send ZEC1DAMS, x27
wait 1s send ZEC1IOWS, x2F
** Step 10H - Stimuli: 071F - Control: A800
wait 30s send ZEC1DAMS, x07
wait 1s send ZEC1IOWS, x1F
** Step 11H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x07
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=0 , IMMED=0**
** Step 12H - Stimuli: 011F - Control: A000
wait 30s send ZEC1ADLS, x4C

wait 1s send ZEC1DAMS, x31
wait 1s send ZEC1IOWS, x21
** Step 13H - Stimuli: 110D - Control: A000
wait 30s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x0D
** Step 14H - Stimuli: 2111 - Control: A000
wait 30s send ZEC1DAMS, x21
wait 1s send ZEC1IOWS, x11
** Step 15H - Stimuli: 3121 - Control: A000
wait 30s send ZEC1DAMS, x31
wait 1s send ZEC1IOWS, x21
** Step 16H - Stimuli: 0517 - Control: A000
wait 30s send ZEC1DAMS, x05
wait 1s send ZEC1IOWS, x17
** Step 17H - Stimuli: 151A - Control: A000
wait 30s send ZEC1DAMS, x15
wait 1s send ZEC1IOWS, x1A
** Step 18H - Stimuli: 2528 - Control: A000
wait 30s send ZEC1DAMS, x25
wait 1s send ZEC1IOWS, x28
** Step 19H - Stimuli: 3530 - Control: A000
wait 30s send ZEC1DAMS, x35
wait 1s send ZEC1IOWS, x30
** Step 20H - Stimuli: 1B3E - Control: A000
wait 30s send ZEC1DAMS, x1B
wait 1s send ZEC1IOWS, x3E
** Step 21H - Stimuli: 2C2A - Control: A000
wait 30s send ZEC1DAMS, x2C
wait 1s send ZEC1IOWS, x2A
** Step 22H - Stimuli: 181C - Control: A000
wait 30s send ZEC1DAMS, x18
wait 1s send ZEC1IOWS, x1C
** Step 23H - Stimuli: 1A38 - Control: A000
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x38
** Step 24H - Stimuli: 1314 - Control: C000
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x14
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xC0
wait 1s send ZEC1IOWS, x00
** Step 25H - Stimuli: 1A23 - Control: C000
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x23
** Step 26H - Stimuli: 1A1D - Control: E000
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x1D

wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xE0
wait 1s send ZEC1IOWS, x00
** Step 27H - Stimuli: 2C34 - Control: E000
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x2C
wait 1s send ZEC1IOWS, x34
** Step 28H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=1 , IMMED=1**
** Step 29H - Stimuli: 021F - Control: B400
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x02
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xB4
wait 1s send ZEC1IOWS, x00
** Step 30H - Stimuli: 120E - Control: B400
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x12
wait 1s send ZEC1IOWS, x0E
** Step 31H - Stimuli: 2212 - Control: B400
wait 30s send ZEC1DAMS, x22
wait 1s send ZEC1IOWS, x12
** Step 32H - Stimuli: 3222 - Control: B400
wait 30s send ZEC1DAMS, x32
wait 1s send ZEC1IOWS, x22
** Step 33H - Stimuli: 1618 - Control: B400
wait 30s send ZEC1DAMS, x16
wait 1s send ZEC1IOWS, x18
** Step 34H - Stimuli: 261B - Control: B400
wait 30s send ZEC1DAMS, x26
wait 1s send ZEC1IOWS, x1B
** Step 35H - Stimuli: 1329 - Control: D400
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x29
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xD4
wait 1s send ZEC1IOWS, x00
** Step 36H - Stimuli: 2431 - Control: D400
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x31

** Step 37H - Stimuli: 1A3F - Control: D400
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x3F
** Step 38H - Stimuli: 192B - Control: F400
wait 30s send ZEC1DAMS, x19
wait 1s send ZEC1IOWS, x2B
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xF4
wait 1s send ZEC1IOWS, x00
** Step 39H - Stimuli: 2A1D - Control: F400
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x2A
wait 1s send ZEC1IOWS, x1D
** Step 40H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=2 , IMMED=0**
** Step 41H - Stimuli: 1024 - Control: A800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x10
wait 1s send ZEC1IOWS, x24
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA8
wait 1s send ZEC1IOWS, x00
** Step 42H - Stimuli: 2034 - Control: A800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x20
wait 1s send ZEC1IOWS, x34
** Step 43H - Stimuli: 3018 - Control: A800
wait 30s send ZEC1DAMS, x30
wait 1s send ZEC1IOWS, x18
** Step 44H - Stimuli: 1426 - Control: A800
wait 30s send ZEC1DAMS, x14
wait 1s send ZEC1IOWS, x26
** Step 45H - Stimuli: 3436 - Control: A800
wait 30s send ZEC1DAMS, x34
wait 1s send ZEC1IOWS, x36
** Step 46H - Stimuli: 241A - Control: C800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x1A
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xC8
wait 1s send ZEC1IOWS, x00

** Step 47H - Stimuli: 1A28 - Control: C800
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x28
** Step 48H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=3 , IMMED=0**
** Step 49H - Stimuli: 1138 - Control: AC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x38
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xAC
wait 1s send ZEC1IOWS, x00
** Step 50H - Stimuli: 111C - Control: CC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x1C
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xCC
wait 1s send ZEC1IOWS, x00
** Step 51H - Stimuli: 242A - Control: CC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x2A
** Step 52H - Stimuli: 153A - Control: CC00
wait 30s send ZEC1DAMS, x15
wait 1s send ZEC1IOWS, x3A
** Step 53H - Stimuli: 361E - Control: AC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x36
wait 1s send ZEC1IOWS, x1E
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xAC
wait 1s send ZEC1IOWS, x00
** Step 54H - Stimuli: 2D2C - Control: CC00
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x2D
wait 1s send ZEC1IOWS, x2C
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1DAMS, xCC
wait 1s send ZEC1IOWS, x00

**** Return to normal operations - Stimulis OFF**

** Step 55H - Stimuli: 0000 - Control: 0000
wait 30s send ZEC1ADLS, x4C
wait 1s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x4D
wait 1s send ZEC1IOWS, x00
wait ~ 30s

5.9.3.10. Procedure: CIS1_LS_STIMULI_LONG

Purpose: Detailed and long test of the electronics of CODIF (CIS1 sensor), low sensitivity section.

Description: This procedure will send stimulis to the input of the electronic boards at various places and various levels. This simulate particles pulses. The result is transmited to ground in the science data and indicate if the electronics is working correctly.

Constraints: This procedure willl be used during the commissioning phase in "Nominal or Partial operation modes".

These procedure shall not be used when the telemetry mode is housekeeping because verification necessitate science data.

Initial conditions: CODIF low sensitivity sections shall be ON. CIS1 shall be in "Calibration" mode (Nominal operation mode 15). This gives the better telemetry products to evaluate results of this test

Final conditions: At the end, stimulis are stopped. Normal data acquisition can continue.

****Test description - long test:**

```
LONG TEST:
REGISTER DATA   OUTPUTS
                (IMMD)  (POLLED)            LOGIC MODES
                (HEX)   (DEC)    PIXEL      PIXEL DMA  POLCAL
STEPSTIM  CTRL  DMA     TOF POS  STIM       ADDED EVT  EVT
--- ----  ----  ---     --- ---  ----       ----  ---  ------
Init0000  0000  -       -   -    -          -     0    0  01
/* BASIC PIXEL TESTING : POLL=2 , IMMED=0
1   001F  A000  *       -   -    -          -     0    2  01
2   100C  A800  80C     012 101  PF1/PR1    -     0    2  01
3   1110  A800  91C     028 102  PF2/PR1    -     0    2  01
4   1220  A800  A62     098 104  PF3/PR1    -     0    2  01
5   1316  A800  B33     051 108  PF4/PR1    -     0    2  01
6   2419  A800  43F     063 210  PF5/PR2    -     0    2  01
7   251F  A800  55D     093 220  PF6/PR2    -     0    2  01
8   2627  A800  685     133 240  PF7/PR2    -     0    2  01
9   272F  A800  7AD     173 280  PF8/PR2    -     0    2  01
10  071F  A800  *       *   *    PF1/-      -     0    2  01
11  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=0 , IMMED=0
12  011F  A000  *       *   *    PF2/-      -     0    0  01
13  110D  A000  910     016 102  PF2/PR1    -     0    0  01
14  2111  A000  11F     031 202  PF2/PR2    -     0    0  01
15  3121  A000  *       103 302  PF2/PR1,2  -     0    0  01
16  0517  A000  *       *   *    PF6/-      -     0    0  01
17  151A  A000  D44     068 120  PF6/PR1    -     0    0  01
18  2528  A000  58A     138 220  PF6/PR2    -     0    0  01
19  3530  A000  *       178 320  PF6/PR1,2  -     0    0  01
20  1B3E  A000  *       248 188  PF4/PR1    PF8   0    0  01
21  2C2A  A000  *794    148 218  PF5/PR2    PF4   0    0  01
22  181C  A000  *       078 111  PF1/PR1    PF5   0    0  01
23  1A38  A000  *       218 144  PF3/PR1    PF7   0    0  01
```

```
24  1314  C000  *       043 18C  PF4/PR1    PF3   0    0  10
25  1A23  C000  *771    113 146  PF3/PR1    PF2,7 0    0  10
26  1A1D  E000  *753    083 14C  PF3/PR1    PF4,7 0    0  11
27  2C34  E000  *7C6    198 138  PF5/PR2    PF4,6 0    0  11
28  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=1 , IMMED=1
29  021F  B400  *       *   *    PF3/-      -     1    1  01
30  120E  B400  A14     020 104  PF3/PR1    -     1    1  01
31  2212  B400  *       *   *    PF3/PR2    -     1    1  01
32  3222  B400  *A6C    *108*304 PF3/PR1,2  -     1    1  01
33  1618  B400  *       *   *    PF7/PR1    -     1    1  01
34  261B  B400  649     073 240  PF7/PR2    -     1    1  01
35  1329  D400  *       *   *    PF4/PR1    PF3   1    1  10
36  2431  D400  *7B7    *182*218 PF5/PR2    PF4   1    1  10
37  1A3F  D400  *       *   *    PF3/PR1    PF2,7 1    1  10
38  192B  F400  *       *   *    PF2/PR1    PF3,6 1    1  11
39  2A1D  F400  *753    *083*24C PF3/PR2    PF4,7 1    1  11
40  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=2 , IMMED=0
41  1024  A800  876     118 101  PF1/PR1    -     2    0  01
42  2034  A800  0C6     198 201  PF1/PR2    -     2    0  01
43  3018  A800  *       *   *    PF1/PR1,2  -     2    0  01
44  1426  A800  C80     128 110  PF5/PR1    -     2    0  01
45  3436  A800  *       *   *    PF5/PR1,2  -     2    0  01
46  241A  C800  *444    *073*218 PF5/PR2    PF4   2    0  10
47  1A28  C800  *78A    *139*146 PF3/PR1    PF2,7 2    0  10
48  0000  A000  *       *   *    -  /-      -     0    0  01
/* MODE TESTING: POLL=3 , IMMED=0
49  1138  AC00  9DA     218 102  PF2/PR1    -     3    0  01
50  111C  CC00  *       078 103  PF2/PR1    PF1   3    0  10
51  242A  CC00  *794    *   *    PF5/PR2    PF4   3    0  10
52  153A  CC00  *       228 130  PF6/PR1    PF5   3    0  10
53  361E  AC00  *       *   *    PF7/PR1,2  -     3    0  01
54  2D2C  CC00  *79E    *158*234 PF6/PR2    PF3,5 3    0  10
55  0000  0000  *       *   *    -  /-      -     0    0  00
EXIT  /* END OF LONG TEST
* = Invalid or no data available-NUMBERS ARE FOR REV 17 ACTEL
- Logic Added Pixels will NOT show up in the Monitor Rates (from
 Rate Counters).
```

** **Initialisation LS section registers**
** Step0H - Stimuli: 0000 - Control: 0000
wait 1s   send ZEC1ADMS, x02   -- Select MSB address
wait 1s   send ZEC1ADLS, x48   -- Select LSB address
wait 1s   send ZEC1DAMS, x00   -- Select MSB data
wait 1s   send ZEC1IOWS, x00   -- Write MS_stimulation value
wait 1s   send ZEC1ADLS, x49   -- Select LSB address
wait 1s   send ZEC1IOWS, x00   -- Write MS_control register

**** Basic pixel testing**
** Step 1H - Stimuli: 001F - Control: A000
wait 30s   send ZEC1ADLS, x48

wait 1s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00
** Step 2H - Stimuli: 100C - Control: A800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x10
wait 1s send ZEC1IOWS, x0C
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA8
wait 1s send ZEC1IOWS, x00
** Step 3H - Stimuli: 1110 - Control: A800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x10
** Step 4H - Stimuli: 1220 - Control: A800
wait 30s send ZEC1DAMS, x12
wait 1s send ZEC1IOWS, x20
** Step 5H - Stimuli: 1316 - Control: A800
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x16
** Step 6H - Stimuli: 2419 - Control: A800
wait 30s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x19
** Step 7H - Stimuli: 251F - Control: A800
wait 30s send ZEC1DAMS, x25
wait 1s send ZEC1IOWS, x1F
** Step 8H - Stimuli: 2627 - Control: A800
wait 30s send ZEC1DAMS, x26
wait 1s send ZEC1IOWS, x27
** Step 9H - Stimuli: 272F - Control: A800
wait 30s send ZEC1DAMS, x27
wait 1s send ZEC1IOWS, x2F
** Step 10H - Stimuli: 071F - Control: A800
wait 30s send ZEC1DAMS, x07
wait 1s send ZEC1IOWS, x1F
** Step 11H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x07
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=0 , IMMED=0**

** Step 12H - Stimuli: 011F - Control: A000
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x31

wait 1s send ZEC1IOWS, x21
** Step 13H - Stimuli: 110D - Control: A000
wait 30s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x0D
** Step 14H - Stimuli: 2111 - Control: A000
wait 30s send ZEC1DAMS, x21
wait 1s send ZEC1IOWS, x11
** Step 15H - Stimuli: 3121 - Control: A000
wait 30s send ZEC1DAMS, x31
wait 1s send ZEC1IOWS, x21
** Step 16H - Stimuli: 0517 - Control: A000
wait 30s send ZEC1DAMS, x05
wait 1s send ZEC1IOWS, x17
** Step 17H - Stimuli: 151A - Control: A000
wait 30s send ZEC1DAMS, x15
wait 1s send ZEC1IOWS, x1A
** Step 18H - Stimuli: 2528 - Control: A000
wait 30s send ZEC1DAMS, x25
wait 1s send ZEC1IOWS, x28
** Step 19H - Stimuli: 3530 - Control: A000
wait 30s send ZEC1DAMS, x35
wait 1s send ZEC1IOWS, x30
** Step 20H - Stimuli: 1B3E - Control: A000
wait 30s send ZEC1DAMS, x1B
wait 1s send ZEC1IOWS, x3E
** Step 21H - Stimuli: 2C2A - Control: A000
wait 30s send ZEC1DAMS, x2C
wait 1s send ZEC1IOWS, x2A
** Step 22H - Stimuli: 181C - Control: A000
wait 30s send ZEC1DAMS, x18
wait 1s send ZEC1IOWS, x1C
** Step 23H - Stimuli: 1A38 - Control: A000
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x38
** Step 24H - Stimuli: 1314 - Control: C000
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x14
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xC0
wait 1s send ZEC1IOWS, x00
** Step 25H - Stimuli: 1A23 - Control: C000
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x23
** Step 26H - Stimuli: 1A1D - Control: E000
wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x1D
wait 1s send ZEC1ADLS, x49

wait 1s send ZEC1DAMS, xE0
wait 1s send ZEC1IOWS, x00
** Step 27H - Stimuli: 2C34 - Control: E000
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x2C
wait 1s send ZEC1IOWS, x34
** Step 28H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=1 , IMMED=1**
** Step 29H - Stimuli: 021F - Control: B400
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x02
wait 1s send ZEC1IOWS, x1F
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xB4
wait 1s send ZEC1IOWS, x00
** Step 30H - Stimuli: 120E - Control: B400
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x12
wait 1s send ZEC1IOWS, x0E
** Step 31H - Stimuli: 2212 - Control: B400
wait 30s send ZEC1DAMS, x22
wait 1s send ZEC1IOWS, x12
** Step 32H - Stimuli: 3222 - Control: B400
wait 30s send ZEC1DAMS, x32
wait 1s send ZEC1IOWS, x22
** Step 33H - Stimuli: 1618 - Control: B400
wait 30s send ZEC1DAMS, x16
wait 1s send ZEC1IOWS, x18
** Step 34H - Stimuli: 261B - Control: B400
wait 30s send ZEC1DAMS, x26
wait 1s send ZEC1IOWS, x1B
** Step 35H - Stimuli: 1329 - Control: D400
wait 30s send ZEC1DAMS, x13
wait 1s send ZEC1IOWS, x29
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xD4
wait 1s send ZEC1IOWS, x00
** Step 36H - Stimuli: 2431 - Control: D400
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x31
** Step 37H - Stimuli: 1A3F - Control: D400

wait 30s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x3F
** Step 38H - Stimuli: 192B - Control: F400
wait 30s send ZEC1DAMS, x19
wait 1s send ZEC1IOWS, x2B
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xF4
wait 1s send ZEC1IOWS, x00
** Step 39H - Stimuli: 2A1D - Control: F400
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x2A
wait 1s send ZEC1IOWS, x1D
** Step 40H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=2 , IMMED=0**
** Step 41H - Stimuli: 1024 - Control: A800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x10
wait 1s send ZEC1IOWS, x24
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA8
wait 1s send ZEC1IOWS, x00
** Step 42H - Stimuli: 2034 - Control: A800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x20
wait 1s send ZEC1IOWS, x34
** Step 43H - Stimuli: 3018 - Control: A800
wait 30s send ZEC1DAMS, x30
wait 1s send ZEC1IOWS, x18
** Step 44H - Stimuli: 1426 - Control: A800
wait 30s send ZEC1DAMS, x14
wait 1s send ZEC1IOWS, x26
** Step 45H - Stimuli: 3436 - Control: A800
wait 30s send ZEC1DAMS, x34
wait 1s send ZEC1IOWS, x36
** Step 46H - Stimuli: 241A - Control: C800
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x1A
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xC8
wait 1s send ZEC1IOWS, x00
** Step 47H - Stimuli: 1A28 - Control: C800

wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x1A
wait 1s send ZEC1IOWS, x28
** Step 48H - Stimuli: 0000 - Control: A000
wait 30s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xA0
wait 1s send ZEC1IOWS, x00

**** Mode testing: POLL=3 , IMMED=0**
** Step 49H - Stimuli: 1138 - Control: AC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x38
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xAC
wait 1s send ZEC1IOWS, x00
** Step 50H - Stimuli: 111C - Control: CC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x11
wait 1s send ZEC1IOWS, x1C
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xCC
wait 1s send ZEC1IOWS, x00
** Step 51H - Stimuli: 242A - Control: CC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x24
wait 1s send ZEC1IOWS, x2A
** Step 52H - Stimuli: 153A - Control: CC00
wait 30s send ZEC1DAMS, x15
wait 1s send ZEC1IOWS, x3A
** Step 53H - Stimuli: 361E - Control: AC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x36
wait 1s send ZEC1IOWS, x1E
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xAC
wait 1s send ZEC1IOWS, x00
** Step 54H - Stimuli: 2D2C - Control: CC00
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x2D
wait 1s send ZEC1IOWS, x2C
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1DAMS, xCC
wait 1s send ZEC1IOWS, x00

**** Return to normal operations - Stimulis OFF**

** Step 55H - Stimuli: 0000 - Control: 0000
wait 30s send ZEC1ADLS, x48
wait 1s send ZEC1DAMS, x00
wait 1s send ZEC1IOWS, x00
wait 1s send ZEC1ADLS, x49
wait 1s send ZEC1IOWS, x00
wait ~ 30s

5.9.3.11. Procedure: RPA_ON

Purpose: RPA voltages switched ON
Description: This procedure switch RPA deflection voltages ON (-153V , -247V, -110V, +220V and RPA cut-off voltage)
Parameter: No parameter
Constraints: This procedure will be used during the commissioning phase .
Initial conditions: RPA is OFF
Final conditions: RPA is ON

verify: ECCRN100< 1volt
verify: ECCRN247< 1volt
verify: ECCRN153< 1.5volt
verify: ECCRP220< 1volt

** Switch RPA ON
send ZEC1RPAN
wait 30s

** When RPA is ON, verify parameters. RPA cut-off voltage is normally set to 0volt
verify: -103volt<ECCRN100< -97volt
verify: -280volt<ECCRN247< -210volt
verify: -180volt<ECCRN153< -125volt
verify: +217volt<ECCRP220< +223volt

5.9.3.12. Procedure: RPA_OFF

Purpose: RPA voltages switched OFF
Description: This procedure switch RPA deflection voltages OFF(-153V , -247V, -110V, +220V and RPA cut-off voltage)
Parameter: no parameter
Constraints: This procedure will be used during the commissioning phase.
Initial conditions: RPA is ON
Final conditions: RPA is OFF

verify: -280volt<ECCRN247< -190volt
verify: -180volt<ECCRN153< -125volt
verify: +217volt<ECCRP220< +248volt

man,0,0,0

** Switch RPA OFF
send ZEC1RPAF
wait 30s

** When RPA is OFF, verify parameters
verify: ECCRN100< 1volt
verify: ECCRN247< 1volt
verify: ECCRN153< 1.5volt
verify: ECCRP220< 1volt

5.9.3.13. Procedure: RPA_SET

Purpose: RPA cut-off voltage setting
Description: This procedure set the RPA cut-off voltage to the required value
Parameter: RPA cut-off voltage setting (rset), range 0-255
Constraints: This procedure will be used during the commissioning phase with the PROM software only (Partial operation mode).
Initial conditions: RPA is ON
Final conditions: RPA is ON with a new setting for RPA cut-off voltage.

** Verify that CIS1 is in partial mode and RPA is ON
verify: ECP1MOD=7
verify: ECCRN100 = -100volt + ECCRVOUT +/-3%
verify that ECCRN247 = c_247 * p_m247 + o_m247 + ECCRVOUT +/-3%
verify that ECCRN153 = c_m153 * p_m153 + o_m153 + ECCRVOUT +/- 3%
verify: ECCRP220 = +220volt + ECCRVOUT +/-3%

** Set RPA cut-off voltage; Write the value at @20FD
** Roughly RPA cut-off voltage is rfinal_set=-0.098039*rset (rset= parameter associated to command for RPA setting)
send ZEC1ADMS, 0x20 -- @msb
wait 1s; send ZEC1ADLS, 0xFD -- @lsb
wait 1s; send ZEC1DAMS, 0xC0 -- data msb (C0->decoded as RPA address)
wait 1s; send ZEC1MEMS, rset -- RPA setting (range 0-255); 255->rfinal_set=25volt
wait 1s; send ZEC1SWPS -- Sweep is computed and RPA cut-off setting too
wait 30s

** When RPA is ON, verify parameters
verify: ECCRVOUT = rset * 0.0985 +/- 3%
verify: ECCRN100 = -100volt + ECCRVOUT +/-3%
verify: ECCRN247 = c_m247 * p_m247 + o_m247 + ECCRVOUT +/-3%
verify: ECCRN153 = c_m153 * P_m153 + o_m153 + ECCRVOUT +/-3%
verify: ECCRP220 = +220volt + ECCRVOUT +/-3%

** c_m247 and c_m153 are the commanded values (bit) of RPA deflection voltages. These values shall be memorised from RPA_M247S and RPA_M153S
** For values of p_m247, o_m247, c_m153 and o_m153, see procedures RPA_M247S (5.9.3.7) and RPA_M153S (5.9.3.8).

5.9.4. Various Procedures

5.9.4.1. Procedure CIS2_SURVIVAL

Purpose: CIS2 software will go from nominal or partial mode to survival mode - CIS1 mode not affected
Description: CIS1 is configured to send the bootstrap command to CIS2 within the 3s seconds following the CIS2 reset Write x000D at I/O @x200.
Constraints: CIS1 will not be affected !
Initial conditions: nominal or partial mode of CIS2 is running
Any mode of CIS1 is running
Final conditions: CIS2 is in survival mode.
CIS1 is staying in the same mode

Note: This procedure is usually followed by procedure 2SURV_TO_PART in order to put CIS2 in partial operation mode.

** Prepare the switch for CIS2 **

send ZEC1ADLS,0
wait 1s
send ZEC1ADMS,2
wait 1s
send ZEC1DAMS,0
wait 1s

** Reset CIS2 **

If primary lpc interface chosen then

send ZECLPC2A
else
send ZECLPC2B
endif
wait 1 second (critical delay)

** CIS2 to survival mode ** This command shall be sent in a delay comprised between 0.1s and 2.9s in order to put CIS in survival mode. If this delay is exceedded, CIS2 will go to nominal mode (EEPROM). This command is sent twice with a delay of 1s and 2s for safety (see NCR CL-DOR-NC-3043).

send ZEC1IOWS,0xD

wait 1 second (critical delay)
send ZEC1IOWS,0xD

5.9.4.2. Procedure CIS12_SURVIVAL

Purpose: CIS1 and CIS2 softwares will go from nominal or partial mode to survival mode

Description:

Constraints: Both units (CIS1 and CIS2) will run in survival mode!

Initial conditions: Any modes running for CIS2 with HV set to 0 and OFF.
Any software from CIS1 is running with HV set to zero and OFF.

Final conditions: CIS1 and CIS2 are in survival mode.

```
If primary lpc interface chosen then

    send ZECLPC3A
else
    send ZECLPC3B
endif
```

5.9.4.3. Procedure CIS2_TO_NOMINAL

Purpose: CIS2 software will go from partial or survival mode to nominal mode.
Description:
Constraints: The CIS2 EEPROM checksum has to be valid
Initial conditions: Any mode of CIS2 is running
Final conditions: nominal mode of CIS2 is running

```
If primary lpc interface chosen then

    send ZECLPC2A
else
    send ZECLPC2B
endif
```

5.9.4.4. Procedure CIS1_TO_NOMINAL

Purpose:	CIS1 software will go from Partial or Survival mode to nominal mode.
Description:	
Constraints:	The CIS1 EEPROM checksum has to be valid
Initial conditions:	Partial or Survival mode of CIS1 is running
Final conditions:	Nominal mode of CIS1 is running. Restart is from current RAM tables, not from default tables, unless the @0040 and @0041 have been modified in order to get a restart from default tables.

** If it is wished that CIS1 restart using default tables, it is necessary to corrupt the indicators at @0041. Equivalent to a jump at address @8000. Address @2000 is only used when CIS restart in Partial mode (for example when the checksum is not valid).

```
send ZEC1ADMS,0x00, wait 1s
send ZEC1ADLS,0x40, wait 1s
send ZEC1DAMS,0x00, wait 1s
send ZEC1MEMS,0, wait 1s
send ZEC1ADLS,0x41, wait 1s
send ZEC1MEMS,0x55, wait 1s
```

** if not CIS1 will restart with fix and op. tables in RAM.

```
If primary lpc interface chosen then
    send ZECLPC1A
else
    send ZECLPC1B
endif
wait 2s
```

** Configure CIS according to the telemetry rate
select Tlm_rate=HKP, NM1, NM2, NM3, BM1, BM2, BM3

```
case "HKP"
    send ZEC1TH0S      -- configure CIS for telemetry rate HKP
case "NM1"
    send ZEC1TN1S      -- configure CIS for telemetry rate NM1
case "NM2"
    send ZEC1TN2S      -- configure CIS for telemetry rate NM2
case "NM3"
    send ZEC1TN3S      -- configure CIS for telemetry rate NM3
case "BM1"
    send ZEC1TB1S      -- configure CIS for telemetry rate BM1
case "BM2"
    send ZEC1TB2S      -- configure CIS for telemetry rate BM2
case "BM3"
    send ZEC1TB3S      -- configure CIS for telemetry rate BM3
end case
    wait 10 seconds
    verify correct setting of CIS telemetry rate
```

5.9.4.5. Procedure 2SURV_TO_PART

Purpose: CIS2 software will go from survival to partial operation mode. Same action as 2EEPPAR2.

Description: Jump at the begining of CIS2 partial operation software (@0386)

Constraints: CIS2 has to be in survival mode

Initial conditions: Survival mode software of CIS2 is running
Any software from CIS1 is running

Final conditions: CIS2 is in Partial Operation Prom mode.
CIS1 is staying in the same mode
After a reset, CIS2 will return in nominal mode.

* Usually, this procedure follows procedure CIS2_SURVIVAL. The purpose is then to change CIS2 mode of operation from nominal to partial.

```
send ZEC2ADLS,0x86
wait 1s
send ZEC2ADMS,0x03
wait 1s
send ZEC2JMPS,0
```

** Verify that CIS2 is now in partial operation mode

verify:ECP2SVER = 1.00

verify that ECP2CONF is updated every format

**If CIS2 is not in partial mode, but in nominal mode of operation (ECP2SVER # 1.00) then repeat the procedures CIS2_SURVIVAL and 2SURV_TO_PART (see NCR CL-DOR-NC-3043).

5.9.4.6. Procedure 1SURV_TO_PART

Purpose: CIS1 software will go from survival to partial mode
Description: Corrupt 2 words first in order to get a CIS1 restart like after a switch on (with the default fix and op. tables) and then jump to the beginning of partial operation software (@00F3).
Constraints: CIS1 shall be in survival mode
Initial conditions: Survival software of CIS1 is running
Final conditions: CIS1 is in Partial operation mode and CIS2 is OFF

** Verify that CIS1 is in survival mode
verify: ECP1CMDW= 0xDEAD
verify: ECP1CONF= 0xDEAD

** Corrupt the indicators of correct operations by writing 0x5555 at @2000 and 0x0000 at @2001

```
send  ZEC1ADMS, 0x20
wait 1s
send  ZEC1ADLS, 0
wait 1s
send  ZEC1DAMS, 0x55
wait 1s
send  ZEC1MEMS, 0x55
wait 1s
send  ZEC1ADLS, 0x01
wait  1s
send ZEC1DAMS, 0
wait 1s
send  ZEC1MEMS, 0
wait 1s
```

**Jump to the beginning of CIS1 partial operation S/W

```
send ZEC1ADMS,0
wait 1s
send ZEC1ADLS,0xF3
wait 1s
send ZEC1JMPS,0
wait 1s
```

** Verify that CIS1 is now in partial operation mode
verify: ECP1MOD E= 7 (PROM)

**If CIS1 is not in partial mode, (this may occur due to a tight timing inside CIS1), but in nominal mode of operation (ECP1MODE # 7) then repeat the procedures CIS12_SURVIVAL and 1SURV_TO_PART (see NCR CL-DOR-NC-3029). Be carreful because CIS12_SURVIVAL switches both units in survival mode.

5.9.4.7. Procedure 1EEPCHK

Purpose: CIS1 EEPROM checksum updated
Description:
Constraints: CIS1 Partial or Nominal mode is running
Initial conditions: CIS1 EEPROM checksum is invalid
Final conditions: CIS1 EEPROM checksum is valid

send ZEC1EECS

** Verification is made by resetting CIS1 (hot reset with ZECLPC1A). CIS1 shall restart in nominal mode (EEPROM software).

Warning : ZEC1EECS is reported in the current command field with the value 0001 if CIS1 is running in Partiel operation mode

ZEC1EECS is reported in the current command field with the value 0F00 if CIS1 is running in Nominal operation mode

5.9.4.8. Procedure 2EEPCHK

Purpose: CIS2 EEPROM checksum updated
Description:
Constraints: CIS2 Partial mode is running
Initial conditions: CIS2 EEPROM Checksum is invalid
Final conditions: CIS2 EEPROM Checksum is valid

send ZEC2SAVS,0

-- In partial operation mode, this command will only update CIS2 EEPROM software check-sum (do not save any table to EEPROM).

CIS2 is restarting in Nominal mode

5.9.4.9. Procedure 1TIMEOUT

Purpose: Modify default time-out used by CIS1 for maximum delay between 2 consecutive commands of a block command (1s), in partial operation mode to increase it to 10s (default value in nominal mode)

Description: Write the value of the time-out at @4616. AIV and SVT tests have shown that maximum delay between transmission by the S/C to CIS of 2 consecutives commands of a block can be larger than 1s. 10s looks fine. So before any S/W patching with CIS1 in partial op. mode, this procedure shall be used.

Constraints: CIS1 in partial operation mode

Initial conditions: Partial software (PROM) of CIS1 is running.

Final conditions: CIS1 is ready for patching S/W to CIS2 or to CIS1.

** Corrupt the indicators of correct operatons

```
send ZEC1ADMS,0x46
wait 1s
send ZEC1ADLS,0x16
wait 1s
send ZEC1DAMS,0x27
wait 1s
send ZEC1MEMS,0x10
wait 1s
```

See table "CIS Commissioning

Step 0 (1 page)
First step" (2 pages)
Second Step (5 pages)

Cluster - CIS

User Manual for CIS Flight Operations

6. NOMINAL OPERATIONS

6.1. SCOPE

This section describe the methods used to control the operation of the CIS instrument, and how the current operational mode of the instrument is reported in the telemetry.

The CIS instrument is conceived as a largely automated system. Differences in operation concern primarily the data products to be computed and transmitted to the ground. These can be changed by ground command, typically not more than four times per orbit and at positions selected well in advance. Other functions which require ground commands (less than once per orbit) include in-flight test sequences.

Occasionally it will be necessary to uplink new sections of code in order to adjust the instrument operation or data compression schemes based on experience gained in-flight. The new code will have been tested before with the simulated system and an instrument prototype. Nevertheless, proper functioning of the instrument should be verified immediately, using realtime science and housekeeping data.

6.2. GENERAL PHILOSOPHY

The Cluster spacecraft will fly through a number of different environments, and there must be a mechanism to change the mode of the instrument with a minimum number of commands when moving from one region to another. The CIS instrument has a large amount of flexibility both in the way the instrument is operated and how the data from the instrument is reduced to fit the available telemetry bandwidth. The instrument must be capable of making many changes to the operational details in response to a few commands.

Another variable which effects the instrument operation is the telemetry mode. This instrument receives a single command when the telemetry mode changes, which changes the bitrate allocation to the instrument. The instrument must respond to this by changing the telemetry collection mechanism to match the available telemetry.

In addition to these mode changes which change with telemetry rate or operational modes, there are some instrument parameters which are mode independent and which must also be programmable, such as MCP voltage.

The situation is somewhat complicated by the memory configuration of the instrument. The instrument has a small PROM, some EEPROM, and some RAM. The EEPROM contains most of the code and parameter tables. It is non-volatile, and so need not be reloaded on power-up. The RAM is used primarily for data blocks and some operational parameters. The PROM contains the bootstrap code needed to load or change the EEPROM; the EEPROM cannot be read while it is being programmed, and programming takes several milliseconds per block. The EEPROM must contain most of the operational parameters so that they do not have to be re-loaded on power-up. Anyway, it is possible to reload tables while the software is running in EEPROM. A change of mode or a reset could be necessary to have these new values taken into account. For a change in the code it is more critical because the instrument operation must be suspended. This is not desirable because it will not only interrupt the instrument operations, but will also disrupt communications.

This could cause the loss of a command.

6.3. DESCRIPTION OF MODES

6.3.1. Magnetospheric Modes:

The 2 instruments can be used with the full energy range (standard mode) or with a reduced energy range. In addition CODIF can use its **R**etarding **P**otential **A**nalyzer (RPA) to study low energy ion populations.

6.3.2. Solar Wind - Beam Modes:

The 2 instruments have a standard solar wind-beam mode. This mode in CODIF with built-in blanking of solar wind proton and alphas in the sweep is optimized for convected distributions.
HIA has also a high energy resolution mode, a high angle resolution mode, and a solar wind search mode. These last 2 modes sweep faster across the solar wind and can be used during intense solar wind fluxes to prevent MCP saturation.

All the magnetospheric and solar wind-beam modes can be accomodated with the 3 different telemetry allocations in the nominal telemetry rate (80% of time in "normal" mode (NM1), 10% in ion mode (NM2), 10% in electron mode (NM3)) and in the burst telemetry rate.

CIS has various options to choose different on-board accumulation schemes of the time, angle, energy, mass distributions in a different way into the memory. Since no hardware configuration changes and no change of the sweeping scheme as well as no change in the telemetry rate occurs, i.e. the operational interface with the S/C and data collection system remain the same, we consider that these options are not additional operational modes.

In the scientific modes the basic CIS measurements are:
- Moments of the distribution function of the ions in 3 energy bands with mass discrimination with CODIF and with high angular resolution with HIA:
- Densities,
- Ion Bulk Velocity vectors,
- Pressure tensors,
- Heat Flux vectors and tensors,
- $T_{//}$ and $T_{\perp}$.

These moments are essential mission products for collaboration.
- 3D distribution functions with flexible resolution in angle, energy, mass.
- 2D pitch angle distributions using the on board link with the magnetometer or 2D azimuthal distributions.

  3D and 2D resolutions (mass, angle, energy, time) depend on telemetry rate.

  3D and 2D distribution functions are possible mission product for collaboration.
- Mass matrix.
- Single counting rates.
- Live Pulse Height Events.

Sampling Time is 1 or 2 ms for HIA and 3.9 ms for CODIF.
The Energy Sweep period is 31.2, 62.5 or 125 ms for HIA and 125 ms for CODIF.

Example : The use of the solar wind and the magnetospheric modes is obvious: as a first cut lets suggest R > 10 RE, 9LT < local time < 15 LT for SW.

The RPA mode will be particularly usefull in the equatorial magnetosphere.
Baseline is to have identical modes on the 4 Cluster S/C.

6.3.3. Back-up Modes:

Back-up modes (still TBD) will be used in case of either sensor failure or in case of magnetometer failure.

6.3.4. In-flight Calibration (Calibration Mode):

- **CODIF sensor:**

Routinely an in-flight-calibration (IFC) pulse generator will stimulate the 2 independent TOF branches of the electronics according to a predefined program. Within this program all important functions of the sensor electronics and the subsequent onboard processing of the data can be automatically tested. Temporal variations of calibration parameter can be visualised. The in-flight calibration can also be triggered by ground command in a very flexible way, e.g. for trouble shooting purpose. In addition, the known prominent location of the proton signal eventually serves as a tracer of changes in the sensor itself.

- **HIA sensor :**

A programmable pulse generator can stimulate the 32 amplifiers under control of the processor. All important functions of the sensor and the associated onboard processing can be tested by this way. A special test mode can be implemented for health checking. This test monitors the health of the microprocessor by making ROM checksums and RAM tests. The sweeping high voltage can be tested by measuring the value of each step. For the 2 sensors, MCP gain can be checked by occasionally stepping MCP HV.
Furthermore a synthetic table can be used to verify all the products. In this case, instead of reading the counters, a table of counts corresponding to a predefined distribution function, stored in EEPROM, is read.

The calibration mode will be used:
- once every month for half an hour (every week during beginning of the mission),
- with no change in resources,
- with typically 3 additional commands (set-up and calibration ON: OFF when finished),
- with the same data format,
- with no input required and no data available for other experiments,
- with automatized inflight stimulation.

6.3.5. Other Engineering Modes:

6.3.5.1. a checkout/service mode:

- detailed diagnostic capability, enchanced housekeeping, memory dump, etc...
- needed for detailed check of instrument during early orbit phase, in case of e.g. MCP bias voltage change, in case of trouble shooting or after minor software change.
- same telemetry rate.
- power may be reduced due to controlled shut-off of various subsystems.
- no scientific data format.
- memory dump needed.
- no regular input from other experiment required.
- no data for other experiments available.
- need on line attendance.

6.3.5.2. Short test mode:

At the beginning of the operations of each new orbit a short test of the status of the experiment will be performed: RAM and ROM memory test, stepping HV and preamplifier verification ...

6.3.5.3. Save mode automatic error detection:

- only DPS on,
- error flag set.
- Survival mode (when experiment is cold in long eclipse mode):
- everything on, except HVs.

6.4. DESCRIPTION OF TABLES

6.4.1. Operational Mode Table

Each mode corresponds to a different default table in EEPROM, which is copied to the current table in RAM when selected. The location of the default tables in EEPROM is indicated in section 6.4.4.4. The format of the tables is indicated in section 6.4.4.3 (sweep modes, RPA mode, etc.).

6.4.2. Telemetry Allocation Table

Each default Operation Mode Table includes 4 Telemetry Allocation tables, one for each telemetry rate. The appropriate Telemetry Allocation Rate table is copied into the current table in RAM when the telemetry mode changes. The Telemetry Allocation Table format is a list of up to 16 entries, each of which indicates a priority (high or low - fill data), telemetry type code (7 bits) and a transmission rate (in spins; 8 bits). The telemetry type codes are defined in section 6.4.3.

6.4.3. Telemetry Rate

It is reported as a 3 bit value corresponding to the 7 spacecraft telemetry rate modes. There are only 4 distinct Telemetry Allocation Tables, as indicated:

Mode #	Telem. Alloc. Table	Name
0	None	Housekeeping Only
1	0	NM1
2	1	NM2
3	2	NM3
4	3	BM1
5	1	BM2 (same rate as NM2)
6	None	BM3 (scratch memory dump)

While in NM1 through NM3 and BM2, the instrument will simultaneously transmit formatted data to the burst memory, where it will be recorded and kept in case of an 'event'. The trigger criteria for an 'event' is defined in annex "CIS2 - FM Normal Operation Software". Playback of the data recorded in the scratch memory is either via BM3 or by slow playback using a fraction of the telemetry. When enabled to playback using normal telemetry, this will be accomplished by dropping the telemetry allocation to table 0 (NM1 rate), and using mode 15 after having set the flag at address C195 hex at a non zero value. When playback is enabled, and a burst is available in the scratch memory, the 'Playback' bit will come on in the telemetry rate housekeeping.

6.4.4. CIS1-Tables

In EEPROM, the Fixed Table contains a "Table Version Number" which starts at zero at launch, and will be increased each time the Fixed or Operation default tables are modified in EEPROM with command ZEC1SAVS. Eight bits are allocated for this in the housekeeping telemetry, allowing 256 versions. In case of modification of the telemetry allocation tables, this counter shall be incremented by memory load command.

In RAM, there are two modification counters; one for the Fixed Table and one for the Operational Mode table. The modification counters are automatically incremented every time the associated current table in RAM is modified by command. Modification counters are set to zero when a new table is loaded, on processor reset for both counters, and also when a new operational mode is selected (only Operational Mode table modification counter).

6.4.4.1. CIS1: Fixed Table (in RAM)

The Fixed Table in RAM contains parameters which do not change with the Operating Mode. The Fixed Table has a modification counter, which is incremented with each automatic change to the table via command effect (e.g., ZEC1CVRN). The table ends with a checksum which is the 16-bit arithmetic sum of the words beginning with the "CIS control bit flags" and ending with the word preceding the checksum. In case of modification by block command or by using ZEC1MEMS, it is the responsibility of the user to increase the modification counter and to recompute and modify the checksum, using command ZEC1MEMS. When a command affecting the fix table is received, the checksum is not fully computed but only take care of the word which is modified. If a manual modification was done previouly and checksum not corrected, the final checksum will still be wrong. The mechanism is reversed for CIS2 (checksum is fully computed when a command modify the fixed table).

6.4.4.2. CIS1: Default Fixed Table (in EEPROM)

The Default Fixed Table contains initial parameters for the Fixed Table (see above).

When the telemetry rate is changed by command, it is written in the fixed table (word 0Bh). The checksum is calculated and stored. If the table is then saved, it will contain the current telemetry mode. It is necessary to save the table when CIS is in the desired default telemetry mode after a reset.

see table " CIS1: Default Fixed Table in EEPROM" at the following page.

CIS1: DEFAULT FIXED TABLE IN EEPROM

Description *Begining address: @= C000h*	*Offset relative to beg. @ offset=[xxh]*	** ECP1CONF offset =[##h]*	*Detailed description*	*Configuration for launch and commissioning*	*Configuration for nominal operations (assumed)***
Table modification counter	00h	echo in HK	Tables version (Op.and fix tables). This word is not realy part of the fix table (not included to compute checksum)	Bit 15-0= 0	+1 every change
CIS control bit flags	01h	00h	Bit 3: CIS2 Power (n.b. 0=on; 1=off) Bit 2: Anal HV stepping enable (1=on) Bit 1: RPA HV enable (1=on) Bit 0 (LSb) Cover enable (1=on) Bit 15-4 unused	Bit 3= 1 (off) Bit 2= 0 (off) Bit 1= 0 (off) Bit 0= 0 (off) Bit 15-0= 0008h	Bit 3= 0 (on) Bit 2= 1 (on) Bit 1= 1 (on) Bit 0= 1 (on) Bit 15-0= 0007h
MCP/PACC HV control bit flags & tracking authorisation	02h	01h	Bit 15 (MSb): Enable PACC HV tracking via hkp Bit 14:Enable MCP HV tracking via hkp Bit 13-8 unused Bit 7-4: PACC HV enable control (x111z = on, x000z = off) Bit 3-0 (LSb): MCP HV enable control (x111z = on, x000z = off)	Bit 15= 0 (off) Bit 14= 0 (off) Bit 7-4= 0000z (off) Bit 3-0= 0000z (off) Bit 15-0= 0000h	Bit 15= 1 (on) Bit 14= 1 (on) Bit 7-4= 0111z (on) Bit 3-0= 0111z (on) Bit 15-0=C077h
PACC and MCP HVs maximum settings	03h	19h	Bit 15-8= maximum setting for PACC HV Bit 7-0 = maximum setting for MCP HV	model dependant	model dependant
CODIF Proton Suppression and H/L Sensitivity bit flags	04h	0Fh	Bit 1: Analyzer Sensitivity (1=high, 0=low) Bit 0 (LSb): Proton Suppression (1=on, 0=off) Bit 15-2 unused	Bit 1= 0 (low) Bit 0= 0 (off) Bit 15-0= 0003h	Bit 1= 1 (high) Bit 0= 1 (on) Bit 15-0= 0003h
CODIF H&L Power Control bit flags	05h	10h	Bit 1: High Sensitivity Power (1 = on, 0 = off) Bit 0 (LSb): Low Sensitivity Power (1 = on, 0 = off) Bit 15-2 unused	Bit 1= 0 (off) Bit 0= 0 (off) Bit 15-0= 0000h	Bit 1= 1 (on) Bit 0= 1 (on) Bit 15-0= 0003h
MCP HV desired setting	06h	02h	Bit 15-8 unused Bit 7-0 = MCP HV setting Max MCP HV = FFh = 5120 V, Min MCP HV = 01h=20V???	Bit 15-8= 00h Bit 7-0= 00h	Bit 15-8= 00h Bit 7-0 model dependant
MCP HV rate of change (+/-1 every n ms)	07h	03h	Bit 15-0 range 0-65535 n= nms	Bit 15-0= 20000 (20s)	Bit 15-0 = 5000 (5s)
PACC HV desired setting	08h	04h	Bit 15-8 unused Bit 7-0 = PACC HV setting Min PACC HV = 01h = 100 V, Max PACC HV = FFh = 25,600 V	Bit 15-8= 00h Bit 7-0= 00h	Bit 15-8= 00h Bit 7-0 model dependant
PACC HV rate of change (+/-1 every n ms)	09h	05h	Bit 15-0 range 0-65535 nbit = nms	Bit 15-0= 20000 (20s)	Bit 15-0 5000 (5s)
Spin phase (1/1024ths of spin)	0Ah	06h	Bit 15-8 unused Bit 7-0 = range 0 to 255	Bit 15-8 = 00h Bit 7-0= 4Bh	Bit 15-8= 00h Bit 7-0= 4Bh

			Nominal value= 26.367° è 75d		
Sector Mode (shall be 1)	0Bh	07h	0000h = sector/spin = 512, HV_sector/spin = 2048 (1:4) 0001h = sector/spin = 1024, HV sector/spin = 4096 (1:4) 0002h = sector/spin = 2048, HV sector/spin = 4096 (1:2) 0003h = sector/spin = 2048, HV sector/spin = 8192 (1:4)	Bit 15-0= 0001h (mode 1)	Bit 15-0= 0001h (mode 1)
Telemetry rate/Operating mode after reset	0Bh	08h	Bit 10-8= telemetry rate - default tlm rate= NM1= 1 Bit 15-11 and 7-4 unused Bit 3-0 = range 0 to 15 - default= mode 0	Bit 15-0 = 0100h	Bit 15-0 = 0100h
model number	OCh		Bit 3-0 = range 4 to 8	Bit 15-4=0000h	Bit 15-4=0000h
Spare word 1	0Dh			Bit 15-0=0000h	Bit 15-0=0000h
Spare word 2	0Eh			Bit 15-0=0000h	Bit 15-0=0000h
Spare word 3	0Fh			Bit 15-0=0000h	Bit 15-0=0000h
Default fixed table checksum (EEPROM)	10h	09h			

- Fixed table in RAM - beg. address: fx_t = @127Ah

*This Fixed Table is transmitted to ground in the subcommutated word ECP1CONF of the CIS housekeepings (see description in section 2.2.9).

[##h] = Offset / first word (Offset= 5 LSbits of frame counter)

** These values can be modified according to the results of commissioning tests

6.4.4.3. CIS1: Operating Mode Table (in RAM)

A Default Operating Table exist for each of the 15 implemented operating modes of operation. When the mode is changed, the corresponding Default Operating Table is first copied into the RAM operating table. Then the modification counter is set to 0. The RAM table ends with a checksum which is the 16-bit arithmetic sum of the words beginning with N°0 and ending with N°14. The beginning of this table is at **om_t = @128Bh**

[##h] = Hkp parameter ECP1CONF Offset (5 LSbits of frame counter = Offset)

Fields in the Operating Mode Table

N° (offset)	Description	ECP1CONF [##h]
0	Pointer to normal sweep generation parameter table	[0Ah]
1	Pointer to alternate sweep generation parameter table.	
2	Alt sweep use index mask, 31-16	*
3	Alt sweep use index mask, 15-0	*
4	NM1 Telemetry Allocation Table pointer	[0Bh]
5	NM2,BM2 Telemetry Allocation Table pointer	[0Ch]
6	NM3 Telemetry Allocation Table pointer	[0Dh]
7	BM1 Telemetry Allocation Table pointer	[0Eh]
8	RPA -247V setting	[11h]
9	RPA -153V setting	[12h]
10	Moment Energy Table pointer	
11	Moment Alternate Energy Table pointer	
12	K1 compression factor	
13	K1 compression factor	
14	spare word	
15	Operating Mode Table checksum (sum of the 15 words above)	[13h]

These 2 words are used to modify the analyser HV sweep in front of the solar wind, in the solar wind modes. The position is given using a phase of 0 (start of the acquisition with the spin pulse). The software is computing the exact position of the solar wind taking into account the value of the phase.

Each bit of the words n°2 and 3 corresponds to one sweep of the analyser HV(32 sweeps per spin) . When this bit is set to 0, the corresponding sweep table used is the nominal one. When it is set to one, the corresponding sweep table used is the alternate one. By this way, it is possible to have a different energy sweep in front of the solar wind and elsewhere.

Following this table, some other miscellaneous parameters are also read out in ECP1CONF parameter: see description of ECP1CONF section 2.2.9.

6.4.4.4. CIS1: Default Operating Tables (in EEPROM)

A Default Operating Mode Table exist for each of the 15 implemented operating modes of operation, including the same parameters (168 words) than in the RAM operating table. The addresses of these tables are indicated below (S/W version 233, 234, 235).

Mode #	Name / Description	Address of the associated mode table (Step of 16 words)
0	Solar Wind 1	C022h
1	Solar Wind 2	C032h
2	Solar Wind 3	C042h
3	Solar Wind 4	C052h
4	Solar Wind Compressed 1	C062h
5	Solar Wind Compressed 2	C072h
6	RPA	C082h
7	Partial mode (prom operations) No mode change if nominal mode (EEPROM)	
8	Magnetosphere 1	C092h
9	Magnetosphere 2	C0A2h
10	Magnetosphere 3	C0B2h
11	Magnetosphere 4	C0C2h
12	Magnetosphere 5	C0D2h
13	Magnetosphere Compressed 1	C0E2h
14	Magnetosphere Compressed 2	C0F2h
15	Calibration	C102h

6.4.5. CIS2-Tables

6.4.5.1. CIS2 EEPROM Nominal Operations - RAM Fixed Table

The Cis-2 experiment operative sub-modes 0..15 maps to a smaller number of operating 0..4 modes set, according to the following cross reference table:

Sub Mode no.	TYPE	Cis-2 internal mode
0	Solar wind / SW priority	0
1	Solar wind / 3D Ions priority	0
2	Solar wind / SW priority	0
3	Solar wind / 3D Ions priority	0
4	Comprression SW-1	2
5	Comprression SW-2	2
6	Mag2	1
7	Survival (Prom) or Mag1	1
8	Magnetophere 1	1
9	Magnetophere 2	1
10	Magnetophere 3	1
11	Magnetophere 4 Sheath/Tail	1
12	Magnetophere 5 Sheath/Tail	1
13	Compression Mag3Ds-1	3
14	Compression Mag3Ds-2	3
15	Calibration	4

6.4.5.2. CIS2: Current and Default Fixed Table

The Fixed Table in RAM contains parameters which do not change with the Operating Mode. The Fixed Table has a modification counter, which is automatically incremented with each change to the table via command effect (e.g., ZEC2CVRN). The table ends with a checksum which is the 16-bit arithmetic sum of the words beginning with offst=01h and ending with offst= 0Ch

In case of modification by block command, it is the responsibility of the user to increase the modification counter and to recompute and modify the checksum, using block comand. When a command affecting one of the tables is received, the checksum is fully recomputed.

The Default Fixed Table (in EEPROM) *(see table "CIS2: Default Fixed Table in EEPROM" at the following page)* contains initial parameters for the RAM Fixed Table (see above). The Fixed table in EEPROM is starting at address @B801 (table version) and ending at address @B80D (checksum). It is followed by the 4 sub-fix tables starting at address @B80E.

The Fixed table in RAM is starting at address @00A0 (table version) and ending at address @00AC (checksum). It is followed by the sub-fix table starting at address @00AD. The Table Version value is incremented whenever the tables (fixed and operative) are saved from RAM to EEPROM.

CIS2: DEFAULT FIXED TABLE IN EEPROM

Description	*Offset relative to @ offset=[xxh]*	** ECP2CONF offset =[##h]*	*Detailed description,* bit allocation and meaning	*Configuration for launch and commissioning*	*Configuration for nominal operations*
Fixed Table Ver. no.	0 (@=B801h)	0		Bit 15-0 = 0	Bit 15-0 = variable
Instrument Default Configuration	1	1	Bit 15-12 and 7-0 unused Bit 11: Amplifier test On/Off flag (0=off, 1=ON) Bit 10: Analyzer On/Off flag (0=off, 1=ON) Bit 9: Mcps HV On/Off flag (0=off, 1=ON) Bit 8: (LSb) Cover Status flag (0=off, 1=ON)	Bit 15-12 and 7-0 =0 Bit 11=0 (off) Bit 10 =0 (off) Bit 9 =0 (off) Bit 8 =0 (off)	Bit 15-12 and 7-0 = 0 Bit 11= 0 (off) Bit 10 =1 (on) Bit 9 =1 (on) Bit 8 = 0 (off)
MCPs High Voltage Setting	2	2	Bit 15-8 unused Bit 8-0 range 0-200	Bit 15-8 = 00h Bit 7-0 = 0 (0 volt)	Bit 15-8 = 00h Bit 7-0 = 124d (1696 volt) apogee: 124d (1696 volt) perigee: 88d (1203 volt)
MCPs rising delay	3	3	Bit 15-0 range 0-65535 (2.5ms/bit)	Bit 15-0= 8000d (20s)	Bit 15-0 = 2000d (5s)
Discriminator 1 treshold (large GF)	4	4	Bit 15-8 unused Bit 8-0 range 0-255 (0,01875 volt/bit)	Bit 15-8 = 00h Bit 7-0 = 255d (4,78 volt)	Bit 15-8 = 00h Bit 7-0 = 160d (3 volt)
Discriminator 2 treshold (small GF)	5	5	Bit 15-8 unused Bit 8-0 range 0-255 (0,01875 volt/bit)	Bit 15-8 = 00h Bit 7-0 = 255 (4,78 volt)	Bit 15-8 = 00h Bit 7-0 = 160 (3 volt)
Default boot operational mode (sub mode)	6	6	Bit 15-4 unused Bit 3-0 range 0-15 (see cross table for description of each mode)	Bit 15-4 = 000h Bit 3-0 = 0h (SW)	Bit 15-4 = 000h Bit 3-0 = 0h (SW)
Current azimuthal displacement phase (be carefull, the value in the table and echoed in ECP2CONF is not the value specified in the command)	7	7	This parameter is affected by cmd ZEC2PHAS, phas (0->255) If phas=0->185 then bit 15-0= 0->370d If phas=186->255 then bit 15-0= 65534d->65396d	Bit 15-0 = 0	Bit 15-0 = 0
Eclipse on/off mode flag	8	8	Bit 15-1 unused Bit 0 range 0-1: 0=off, 1=on	Bit 15-0 = 0000h (off)	Bit 15-0 = 0000h (off)
Auto change mode on/off flag	9	9	Bit 15-1 unused Bit 0 range 0-1: 0=disabled, 1=enabled	Bit 15-0 = 0000h (disabled)	Bit 15-0 = 0000h (disabled)
Synchro word #1 for hk word config2	10	10	Bit 15-0= F5AAh	Bit 15-0= F5AAh	Bit 15-0= F5AAh
Synchro word #2 for hk word config2	11	11	Bit 15-0= 0A55h	Bit 15-0= 0A55h	Bit 15-0= 0A55h
Fixed Table Checksum	12 (@=B80Dh)	12	C.S.=sum of words 0 to 11	213Dh	tbd

Fixed table in RAM - beg. address: @00A0h

Specific switch description	**Address in EEPROM**	**Function**
Counters/Synthetic tables mode flag	@B81Ch	0 -> counter data mode 1 -> synthetic table data used

* RAM Fixed table (13 words) and the current Operative Table (9 words) are transmitted to ground in the HK word CONFIG2 (22 subcommutated words total)

6.4.5.3. CIS2 Nominal Operation Tables - Operative Tables

The 5 default operative tables (in EEPROM) contain initial parameters for the RAM operative table. Only one is loaded in RAM according to the mode of operation selected (see 6.4.5.1)

The operative table in RAM is starting at address @00D2 (table version) and ending at address @00DA (checksum). It is followed by the sub-operative table starting at address @00DB. The Table Version value is incremented whenever the tables (fixed and operative) are saved from RAM to EEPROM table (see above).

EEPROM Operative Table # 0

No.	Group 0 - Solar wind activity	Value	ECP2CONF Offset
1	MSB Mode group info, LSB O.T. Version number	0000h	13
2	Sweeping Type (Normal - 2ms)	1	14
3	Mechanical phase (14.7° +135° Begin SW LO 'g')	0354h	15
4	Max Counter count for HOT (G) side (Momenta)	7FFFh	16
5	Max Counter count for COLD (g) side (Momenta)	7FFFh	17
6	Normal Tlm allocation table idx	0	18
7	Default 'k1' compression factor	0	19
8	Default 'k2' compression factor	0	20
9	Cheksum for group 0	0353h	21

EEPROM Operative Table #1

No.	Group 1 - Magnetosphere activity	Value	ECP2CONF Offset
1	MSB Mode group info, LSB O.T. Version number	0100h	13
2	Sweeping Type (Normal - 2ms)	1	14
3	Mechanical phase (14.7° End Of SW influence)	0096h	15
4	Max Counter count for HOT (G) side (Momenta)	7FFFh	16
5	Max Counter count for COLD (g) side (Momenta)	7FFFh	17
6	Normal Tlm allocation table idx	0	18
7	Default 'k1' compression factor	0	19
8	Default 'k2' compression factor	0	20
9	Cheksum for group 1	0195h	21

EEPROM Operative Table #2

No.	Group 2 - Compressed Solar wind activity	Value	ECP2CONF Offset
1	MSB Mode group info, LSB O.T. Version number	0200h	13
2	Sweeping Type (Normal - 2ms)	1	14
3	Mechanical phase (14.7° +135° Begin SW LO 'g')	0354h	15
4	Max Counter count for HOT (G) side (Momenta)	7FFFh	16
5	Max Counter count for COLD (g) side (Momenta)	7FFFh	17
6	Normal Tlm allocation table idx	0	18
7	Default 'k1' compression factor	2	19
8	Default 'k2' compression factor	0	20
9	Cheksum for group 2	0555h	21

EEPROM Operative Table #3

No.	Group 3 - Compressed Magnetosphere activity	Value	ECP2CONF Offset
1	MSB Mode group info, LSB O.T. Version number	0300h	13
2	Sweeping Type (Normal - 2ms)	1	14
3	Mechanical phase (26.367° End Of SW influence)	0096h	15
4	Max Counter count for HOT (G) side (Momenta)	7FFFh	16
5	Max Counter count for COLD (g) side (Momenta)	7FFFh	17
6	Normal Tlm allocation table idx	0	18
7	Default 'k1' compression factor	2	19
8	Default 'k2' compression factor	0	20
9	Cheksum for group 0	0397h	21

EEPROM Operative Table #4

No.	Group 4 - Calibration activity	Value	ECP2CONF Offset
1	MSB Mode group info, LSB O.T. Version number	0400h	13
2	Sweeping Type (Normal - 2ms)	1	14
3	Mechanical phase (26.367° End Of SW influence)	0096h	15
4	Max Counter count for HOT (G) side (Momenta)	7FFFh	16
5	Max Counter count for COLD (g) side (Momenta)	7FFFh	17
6	Normal Tlm allocation table idx	0	18
7	Default 'k1' compression factor	0	19
8	Default 'k2' compression factor	0	20
9	Cheksum for group 4	0494h	21

6.4.5.4. CIS2 PROM Partial Operations - Fixed Table

Instrument Default Configuration	0000h
Spin phase offset	0001h
MCPs High Voltage Setting	0000h
Discriminator 1 treshold	00FFh
Discriminator 2 treshold	00FFh
Energy factor (= 0.933282) i.e. ...	7775h
...HV step table val. = 0xfff*$(0.93)^n$	CB00h
Table of telemetry buffer addresses	4321h
last tlm_buf # ptr	4641h
Table of data buffer addresses	5000h
last tlm_buf # ptr	5C46h
SAMPLE 00 (P0) handler address	068Eh
SAMPLE 01 (P1) handler address	06BBh
SAMPLE 00 (dummy) handler address	06DDh
Error FIFO size	0100h
Error fifo buffer offset	4094h
Diagnostic operations Address pointer	4194h
Diagnostic operations Data buffer ptr	4198h
Diag. data w. MSB (used for ZEC2IOWS)	4195h
Interface status table ptr	4B8Ch
Rx Dma block address: buffer 0	4B9Fh
" " " " buffer 1	4C03h

Rx Multi Word address: buffer 0	4C67h
" " " " buffer 1	4CCBh
Tx Multi Word buf. ptr (Diag. use only)	4198h
Fixed Table Checksum	528Fh

where in the *Instrument Default Configuration word* the bits have the following meaning:

```
15  14  13  12  11   10    9    8   7   6   5   4   3   2   1   0
<   unused    > HT   HA   HM   HC   <          unused            >
```

HT = Amplifier test On/Off flag;
HA = Analyzer On/Off flag;
HM = Mcps HV On/Off flag; HC = Cover Status flag;
The **default** startup configuration is 0x0000 means **all OFF.**

6.4.5.5. CIS2 PROM Partial Operations - Operative Table

Operative Table identity #	0
Default operational mode (PROM)	7
Default Tlm mode (NM1)	1
Mode 7 offset: Sweeping regime (SLOW)	0
Mode 7 Spin sector acquisition phase	0
Mode 7: default operative config.	0
Mode 7: n. of Hv steps	80h
Mode 7: LO/HI sens. transition HV step	28h
Mode 7 N. of Partial Oper. acquired samples	3
Mode 7 Size of the First data sample	0040h
Mode 7 Size of the Second data sample	0C00h
Mode 7 " Third " (dummy)	0000h
Operative table (common + 7): checksum	0CF3h

6.4.6. Software modes: configurations for CIS

This table explain the various combinaisons of CIS software modes and their utility.

CIS1 CIS2	Nominal (EEPROM software)	Partial (PROM software)	Survival (PROM software)
Nominal (EEPROM software)	**This is the normal mode of operation for scientific operations of CIS**	This is not a normal way to operate. Can be used for CIS1 software patching but not at full command rate	No meaning because no data from CIS2 transmited
Partial (PROM software	This mode can be used during commissioning for hardware test. Can be used for CIS2 software patching but not at full command rate	This mode will be used during commissioning for hardware test. It is also convenient for analysis of IEL data and for CODIF tests (specific products implemented). Will be used for **CIS2 software patching** but not at full command rate	No meaning because no data from CIS2 transmited
Survival (PROM software)	Can be used for software patching to CIS2 but only for small piece of software. Commands are not accepted at full rate	Can be used for CIS2 software patching but not at full command rate	This state is reached after a cold reset. There is no housekeeping transmited to S/C (DEAD only)
CIS2 OFF			This configuration **will be used for CIS1 software patching, mainly to patch large piece of software**

6.4.7. Software modes:transitions between the various states

CIS1 CIS2 From/To	From	Nominal Nominal	Nominal Partial	Nominal Survival	Partial Nominal	Partial Partial	Partial Survival	Survival Nominal (no meaning)	Survival Partial (no meaning)	Survival Survival
To										
Nominal Nominal			if C.S OK ZECLPC2A/B if C.S. wrong then jump to @8100		ZECLPC1A/B	ZECLPC1A/B + ZECLPC2A/B		N/A	N/A	ZECLPC1A/B + ZECLPC2
Nominal Partial		N/A		2EEPPAR2	N/A	ZECLPC1A/B	N/A	N/A	N/A	N/A
Nominal Survival		CIS2_survival	OK		N/A	N/A	ZECLPC1A/B	N/A	N/A	ZECLPC1A/B
Partial Nominal		N/A	N/A	N/A		ZECLPC2A/B		N/A	N/A	N/A
Partial Partial		N/A	N/A	N/A	N/A		2EEPPAR2	N/A	N/A	N/A
Partial Survival		N/A	N/A	N/A	CIS2_SURVIVAL	CIS2_SURVIVAL		N/A	N/A	1EEPPART
Survival Nominal (no meaning)		N/A	N/A	N/A	N/A	N/A	N/A		N/A	N/A
Survival Partial (no meaning)		N/A	N/A	N/A	N/A	N/A	N/A	N/A		N/A
Survival Survival		ZECLPC3A/B	ZECLPC3A/B	ZECLPC3A/B	ZECLPC3A/B	ZECLPC3A/B	ZECLPC3A/B	N/A	N/A	

6.4.8. CIS/ Top Level Modes for Nominal Operations

See ESOC document "Command Analysis Reference Document for CIS"
Doc. N°: DS-JSO-CA-0005

6.5. PROCEDURES

6.5.1. Procedures for nominal operations

NOMINAL OPERATIONS PROCEDURES		
no.	Procedure	Purpose
1.1.	**CISON**	Switch CIS ON, configure interfaces according to the one selected (primary or redundant), configure CIS according to the telemetry rate at switch ON time, and verify that the status reached is the correct one
1.2	**CISOFF**	Switch CIS OFF
1.3	**CISAMHVON**	Switch CIS1 acceleration and MCP HVs ON Switch CIS2 MCP HV ON
1.4	**CISAMHVOFF**	Switch CIS1 acceleration and MCP HVs OFF Switch CIS2 MCP HV OFF
1.5	**CISANLON**	CIS1 and CIS2 analyser high voltages switch ON
1.6	**CISANLOFF**	CIS1 and CIS2 analyser high voltages switch OFF
1.7	**CISHVSET**	CIS1 acceleration and MCP HVs setting and CIS2 MCP HV setting
1.8	**CISMODECHG**	Scientific modes of operation modification
1.9	**CISMCPGCAL**	Verification of the gain of CODIF MCPs, of the gain of CIS2 MCPs, and of the correct setting of MCP high voltages.

6.5.1.1. Procedure: CISON

Purpose: The purpose of this procedure is to switch CIS ON, to configure interfaces according to the one selected (primary or redundant), to initialise correctly configuration words, to configure CIS according to the telemetry rate at switch ON time, and to verify that the status reached is the correct one.

Description:

Initial conditons: CIS is OFF

Final Conditions: CIS is ON, interfaces correctly configured and working with the current telemetry format.

```
** Select which LCL will be used, and switch CIS ON
If LCL-A selected then
        send ZCISAONN                -- CIS LCL-A ON
        send ZEXEMLCZ                -- Execute Ml cmd
        wait 10 seconds
        verify LCL-A status PLCISA_A = ON
else
        send ZCISBONN                -- CIS LCL-B ON
        send ZEXEMLCZ                -- Execute Ml cmd
        wait 10 seconds
        verify LCL-B status PLCISA_A = ON
endif

** Select primary or redundant interface for low power commands
If primary lpc interface chosen then
        send ZECLPC2A        -- select primary I/F and reset CIS2
        wait 1s
        send ZECLPC1A        -- CIS1 hot reset
        record that primary low power command I/F is selected
else
        send ZECLPC2B        -- select primary I/F and reset CIS2
        wait 1s
        send ZECLPC1B        -- CIS1 hot reset
        record that redundant low power command I/F is selected
endif
wait 4 formats
** Select primary/redundant CIS I/F with the OBDH by sending a dummy command
send ZEC1ADMS,0

** Initialise configuration words

wait 1s
send ZEC1ADMS,0              -- Adress 0x0041
wait 1s
send ZEC1ADLS,0x41
wait 1s
```

```
send ZEC1DAMS,0            -- Data= 0x0000 -> @0x0041
wait 1s
send ZEC1MEMS,0
wait 1s
send ZEC1ADLS,0x40         -- Adress 0x0040
wait 1s
send ZEC1MEMS,0x55         -- Data= 0x0055 -> @0x0040
wait 1s
send MDUS,0                -- Verification: Dump 1 page starting at @0040
wait 10s


** Reset CIS1 processor
If primary lpc interface selected then
        send ZECLPC1A      -- CIS1 hot reset
else
        send ZECLPC1B      -- CIS1 hot reset
endif

wait 5s

** Configure CIS according to the telemetry rate
select Tlm_rate=HKP, NM1, NM2, NM3, BM1, BM2, BM3

case "HKP"
        send ZEC1TH0S      -- configure CIS for telemetry rate HKP
case "NM1"
        send ZEC1TN1S      -- configure CIS for telemetry rate NM1
case "NM2"
        send ZEC1TN2S      -- configure CIS for telemetry rate NM2
case "NM3"
        send ZEC1TN3S      -- configure CIS for telemetry rate NM3
case "BM1"
        send ZEC1TB1S      -- configure CIS for telemetry rate BM1
case "BM2"
        send ZEC1TB2S      -- configure CIS for telemetry rate BM2
case "BM3"
        send ZEC1TB3S      -- configure CIS for telemetry rate BM3
end case
        wait 10 seconds
        verify correct setting of CIS telemetry rate
```

**** Verification of CIS status after switch ON**

```
** Verification of low power voltages and currents
+4.8V <ECL1VP5_< +5.2V          -- CIS1 DPU +5V
-5.2V <ECL1VN5_< -4.8V          -- CIS1 DPU -5V
+11.8V <ECL1VP12< +12.2V        -- CIS1 DPU +12V
-12.2V <ECL1VN12< -11.8V -- CIS1 DPU -12V
```

+3.9V <ECCAVP5_< +4.8V -- CIS1 CODIF +5V
+11.8V <ECCAVP12< +12.2V -- CIS1 CODIF +12V
-5.1V <ECCAVN12< -4.9V -- CIS1 CODIF -5V

** the following verifications can be different according to what is defined in the default fix table in EEPROM (HV status, HV value, CIS2 status, etc...). The value indicated below are only for the launch configuration.

130mA <EC<160mA -- CIS LCL current (total)
130mA <ECL1ITOT< 160mA CIS1 total current

** Verification of CIS1 status after switch ON
ECCHACCS= OFF -- acceleration HV OFF

ECCHMCPS= OFF -- MCP HV OFF

ECCHANLS= OFF -- Analyser HV OFF
-- Cover actuator status OFF
-- ECCACVRS=OFF

-- RPA voltages
ECCRN100<1volt
ECCRN153<1.5volt
ECCRN247<1volt
ECCRP220<1volt
ECCRVOUT<0.2vol
-- CIS2 OFF

Total duration: 51s + 10s for verification

6.5.1.2. Procedure: CISOFF

Purpose:	Switches CIS OFF.
Description:	This procedure configure CIS in order to have a correct status after the next switch ON, and finally remove power.
Constraints:	This procedure should be used in survival mode. In case of emergency use procedure CIS_OFF_EMER.
Initial conditions:	CIS ON in survival mode
Final conditions:	CIS OFF.

** In case of a watch-dog reset, CIS1 distinguish a watch-dog reset or a hot reset from a normal switch ON, by testing the status of 2 memory addresses that are incremented in a different way. Normally, when CIS is OFF, these addresses are cleared and at power ON CIS knows that it is a switch ON and initialisation is different than for a watch-dog or hot reset. However we noted during the AIV phase that this 2 memory words are not always cleared when CIS is OFF, due to a residual voltage existing because CIS is still receiving the S/C signals. So, in order to have a good configuration at switch ON, it is necessary to clear these 2 memory words. It is the purpose of the following commands. **

```
send ZEC1ADLS,0x41          -- Adress 0x0041
wait 1s
send ZEC1ADMS,0
wait 1s
send ZEC1DAMS,0         -- Data= 0x0000 -> @0x0041
wait 1s
send ZEC1MEMS,0
wait 1s
send ZEC1ADLS,0x40      -- Adress 0x0040
wait 1s
send ZEC1MEMS,0x55      -- Data= 0x0055 -> @0x0040
wait 1s
send MDUS,0             -- Verification: Dump 1 page starting at @0040
wait 1s
send ZEC1ADLS,1         -- Adress 0x2001
wait 1s
send ZEC1ADMS,0x20
wait 1s
send ZEC1DAMS,0         -- Data= 0x0000 -> @0x2001
wait 1s
send ZEC1MEMS,0
wait 1s
send ZEC1ADLS,0         -- Adress 0x2000
wait 1s
send ZEC1MEMS,0x55      -- Data= 0x0055 -> @0x2000
wait 1s
send ZEC1MDUS,0             -- Verification: Dump 1 page starting at @2000
wait 1s
```

```
** Switch OFF LCL A and B
send ZEC1AFFN, ZEXEMLCZ          -- LCL_A OFF
send YCISBFFN, ZEXEMLCY          -- LCL_B OFF
wait 20s

** Verify LCL_A et LCL_B  status
verify PLCISA_S=OFF
verify PLCISB_S=OFF
```

Total duration: 43s + 20s for verification

6.5.1.3. Procedure: CISAMHVON

Purpose:	CIS1 acceleration and MCP HVs ON. CIS2 MCP HV ON
Description:	This procedure initialises CIS1 acceleration and MCP HVs, CIS2 MCP HV to 0 and switches them ON
Constraints:	This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions:	CIS1 acceleration and MCP high voltages, CIS2 MCP high voltage are OFF
Final conditions:	At the end, CIS1 acceleration and MCP high voltages, CIS2 MCP high voltage, are ON, at the lower value.

** Verify that CIS1 acceleration and MCP HVs, and CIS2 MCP HV are OFF
verify ECCHACCS = OFF, ECCHMCPS = OFF, ECHHMCPS = OFF
record ECL1ITOT and ECL2ITOT

** Set value to 0
send ZEC1ACCS,0 ;wait 1s
send ZEC1MCPS,0 ;wait 1s
send ZEC2MCPS,0 ;wait 1s
wait 10s
** Switches HVS ON
send ZEC1ACCN ;wait 1s
send ZEC1MCPN ;wait 1s
send ZEC2MCPN ;wait 1s
wait ~20s before verification

** Verify HV status
verify ECL1ITOT increase by cis1_delta_i mA -- increase is small relatively to the fluctuations of this parameter; difficult to evaluate
verify ECL2ITOT increase by cis2_delta_i mA -- increase is small relatively to the fluctuations of this parameter; difficult to evaluate
verify ECCHACCS= ON
verify ECCHMCPS= ON
verify ECHHMCPS= ON
verify ECCHVACC= acc_init_voltage
verify ECCHVMCP= mcp1_init_voltage
verify ECCHVACC= mcp2_init_voltage
verify ECCHIACC= acc_init_current
verify ECCHIMCP= imcp_init_current
verify ECHHIMCP= mcp2_init_current

Initial value of high voltage parameters

Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4 spare
cis1_delta_i (mA)	2	2	2	2	2
cis2_delta_i (mA)	2	2	2	2	2
acc_init_voltage (volt)	1 429	1 429	1 429	1 429	1 429
mcp1_init_voltage (volt)	191	191	191	191	191
mcp2_init_voltage (volt)	-6	-6	-6	-6	-6
acc_init_current (mA)	1.6	1.6	1.6	1.6	1.6
mcp1_init_current (mA)	5.8	5.8	5.8	5.8	5.8
mcp2_init_current (mA)	0.9	0.9	0.9	0.9	0.9

Total duration: 16s + 20s for verification

6.5.1.4. Procedure: CISAMHVOFF

Purpose: CIS1 acceleration and MCP HVs OFF. CIS2 MCP HV OFF

Description: This procedure switches CIS1 acceleration and MCP HVs, and CIS2 MCP HV, OFF.

Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".

Initial conditions: CIS1 acceleration and MCP high voltages, CIS2 MCP high voltage are ON, at the lower value.

Final conditions: At the end, CIS1 acceleration and MCP high voltages, CIS2 MCP high voltage, are OFF, at the lower value.

** Verify that CIS1 acceleration and MCP HVs, and CIS2 MCP HV are ON
verify ECCHACCS = ON, ECCHMCPS = ON, ECHHMCPS = ON
record ECL1ITOT and ECL2ITOT

** Switches HVS OFF
send ZEC1ACCF ;wait 1s
send ZEC1MCPF ;wait 1s
send ZEC2MCPF
wait ~30s before verification

** Verify HV status
verify ECL1ITOT decrease by cis1_delta_i mA
verify ECL2ITOT decrease by cis2_delta_i mA
verify ECCHACCS= OFF
verify ECCHMCPS= OFF
verify ECHHMCPS= OFF

Value of parameters

Model / Parameter	CIS1-FS clu #1	CIS1-F1 clu #2	CIS1-F2 clu #3	CIS1-F3 clu #4	CIS1-F4 spare
cis1_delta_i (mA)	-2	-2	-2	-2	-2
cis2_delta_i (mA)	-2	-2	-2	-2	-2

Total duration: 2s + 20s for verification

6.5.1.5. Procedure: CISANLON

Purpose : CIS1 analyser high voltage and CIS2 analyser high voltage switch ON.
Description : This procedure will switch CIS1 analyser and CIS2 analyser HV ON. After that, these HVs will sweep.
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".

Initial conditions: CIS1 Analyser voltage OFF (ECCHANLS = OFF) and CIS2 Analyser high

voltage OFF (ECHHANLS = OFF).
Final conditions: CIS1 Analyser high voltage ON and sweeping according to the mode selected (ECCHANLS = ON). CIS2 Analyser high voltage ON and sweeping according to the mode selected (ECHHANLS = ON)Affected parameters are: ECCHANLS, ECCHVANL, ECCHIANL, ECCHID_, and ECL1ITOT for CIS1 and ECHHANLS, ECHHVANL, ECHHIANL, ECHHID_, and ECL2ITOT for CIS2

** Verify initial status
ECCHANLS=OFF
ECCHVANL=~ 5228 volt
ECCHIANL~= 9,6mA (not valid) -- this value has no real engineering meaning but reflect the way the HV is disabled.
ECCHID_<0.3mA
ECHHANLS=OFF
ECHHVANL=~ 4800 volt
ECHHIANL~= 9,6mA (not valid) -- this value has no real engineering meaning but reflect the way the HV is disabled.
ECHHID_<0.3mA
record ECL1ITOT
record ECL2ITOT** CIS1 analyser HV switch ON
send ZEC1ANLN, wait 1s
send ZEC2ANLN
wait ~30s before verification
** Verify HV status

verify ECL1ITOT increase by delta_i mA -- very small increase relatively to the flutuations of this parameter
verify ECCHANLS= ON
verify ECCHVANL= init_voltage
verify ECCHIANL= init_current
verify ECCHID__= init_idiod
verify ECL2ITOT increase by delta_i mA -- very small increase relatively to the flutuations of this parameter
verify ECHHANLS= ON
verify ECHHVANL= init_voltage
verify ECHHIANL= init_current (valid)
verify ECHHID__= init_idiod

** In case of error execute emergency procedure CISANLOFF

Initial value of high voltage parameters

Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4 spare
delta_i (mA)	2	2	2	2	2
init_voltage (volt)	-5675	-5613	-5676	-5676	
init_current (mA)	1,5	1,5	1,5	1,5	1,5
init_idiod (mA)	1.1	1.1	1.1	1.1	1.1

Model / Parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS2-F6 clu #7	CIS2-F7 clu #8	CIS2-F4 spare
delta_i (mA)	2	2	2	2	2
init_voltage (V)	-5159	-5130	-4902	-5013	
init_current (mA)	2,2	2,2	2,2	2,2	2,2
init_idiod (mA)	1.2	1.2	1.2	1.2	1.2

Total duration: 1s + 30s for verification

6.5.1.6. Procedure CISANLOFF

Purpose: Switches CIS1 analyser HV and CIS2 analyser HV OFF
Description: This procedure switches Analyser HVs OFF
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".
Initial conditions: Analyser high voltages ON, and sweeping according to the mode selected.
Final conditions: CIS1 analyser high voltage OFF (ECCHANLS = OFF) and CIS2 analyser high voltage OFF (ECHHANLS = OFF). Affected parameters are: ECCHANLS, ECCHVANL, ECCHIANL, ECCHID_, and ECL1ITOT for CIS1 and ECHHANLS, ECHHVANL, ECHHIANL, ECHHID_, and ECL2ITOT for CIS2.

** Verify initial status
ECCHANLS=ON
ECCHVANL~= 5220volt
ECCHIANL~=1.3mA (valid)
ECCHID_~=1.1mA
ECHHANLS=ON
ECHHVANL~= 4750 volt
ECHHIANL~=1.2mA (valid)
ECHHID_~=1.2mA
record ECL1ITOT
record ECL2ITOT

** Analyser HVs switch OFF
send ZEC1ANLF ;wait 1s
send ZEC2ANLF
Wait 30s before verification
** Verify final status
ECCHANLS=OFF
ECCHVANL<5220 volt
ECCHIANL~= 9,6mA (not valid)
ECCHID_<0.3mA
ECL1ITOT decrease by about delta-i1 mA -- very small increase relatively to the flutuations of this parameter; difficult to see
ECHHANLS=OFF
ECHHIANL~= 9,6mA (not valid)
ECHHID_<0.3mA
ECL2ITOT decrease by delta-i2 mA -- very small increase relatively to the flutuations of this parameter; difficult to see

** In case of error execute emergency procedure CISOFF.

Value of parameters

Model / Parameter	CIS1-FS clu #1	CIS1-F1 clu #2	CIS1-F2 clu #3	CIS1-F3 clu #4
delta_i1 (mA)	-2	-2	-2	-2
delta_i2 (mA)	-2	-2	-2	-2

Total duration: 1s + 30s for verification

6.5.1.7. Procedure: CISHVSET

Purpose: CIS1 acceleration and MCP HVs setting. CIS2 MCP HV setting

Description: This procedure modify the current setting of CIS1 acceleration HV, CIS1 MCP HV and CIS2 MCP HV.

Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, in "Nominal operation modes".

Initial conditions: CIS1 acceleration and MCP high voltages, CIS2 MCP high voltage are ON.

Final conditions: At the end, CIS1 acceleration and MCP high voltages, CIS2 MCP high voltage, are still ON, at set the new value.

** Verify that CIS1 acceleration and MCP HVs, and CIS2 MCP HV are ON
verify ECCHACCS = ON, ECCHMCPS = ON, ECHHMCPS = ON
record ECL1ITOT and ECL2ITOT
record current setting:
ECCHVACC, ECCHVMCP, ECCHVACC, ECCHIACC, ECCHIMCP, ECHHIMCP

** Set value to requested value
send ZEC1ACCS, $setacc ;wait 1s
send ZEC1MCPS, $setmcp1 ;wait 1s
send ZEC2MCPS, $setmcp2
** HVs increase and decrease slowly. So the time to reach the specified value can varie according to the difference between initial setting and final setting. So, wait for final setting.
wait delay_for_setting

** Verify HV status
verify ECL1ITOT
verify ECL2ITOT
verify ECCHVACC= acc_voltage
verify ECCHVMCP= mcp1_voltage
verify ECCHVACC= mcp2_voltage
verify ECCHIACC= acc_current
verify ECCHIMCP= mcp1_current
verify ECHHIMCP= mcp2_current

Henceforth parameters

	Value for CLU #1,2,3,4 (dec)				
Name of parameter	mode: LOWER	mode: SAFE	mode: APOGEE	mode: PERIGEE	Comments
$setacc	0d (1400 volt)	94d (10031 volt)	141d (15021 volt)	122d (13004 volt)	command parameters values are in decimal
$setmcp1	0d (0 volt)	92d (1511volt)	134d (2205 volt)	84d (1500 volt)	command parameters values are in decimal
$setmcp2	0d (0 volt)	88 (1203 volt)	132 (1805 volt)	110 (1500 volt)	command parameters values are in decimal

	mode: FLIGHT (nominal operations)				
Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4 spare
$setacc_fm	170d (18099 volt)	170d (18099 volt)	170d (18099 volt)	170d (18099 volt)	170d (18099 volt)
$setmcp1_fm	8Ch=140d (2519 volt)	8Eh=142d (2564 volt)	94h=148d (2651 volt)	8Ch=140d (2519 volt)	
$setmcp2_fm	172d (2353 volt)	168d (2300 volt)	168d (2300 volt)	168d (2300 volt)	

Value of transition duration according to the transition (delay_for_setting in seconds)

Assumption: increase by 1 every 5s for nominal operations

mode name	LOWER	SAFE	APOGEE	PERIGEE	FLIGHT
LOWER	N/A	94*5=470	141*5=705	122*5=610	170*5=850
SAFE	94*5=470	N/A	47*5=235	28*5=140	76*5=380
APOGEE	141*5=705	47*5=235	N/A	19*5=95	29*5=145
PERIGEE	122*5=610	28*5=140	19*5=95	N/A	48*5=240
FLIGHT	170*5=850	76*5=380	29*5=145	48*5=240	N/A

Total duration: 2s + delay_for_setting

6.5.1.8. Procedure CISMODECHG

Purpose: Switches to a new mode of operation.
Description: This procedure change the current mode of operation
Constraints: This procedure will be used in "Nominal operation modes", only.
Initial conditions: Current scientific mode of operation.
Final conditions: At the end, CIS will work in the new mode of operation.

** Switches to the new mode of operation.
send ZEC1MODS, $modenumber
wait 1s

** Verification
after 15s verify that CIS has switched to the new mode of operation.
ECP1MODE= $modenumber (or mode_name)
**Mode name
The description of $mode_number and mode_name is described section 6.4.4.4

Total duration: 1s + 15s for verification

6.5.1.9. Procedure: CISMCPGCAL

Purpose : Verification of the gain of CODIF MCPs, of the correct setting of CIS1 MCP high voltage, of the gain of HIA MCPs and of the correct setting of CIS2 MCP high voltage.

Description: This procedure commands CIS1 MCP high voltage at 5 levels around the nominal setting value. This procedure commands also CIS2 MCP high voltage at 5 levels around the nominal setting values. For each value, the discriminator level is set to 10 value around 3.2 volts.

Constraints: This procedure can be used during the commissioning phase with the PROM software (Partial operation mode). It will also be used, on a routine basis (about once per month), in "Nominal operation modes", to verify that the gain of CODIF MCPs has not decrease and that the setting of MCP high voltage is still correct.

Initial conditions: CODIF high sensitivity and low sensitivity sections are ON. MCP high voltage is set to the nominal level and acceleration high voltage too. CIS2 MCP high voltage is set to the nominal level. Analyser high voltage is ON, and sweeping. CIS is in nominal mode 15 (Calibration mode)

Final conditions: At the end, CIS1 MCP high voltage, and CIS2 MCP high voltage return to its nominal value.

```
** Record CIS1 and CIS2 currents
record ECL1ITOT
record ECL2ITOT

**Save current setting of CIS1 and CIS2 MCP high voltages

** Set CIS1 MCP high voltage to codif_val1 (lower value)
send ZEC1MCPS,codif_val1
wait 5s
monitor ECL1ITOT    -- monitor CIS1 current (decrease)
monitor             -- monitor MCP voltage
monitor             -- monitor MCP current

** Set CIS2 MCP high voltage to hia_val1 (lower value)
send ZEC2MCPS,hia_val1
wait 5s
monitor ECL2ITOT        -- monitor CIS1 current (decrease)
monitor ECHHVMO_        -- monitor MCP voltage
monitor ECHHIMCP        -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155      -- 2,9 volt
wait 1s ; send ZEC2DL2S, 155      -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160      -- 3,0 volt
wait 1s ; send zec2dl2s, 160      -- 3,0 volt
wait 1mn
```

** Set discriminator level dl3
send ZEC2DL1S, 165 -- 3,1 volt
wait 1s ; send zec2dl2s, 165 -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171 -- 3,2 volt
wait 1s ; send zec2dl2s, 171 -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176 -- 3,3 volt
wait 1s ; send zec2dl2s, 176 -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181 -- 3,4 volt
wait 1s ; send zec2dl2s, 181 -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187 -- 3,5 volt
wait 1s ; send zec2dl2s, 187 -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192 -- 3,6 volt
wait 1s ; send zec2dl2s, 192 -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197 -- 3,7 volt
wait 1s ; send zec2dl2s, 197 -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203 -- 3,8 volt
wait 1s ; send zec2dl2s, 203 -- 3,8 volt
wait 1mn

** Set CIS1 MCP high voltage to codif_val 2
send ZEC1MCPS, codif_val2
wait 5s
monitor ECL1ITOT -- monitor CIS1 current (decrease)
monitor -- monitor MCP voltage
monitor -- monitor MCP current
wait 1mn

** Set CIS2 MCP high voltage to hia_val 2
send ZEC2MCPS, hia_val2
wait 5s
monitor ECL2ITOT -- monitor CIS1 current (decrease)
monitor ECHHVMO_ -- monitor MCP voltage
monitor ECHHIMCP -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155 -- 2,9 volt

```
wait 1s ; send zec2dl2s, 155            -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160          -- 3,0 volt
wait 1s ; send zec2dl2s, 160            -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165          -- 3,1 volt
wait 1s ; send zec2dl2s, 165            -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171          -- 3,2 volt
wait 1s ; send zec2dl2s, 171            -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176           -- 3,3 volt
wait 1s ; send zec2dl2s, 176            -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181          -- 3,4 volt
wait 1s ; send zec2dl2s, 181            -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187          -- 3,5 volt
wait 1s ; send zec2dl2s, 187            -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192          -- 3,6 volt
wait 1s ; send zec2dl2s, 192            -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197          -- 3,7 volt
wait 1s ; send zec2dl2s, 197            -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203          -- 3,8 volt
wait 1s ; send zec2dl2s, 203            -- 3,8 volt
wait 1mn

** Set CIS1 MCP high voltage to codif_val 3
send ZEC1MCPS, codif_val3
wait 5s
monitor ECL1ITOT     -- monitor CIS1 current (decrease)
monitor              -- monitor MCP voltage
monitor              -- monitor MCP current
wait 1mn

** Set CIS2 MCP high voltage to hia_val 3
send ZEC2MCPS, hia_val3
```

```
wait 5s
monitor ECL2ITOT              -- monitor CIS1 current (decrease)
monitor ECHHVMO_              -- monitor MCP voltage
monitor ECHHIMCP              -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155            -- 2,9 volt
wait 1s ; send zec2dl2s, 155          -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160            -- 3,0 volt
wait 1s ; send zec2dl2s, 160          -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165            -- 3,1 volt
wait 1s ; send zec2dl2s, 165          -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171            -- 3,2 volt
wait 1s ; send zec2dl2s, 171          -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176             -- 3,3 volt
wait 1s ; send zec2dl2s, 176          -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181            -- 3,4 volt
wait 1s ; send zec2dl2s, 181          -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187            -- 3,5 volt
wait 1s ; send zec2dl2s, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192            -- 3,6 volt
wait 1s ; send zec2dl2s, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197            -- 3,7 volt
wait 1s ; send zec2dl2s, 197          -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203            -- 3,8 volt
wait 1s ; send zec2dl2s, 203          -- 3,8 volt
wait 1mn

** Set CIS1 MCP high voltage to codif_val 4 (nominal value)
send ZEC1MCPS, codif_val4
wait 5s
monitor ECL1ITOT     -- monitor CIS1 current (decrease)
```

```
monitor                 -- monitor MCP voltage
monitor                 -- monitor MCP current
wait 1mn

** Set CIS2 MCP high voltage to hia_val 4 (nominal value)
send ZEC2MCPS, hia_val4
wait 5s
monitor ECL1ITOT              -- monitor CIS1 current (decrease)
monitor ECHHVMO_              -- monitor MCP voltage
monitor ECHHIMCP              -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155            -- 2,9 volt
wait 1s ; send zec2dl2s, 155          -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160            -- 3,0 volt
wait 1s ; send zec2dl2s, 160          -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165            -- 3,1 volt
wait 1s ; send zec2dl2s, 165          -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171            -- 3,2 volt
wait 1s ; send zec2dl2s, 171          -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176             -- 3,3 volt
wait 1s ; send zec2dl2s, 176          -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181            -- 3,4 volt
wait 1s ; send zec2dl2s, 181          -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187            -- 3,5 volt
wait 1s ; send zec2dl2s, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192            -- 3,6 volt
wait 1s ; send zec2dl2s, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
send ZEC2DL1S, 197            -- 3,7 volt
wait 1s ; send zec2dl2s, 197          -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203            -- 3,8 volt
wait 1s ; send zec2dl2s, 203          -- 3,8 volt
```

```
wait 1mn

** Set CIS1 MCP high voltage to codif_val5 (higher value)
send ZEC1MCPS, codif_val5
wait 5s
monitor ECL1ITOT     -- monitor CIS1 current (decrease)
monitor              -- monitor MCP voltage
monitor              -- monitor MCP current
wait 1mn

** Set CIS2 MCP high voltage to hia_val5 (higher value)
send ZEC2MCPS, hia_val5
wait 5s
monitor ECL2ITOT            -- monitor CIS1 current (decrease)
monitor ECHHVMO_            -- monitor MCP voltage
monitor ECHHIMCP            -- monitor MCP current
** Set discriminator level dl1
send ZEC2DL1S, 155          - 2,9 volt
wait 1s ; send zec2dl2s, 155          -- 2,9 volt
wait 1mn
** Set discriminator level dl2
send ZEC2DL1S, 160          -- 3,0 volt
wait 1s ; send zec2dl2s, 160          -- 3,0 volt
wait 1mn
** Set discriminator level dl3
send ZEC2DL1S, 165          -- 3,1 volt
wait 1s ; send zec2dl2s, 165          -- 3,1 volt
wait 1mn
** Set discriminator level dl4
send ZEC2DL1S, 171          -- 3,2 volt
wait 1s ; send zec2dl2s, 171          -- 3,2 volt
wait 1mn
** Set discriminator level dl5
send ZEC2DL1S 176           -- 3,3 volt
wait 1s ; send zec2dl2s, 176          -- 3,3 volt
wait 1mn
** Set discriminator level dl6
send ZEC2DL1S, 181          -- 3,4 volt
wait 1s ; send zec2dl2s, 181          -- 3,4 volt
wait 1mn
** Set discriminator level dl7
send ZEC2DL1S, 187          -- 3,5 volt
wait 1s ; send zec2dl2s, 187          -- 3,5 volt
wait 1mn
** Set discriminator level dl8
send ZEC2DL1S, 192          -- 3,6 volt
wait 1s ; send zec2dl2s, 192          -- 3,6 volt
wait 1mn
** Set discriminator level dl9
```

```
send ZEC2DL1S, 197              -- 3,7 volt
wait 1s ; send zec2dl2s, 197              -- 3,7 volt
wait 1mn
** Set discriminator level dl10
send ZEC2DL1S, 203              -- 3,8 volt
wait 1s ; send zec2dl2s, 203              -- 3,8 volt
wait 1mn

** Set CIS1 MCP high voltage to codif_val 4 (return to nominal value)
send ZEC1MCPS, codif_val4
wait 5s
monitor ECL1ITOT     -- monitor CIS1 current (decrease)
monitor              -- monitor MCP voltage
monitor              -- monitor MCP current
wait 1mn

** Set CIS2 MCP high voltage to hia_val 4 (nominal value)
send ZEC2MCPS, hia_val4
wait 5s
monitor ECL2ITOT                -- monitor CIS1 current (decrease)
monitor ECHHVMO_                -- monitor MCP voltage
monitor ECHHIMCP                -- monitor MCP current
** Set discriminator level dl2 (nominal value)
send ZEC2DL1S, 160              -- 3,0 volt
wait 1s
send ZEC2DL2S, 160              -- 3,0 volt
wait 1mn
```

Total duration: 3381s = 56mn21s

Value of the paramater used for commanding, according to CIS1 model #
(henceforth parameters)

Model/ Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4 spare
codif_val1	80h=128d	82h=130	88h=136d	80h=128d	
codif_val2	84h=132d	86h=134d	8Ch=140d	84h=132d	
codif_val3	88h=136d	8Ah=138d	90h=144d	88h=136d	
codif_val4 (nominal value)	8Ch=140d	8Eh=142d	94h=148d	8Ch=140d	
codif_val5	90h=144d	92h=146d	98h=152d	90h=144d	

Value of the parameter used for commanding, according to CIS2 model #

Model/ Parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS2-F6 clu #7	CIS2-F7 clu #8	CIS2-F4 spare
hia_val1	160 (2188v)	156 (2134v)	156 (2134v)	156 (2134v)	
hia_val2	164 (2243v)	160 (2188v)	160 (2188v)	160 (2188v)	
hia_val3	168 (2300v)	164 (2243v)	164 (2243v)	164 (2243v)	
hia_val4 (nominal value)	172 (2353v)	168 (2300v)	168 (2300v)	168 (2300v)	
hia_val5	176 (2406v)	172 (2353v)	172 (2353v)	172 (2353v)	

6.5.2. Technical Adjustement Procedures

TECHNICAL ADJUSTEMENT PROCEDURES		
No.	**Name**	**Purpose**
2.1	**CIS1TABSAVE**	Save CIS1 fix or/and operating tables from RAM to EEPROM. They becomes the default fix/operating tables
2.2	**CIS2TABSAVE**	Save CIS2 tables from RAM to EEPROM. They becomes the default tables
2.3	**CIS1_MDUMP**	Dump of n pages of an area of the CIS1 memory
2.4	**CIS2_MDUMP**	Dump of n pages of an area of the CIS2 memory
2.5	**CIS1_STIMULIS**	Test of the electronics of CODIF, high and low sensitivity section
2.6	**CIS2_AMPTST**	Test of the electronics of CIS2 (amplifiers + counters + DPU)
2.7	**CIS1_RPADEFL**	Modification of voltages applied to the RPA deflection plates
2.8	**CIS1_RPASWEEP**	Modification of parameters defining a RPA sweep
2.9	**CIS1_SWEEPTHRESH**	Modification of parameters defining the analyser HV sweep
2.10	**CIS1MEMWR1W**	Writes 1 word in CIS1 RAM
2.11	**CIS2MEMWR1W**	Writes 1 word in CIS2 RAM
2.12	**CIS1_SCRATCHOFF**	Switches scratch memory OFF
2.13	**CIS1_SCRATCHON**	Switches scratch memory ON
2.14	**CIS1_SCRATCHTST**	Test of scratch memory
2.15	**CIS1_SPINPHADJ**	Adjust the phase of the beginning of measurement of CIS1 relative to sun reference pulse
2.16	**CIS2_SPINPHADJ**	Adjust the phase of the beginning of measurement of CIS2 relative to sun reference pulse
2.17	**CIS2_DISCRISET**	CIS2 discriminator levels adjustement
2.18	**CIS1_ACCHVFAST**	Writes 1 word in CIS1 RAM in order to decrease acceleration HV quickly
2.19	**CIS1_MCPHVFAST**	Writes 1 word in CIS1 RAM in order to decrease MCP HV quickly
2.20	**CIS2_MCPHVFAST**	Writes 1 word in CIS2 RAM in order to decrease MCP HV quickly
2.21	**RPA_ON**	RPA voltages switched ON
2.22	**RPA_OFF**	RPA voltages switched OFF
2.23	**HS/LS_SEL**	Select data from HS or LS sections
2.24	**ANY_CMD**	Send one command to CIS (any command)
2.25	**CIS2ON**	Switches CIS2 ON
2.26	**CIS2OFF**	Switches CIS2 OFF
2.27	**CIS1I/OWR1W**	Writes 1 I/O word in CIS1
2.28	**CIS2I/OWR1W**	Writes 1 I/O word in CIS2
2.29	**HS/LS_ONOFF**	Switches CODIF HS or/and LS ON or OFF
2.3	**CIS1_HOTRST**	CIS1 hot reset
2.31	**BLCK_CMD**	Send a block comand to CIS

6.5.2.1. Procedure: CIS1TABSAVE

Purpose : Saves CIS1 fix or/and operating tables from RAM to EEPROM. They becomes the default fix/operating tables
Description :
Constraints: RAM table shall have a correct checksum
Initial conditions: Fix or/and operating tables in RAM have the correct value (CIS in the required status).
Final conditions: EEPROM fix or/and operating tables are updated. EEPROM checksums are updated and the table number is incremented by one.

** To save RAM fix table to default fix table (EEPROM), then execute:
Send ZEC1SAVS, 1 -- save fix table in RAM to default fix table in EEPROM
wait 1s

°°°

** To save RAM current operating table to default operating table (EEPROM), then execute:
Send ZEC1SAVS, 0 -- save operating table in RAM to default operating table in EEPROM
wait 1s

** The current operating table is saved in the area corresponding to the current scientific mode. Only the default table relative to this scientific mode is modified. It is necessary to repeat the same operation in the other scientific modes (total 15) to modify their operating tables, if needed.
°°°

** Verification is made by dumping the EEPROM fix and operating tables using procedure CIS1_MDUMP, 1 page starting at address defined in section 6.4.4.2 (currently @C000h).

** EEPROM checksum tables are not updated by ZEC1SAVS, so, after verification of the tables, it is is necessary to update EEPROM checksums table (32 words).

send ZEC1EECS
wait 10s
** CIS1 is not reseted by ZEC1SAVS nor ZEC1EECS.

Total duration: 11s + duration of CIS1_MDUMP

6.5.2.2. Procedure: CIS2TABSAVE

Purpose : Saves CIS2 current fix and operating tables from RAM to EEPROM. They becomes the default tables

Description :

Constraints: RAM table shall have a correct checksum

Initial conditions: Fix and operating tables in RAM have the correct value (CIS in the required status) and the correct checksum.

Final conditions: EEPROM fix and operating tables are updated. The new table number is the value of the parameter $tabnumber and the checksum of each table is recomputed and updated. The EEPROM checksum table is also updated by ZEC2SAVS. Then CIS2 is reseted automaticaly and restart in the same state.

** RAM fix tables becomes default fix table (EEPROM)
Send ZEC2SAVS,$tabnumb -- save tables in RAM to default tables in EEPROM
-- $tabnumb = 0 - 255 shall be incremented every time the RAM -- tables are saved in EEPROM. No automatic increment is -- performed by the on board software.
wait 30s

** Verification is made by dumping the EEPROM tables using procedure CIS1_MDUMP, 1 page starting at address @B800h

** The current operating table is saved in the area corresponding to the current scientific mode. Only the default table relative to this scientific mode is modified. It is necessary to repeat the same operation in the other scientific modes (total 5 tables) to modify their operating tables,if needed.

Total duration: 30s + duration of CIS1_MDUMP

6.5.2.3. Procedure CIS1_MDUMP

Purpose : Dump of n pages of an area of the CIS1 memory
Description : This procedure needs the address of the beginning of the dump and the number of pages to be dumped (256 words).
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It can also be used, in "Nominal operation modes". Not in housekeeping TM rate.
Initial conditions: No particular condition required
Final conditions: At the end, CIS1 continue to operate in the same mode.

**** Variables**
** start_addr_msb= MSB of the address of the beginning of the dump
** start_addr_lsb= LSB of the address of the beginning of the dump
** npagem_m1= number of pages to dump minus 1.

** Write MSB of the address
send ZEC1ADMS, start_addr_msb
wait 1s

** Write LSB of the address
send ZEC1ADLS, start_addr_lsb
wait 1s

** Start dump process for n pages
send ZEC1MDUS, npagem_m1
wait 20s for verification

** Verification: Dumped data are included in the science packet

Total duration: 2s + 20s for verification

6.5.2.4. Procedure: CIS2_MDUMP

Purpose : Dump of n pages of an area of the CIS2 memory
Description : This procedure needs the address of the beginning of the dump and the number of pages to be dumped (256 words).
Constraints: This procedure will be used during the commissioning phase with the PROM software (Partial operation mode). It can also be used, in "Nominal operation modes". Not in housekeeping mode.
Initial conditions: No particular condition required
Final conditions: At the end, CIS2 continue to operate in the same mode.

**** Variables**
** start_addr_msb= MSB of the address of the beginning of the dump
** start_addr_lsb= LSB of the address of the beginning of the dump
** npagem_m1= number of pages to dump minus 1.

** Write MSB of the address
send ZEC2ADMS, start_addr_msb
wait 1s

** Write LSB of the address
send ZEC2ADLS, start_addr_lsb
wait 1s

** Start dump process for n pages
send ZEC2MDUS, npagem_m1
wait 20s for verification

** Verification: Dumped data are included in the science packet

Total duration: 2s + 20s for verification

6.5.2.5. Procedure: CIS1_STIMULIS

Purpose: Test of the electronics of CODIF (CIS1 sensor), high and low sensitivity sections at the same time.

Description: This procedure will send stimulis to the input of the electronic boards at various places and various levels. This simulate particles pulses. The result is transmited to ground in the science data and indicate if the electronics is working correctly.

Constraints: This procedure willl be used during the nominal operation phase, on a routine basis (every months) to evaluate performances of the electronics of CODIF. It can also be used during the commissioning phase in "Nominal or Partial operation modes".

These procedure shall not be used when the telemetry mode is housekeeping because verification requires science data.

Initial conditions: CODIF high and low sensitivity sections shall be ON. CIS1 shall be in "Calibration" mode (Nominal operation mode 15). This gives the better telemetry products to evaluate results of this test

Final conditions: At the end, stimulis are stopped. Normal data acquisition can continue.

****Test description - short test:**

```
REGISTER DATA   OUTPUTS
                (IMMD)  (POLLED)          LOGIC MODES
                (HEX)   (DEC)    PIXEL       PIXEL DMA  POLCAL
STEP STIM CTRL  DMA     TOF POS  STIM        ADDED EVT  EVT
--- ----  ----  ---     --- ---  ----        ----  ---  ------
Init0000  0000  -       -   -    -           -     0    0  01
/* BASIC PIXEL TESTING : POLL=2 , IMMED=0
1   001F  A000  *       -   -    -           -     0    2  01
2   100C  A800  80C     012 101  PF1/PR1     -     0    2  01
3   1110  A800  91C     028 102  PF2/PR1     -     0    2  01
4   1220  A800  A62     098 104  PF3/PR1     -     0    2  01
5   1316  A800  B33     051 108  PF4/PR1     -     0    2  01
6   2419  A800  43F     063 210  PF5/PR2     -     0    2  01
7   251F  A800  55D     093 220  PF6/PR2     -     0    2  01
8   2627  A800  685     133 240  PF7/PR2     -     0    2  01
9   272F  A800  7AD     173 280  PF8/PR2     -     0    2  01
10  071F  A800  *       *   *    PF1/-       -     0    2  01
/* MODE TESTING:
11  3121  A000  *       103 302  PF2/PR1,2   -     0    0  01
12  1A23  C000  *771    113 146  PF3/PR1     PF2,7 0    0  10
13  2212  B400  *       *   *    PF3/PR2     -     1    1  01
14  3222  B400  *A6C    *108*304 PF3/PR1,2   -     1    1  01
15  1A28  C800  *78A    *139*104 PF3/PR1     PF2,7 2    0  10
16  111C  CC00  *       078 103  PF2/PR1     PF1   3    0  10
17  242A  CC00  *794    *   *    PF5/PR2     PF4   3    0  10
18  153A  CC00  *       228 130  PF6/PR1     PF5   3    0  10
19  0000  0000  *       *   *    -  /-       -     0    0  00
EXIT /* END OF SHORT TEST

* = Invalid or no data available (NUMBERS ARE FOR REV 17 ACTELS)
```

Henceforth parameters

name @024C msb @0248 msb	msbstim (hex)	name @024C lsb @0248 lsb	lsbstim (hex)	name @024D msb @0249 msb	msbpix (hex)	name @024D lsb @0249 lsb	lsbpix (hex)
msbstim1	x00	lsbstim1	x1F	msbpix1	xA0	lsbpix1	x00
msbstim2	x10	lsbstim2	x0C	msbpix2	xA8	lsbpix2	x00
msbstim3	x11	lsbstim3	x10	msbpix3*	xA8	lsbpix3	x00
msbstim4	x12	lsbstim4	x20	msbpix4*	xA8	lsbpix4	x00
msbstim5	x13	lsbstim5	x16	msbpix5*	xA8	lsbpix5	x00
msbstim6	x24	lsbstim6	x19	msbpix6*	xA8	lsbpix6	x00
msbstim7	x25	lsbstim7	x1F	msbpix7*	xA8	lsbpix7	x00
msbstim8	x26	lsbstim8	x27	msbpix8*	xA8	lsbpix8	x00
msbstim9	X27	lsbstim9	x2F	msbpix9*	xA8	lsbpix9	x00
msbstim10	x07	lsbstim10	x1F	msbpix10*	xA8	lsbpix10	x00
msbstim11	x31	lsbstim11	x21	msbpix11	xA0	lsbpix11	x00
msbstim12	x1A	lsbstim12	x23	msbpix12	xC0	lsbpix12	x00
msbstim13	x22	lsbstim13	x12	msbpix13	xB4	lsbpix13	x00
msbstim14	x32	lsbstim14	x22	msbpix14*	xB4	lsbpix14	x00
msbstim15	x1A	lsbstim15	x28	msbpix15	xC8	lsbpix15	x00
msbstim16	x11	lsbstim16	x1C	msbpix16	xCC	lsbpix16	x00
msbstim17	x24	lsbstim17	x2A	msbpix17*	xCC	lsbpix17	x00
msbstim18	x15	lsbstim18	x3A	msbpix18*	xCC	lsbpix18	x00

* These parameters are never used in this procedure

** **Initialisation HS section registers**
** Step0H - Stimuli: 0000 - Control: 0000

```
00:00:00    send ZEC1ADMS,0x02   -- Select MSB address
wait 1s     send ZEC1ADLS,0x4C   -- Select LSB address
wait 1s     send ZEC1DAMS,0x00   -- Select MSB data
wait 1s     send ZEC1IOWS,0x00   -- Write MS_stimulation value
wait 1s     send ZEC1ADLS,0x4D   -- Select LSB address
wait 1s     send ZEC1IOWS,0x00   -- Write MS_control register
```

**** Initialisation LS section registers**
** Step0L - Stimuli: 0000 - Control: 0000

```
wait 1s     send  ZEC1ADLS,0x48  -- Select LSB address
wait 1s     send  ZEC1IOWS,0x00  -- Write LS_stimulation value
wait 1s     send  ZEC1ADLS,0x49  -- Select LSB address
wait 1s     send  ZEC1IOWS,0x00  -- Write LS_control register
wait ~ 20s
```

**** Basic pixel testing**
** Step 1H - Stimuli: 001F - Control: A000

```
            send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim1
wait 1s     send ZEC1IOWS, lsbstim1
wait 1s     send ZEC1ADLS,0x4D
wait 1s     send ZEC1DAMS, msbpix1
wait 1s     send ZEC1IOWS, lsbpix1
wait ~15s
```

** Step 1L - Stimuli: 001F - Control: A000

```
            send  ZEC1ADLS,0x48
wait 1s     send ZEC1DAMS, msbstim1
wait 1s     send ZEC1IOWS, lsbstim1
wait 1s     send  ZEC1ADLS,0x49
wait 1s     send ZEC1DAMS, msbpix1
wait 1s     send ZEC1IOWS, lsbpix1
wait ~ 15s
```

** Step 2H - Stimuli: 100C - Control: A800

```
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim2
wait 1s     send ZEC1IOWS, lsbstim2
wait 1s     send  ZEC1ADLS,0x4D
wait 1s     send  ZEC1DAMS, msbpix2
wait 1s     send  ZEC1IOWS, lsbpix2
wait ~15s
```

** Step 2L - Stimuli: 100C - Control: A800

```
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1DAMS, msbstim2
```

```
wait 1s     send  ZEC1IOWS, lsbstim2
wait 1s     send  ZEC1ADLS,0x49
wait 1s     send  ZEC1DAMS, msbpix2
wait 1s     send  ZEC1IOWS, lsbpix2
wait ~ 15s

** Step 3H - Stimuli: 1110 - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim3
wait 1s     send ZEC1IOWS, lsbstim3
wait ~ 15s

** Step 3L - Stimuli: 1110 - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim3
wait ~ 15s

** Step 4H - Stimuli: 1220 - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim4
wait 1s     send ZEC1IOWS, lsbstim4
wait ~15s

** Step 4L - Stimuli: 1220 - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim4
wait ~ 15s

** Step 5H - Stimuli: 1316 - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim5
wait 1s     send ZEC1IOWS, lsbstim5
wait ~15s

** Step 5L - Stimuli: 1316 - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim5
wait ~ 15s

** Step 6H - Stimuli: 2419 - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim6
wait 1s     send ZEC1IOWS, lsbstim6
wait ~15s

** Step 6L - Stimuli: 2419 - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim6
wait ~ 15s
```

```
** Step 7H - Stimuli: 251F - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim7
wait 1s     send ZEC1IOWS, lsbstim7
wait ~15s

** Step 7L - Stimuli: 251F - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim7
wait ~ 15s

** Step 8H - Stimuli: 2627 - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim8
wait 1s     send ZEC1IOWS, lsbstim8
wait ~ 15s

** Step 8L - Stimuli: 2627 - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim8
wait ~ 15s

** Step 9H - Stimuli: 272F - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim9
wait 1s     send ZEC1IOWS, lsbstim9
wait ~ 15s

** Step 9L - Stimuli: 272F - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim9
wait ~ 15s

** Step 10H - Stimuli: 071F - Control: A800
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS, msbstim10
wait 1s     send ZEC1IOWS, lsbstim10
wait ~ 15s

** Step 10L - Stimuli: 071F - Control: A800
   send  ZEC1ADLS,0x48
wait 1s     send  ZEC1IOWS, lsbstim10
wait ~ 15s
```

**** Mode testing**

```
** Step 11H - Stimuli: 3121 - Control: A000
   send ZEC1ADLS,0x4C
wait 1s     send ZEC1DAMS,  msbstim11
```

wait 1s send ZEC1IOWS, lsbstim11
wait 1s send ZEC1ADLS,0x4D
wait 1s send ZEC1DAMS, msbpix11
wait 1s send ZEC1IOWS, lsbpix11
wait ~ 15s

** Step 11L - Stimuli: 3121 - Control: A000
send ZEC1ADLS,0x48
wait 1s send ZEC1DAMS, msbstim11
wait 1s send ZEC1IOWS, lsbstim11
wait 1s send ZEC1ADLS,0x49
wait 1s send ZEC1DAMS, msbpix11
wait 1s send ZEC1IOWS, lsbpix11
wait ~ 15s

** Step 12H - Stimuli: 1A23 - Control: C000
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim12
wait 1s send ZEC1IOWS, lsbstim12
wait 1s send ZEC1ADLS,0x4D
wait 1s send ZEC1DAMS, msbpix12
wait 1s send ZEC1IOWS, lsbpix12
wait ~ 15s

** Step 12L - Stimuli: 1A23 - Control: C000
send ZEC1ADLS,0x48
wait 1s send ZEC1DAMS, msbstim12
wait 1s send ZEC1IOWS, lsbstim12
wait 1s send ZEC1ADLS,0x49
wait 1s send ZEC1DAMS, msbpix12
wait 1s send ZEC1IOWS, lsbstim12
wait ~ 15s

** Step 13H - Stimuli: 2212 - Control: B400
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim13
wait 1s send ZEC1IOWS, lsbstim13
wait 1s send ZEC1ADLS,0x4D
wait 1s send ZEC1DAMS, msbpix13
wait 1s send ZEC1IOWS, lsbpix13
wait ~ 15s

** Step 13L - Stimuli: 2212 - Control: B400
send ZEC1ADLS,0x48
wait 1s send ZEC1DAMS, msbstim13
wait 1s send ZEC1IOWS, lsbstim13
wait 1s send ZEC1ADLS,0x49
wait 1s send ZEC1DAMS, msbpix13
wait 1s send ZEC1IOWS, lsbpix13

wait ~ 15s

** Step 14H - Stimuli: 3222 - Control: B400
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim14
wait 1s send ZEC1IOWS, lsbstim14
wait ~ 15s

** Step 14L - Stimuli: 3222 - Control: B400
send ZEC1ADLS,0x48
wait 1s send ZEC1IOWS, lsbstim14
wait ~ 15s

** Step 15 H - Stimuli: 1A28 - Control: C800
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim15
wait 1s send ZEC1IOWS, lsbstim15
wait 1s send ZEC1ADLS,0x4D
wait 1s send ZEC1DAMS, msbpix15
wait 1s send ZEC1IOWS, lsbpix15
wait ~ 15s

** Step 15L - Stimuli: 1A28 - Control: C800
send ZEC1ADLS,0x48
wait 1s send ZEC1DAMS, msbstim15
wait 1s send ZEC1IOWS, lsbstim15
wait 1s send ZEC1ADLS,0x49
wait 1s send ZEC1DAMS, msbpix15
wait 1s send ZEC1IOWS, lsbpix15
wait ~ 15s

** Step 16H - Stimuli: 111C - Control: CC00
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim16
wait 1s send ZEC1IOWS, lsbstim16
wait 1s send ZEC1ADLS,0x4D
wait 1s send ZEC1DAMS, msbpix16
wait 1s send ZEC1IOWS, lsbpix16
wait ~ 15s

** Step 16L - Stimuli: 111C - Control: CC00
send ZEC1ADLS,0x48
wait 1s send ZEC1DAMS, msbstim16
wait 1s send ZEC1IOWS, lsbstim16
wait 1s send ZEC1ADLS,0x49
wait 1s send ZEC1DAMS, msbpix16
wait 1s send ZEC1IOWS, lsbpix16
wait ~ 15s

** Step 17H - Stimuli: 242A - Control: CC00
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim17
wait 1s send ZEC1IOWS, lsbstim17
wait ~ 15s

** Step 17L - Stimuli: 242A - Control: CC00
send ZEC1ADLS,0x48
wait 1s send ZEC1IOWS, lsbstim17
wait ~ 15s

** Step 18H - Stimuli: 153A - Control: CC00
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS, msbstim18
wait 1s send ZEC1IOWS, lsbstim18
wait ~ 15s

** Step 18L - Stimuli: 153A - Control: CC00
send ZEC1ADLS,0x48
wait 1s send ZEC1IOWS, lsbstim18
wait ~ 15s

**** Return to normal operations - Stimulis OFF**
** Step 19H - Stimuli: 0000 - Control: 0000
send ZEC1ADLS,0x4C
wait 1s send ZEC1DAMS,0x00
wait 1s send ZEC1IOWS,0x00
wait 1s send ZEC1ADLS,0x4D
wait 1s send ZEC1IOWS,0x00
wait ~ 15s

** Step 19L - Stimuli: 0000 - Control: 0000
send ZEC1ADLS,0x48
wait 1s send ZEC1IOWS,0x00
wait 1s send ZEC1ADLS,0x49
wait 1s send ZEC1IOWS,0x00
wait ~ 30s

`Total duration: 724s = 12mn04s`

6.5.2.6. Procedure: CIS2_AMPTST

Purpose: Test of the electronics of CIS2 (amplifiers + counters + DPU)

Description: This procedure will send stimulis to the input of the amplifiers.This simulate particle pulses. The result is transmited to ground in the science data and indicate if the electronics is working correctly.

Constraints: This procedure willl be used during the nominal operation phase, on a routine basis (every months) to evaluate performances of the electronics of CIS2. It will also be used during the commissioning phase in "Nominal or Partial operation modes".

This procedure shall not be used when the telemetry mode is housekeeping because verification requires science data.

Initial conditions: CIS2 discriminators level are at the nominal level. Test generator is OFF. CIS is in "Calibration" mode (Nominal operation mode 15). This gives the better telemetry products to evaluate results of this test but this is not mandatory.

Final conditions: At the end, test generator is stopped. Discriminator levels are set to the nominal value for acquisition of scientific data. Normal data acquisition can continue.

Henceforth parameters

Name of parameter	CIS2-F8 clu #5	CIS2-F5 clu #6	CIS2-F6 clu #7	CIS2-F7 clu #8	CIS2-F4 spare	comments
$disc1lvltst	213	213	213	213	213	Discriminator level, high sensitivity section. Level used for amplifiers testing (~4,0volt)
$disc2lvltst	213	213	213	213	213	Discriminator level, low sensitivity section. Level used for amplifiers testing (~4,0volt)
$disc1lvlnom	160	160	160	160	160	Discriminator level, high sensitivity section. Level used for nominal operations (~3,0volt)
$disc2lvlnom	160	160	160	160	160	Discriminator level, low sensitivity section. Level used for nominal operations (~3,0volt)

```
** Discriminator levels are set to the value compatible with test generator.
send ZEC2DL1S, $disc1lvltst
wait 1s
send ZEC2DL2S, $disc2lvltst
wait 1s

** Test generator active for 60s
send ZEC2TSTN
wait30s and verify discriminator levels
ECHADIS1= 4,0v
ECHADIS2= 4,0v
wait 30s
send ZEC2TSTF
```

**Discriminator levels are returned to the nominal value.
send ZEC2DL1S, $disc1lvlnom
wait 1s
send ZEC2DL2S, $disc2lvlnom
wait 30s
verify discriminator levels
ECHADIS1~3,0vECHADIS2~3,0v

Total duration: 93s = 1mn33s

**** end**

6.5.2.7. Procedure: CIS1_RPADEFL

Purpose: Modification of voltages applied to the RPA deflection plates.
Description: This procedure modify RPA -247v and RPA -153v.
Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".
Initial conditions: Initial RPA deflection voltages .
Final conditions: At the end, the new voltages are applied to the RPA deflection plates.

Henceforth parameters

Model/Name of parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4 spare	Comments
$c_m247	121d (-245.7v)	139d (-250.4v)	118d (-244.5v)	187d (-264v)	110d (-243v)	
$c_m153	188d (-163.6v)	169d (-160.2v)	174d (-159.5v)	202d (-166v)	120d (-152v)	

** Adjust RPA deflection plate voltage N°1 (-247 volt) to the required level.
send ZEC1RA1S,$c_m247 -- 0 < $c_m247 < 192
wait 1s
** Adjust RPA deflection plate voltage N°2 (-153 volt) to the required level
send ZEC1RA2S, $c_m153; wait 5s -- 0 < $c_m153 < 255
** The commanded value is saved in the RAM operating table. Verification is made by dumping the EEPROM fix and operating tables using procedure CIS1_MDUMP, 1 page starting at address defined in section 6.4.4.2 (currently @B000). To become the default value, it shall be saved in EEPROM

** When RPA is ON, verify that:
ECCRN247 = c_m247* p_m247 + o_m247 + ECCRVOUT +/- 3%
ECCRN153 = c_m153 * p_m153 + o_m153 + ECCRVOUT +/- 3%

Parameters for verification

Model / Parameter	CIS1-F8 clu #5	CIS1-F5 clu #6	CIS1-F6 clu #7	CIS1-F7 clu #8	CIS1-F4 spare
p_m247 (volt/bit)	-0.277	-0.275	-0.276	-0.277	-0.276
o_m247 (volt)	-212.2	-211.74	-212	-212.31	-212.54
p_m153 (volt/bit)	-0.17	-0.17	-0.159	-0.17	-0.17
o_m153 (volt)	-131.52	-131.3	-131.9	-131.52	-131.52

Total duration: 6s + duration of CIS1_MDUMP

6.5.2.8. Procedure: CIS1_RPASWEEP

Purpose: Modification of parameters defining the RPA sweep

Description: This procedure modify 13 parameters in EEPROM(base, modifier parameters used to compute the caracteristics of a new sweep for RPA and also the parameters used to compute the thresholds for the various ion species). At the end the new value of the parameters is stored in the table. After a the command setting the RPA mode (number 6), computation is executed and a new sweep is generated and replace the old one in RAM. Thresholds are updated.

Constraints: This procedure can be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal operation modes".

These procedure shall not be used when the telemetry mode is housekeeping because verification necessitate science data.

Initial conditions: Nominal mode, initial RPA sweep, initial thesholds.

Final conditions: At the end, RPA sweep is the new one defined by the new parameters and thresholds are replaced by the new ones.

** For RPA mode (number 6) one table is available in EEPROM, containing 13 parameters. The address of this table is contained in the operating table relative to the RPA mode of operation (word N°1 and 2). It contains 13 parameters that are used to compute on board the RPA sweep and the thresholds for the various ion species. Every time the command ZEC1ECMOD,6 is received by CIS the appropriate operating table is loaded and the sweep tables and thresholds are recomputed, even if the RPA mode is alraedy running.

So, the modification of the RPA sweep in nominal mode can only be performed by loading the new 13 parameters using a block command .

The procedure is the following:

1) Upload the new 13 parameters (or more if more than 1 table should be modified) by using block command (IPCH file).

2) Dump the memory area starting at address C156 hex, one page to verify that uploading is correct, using procedure CIS1_MDUMP (6.5.2.3).

3) After verification, recompute EEPROM checksum table, using procedure 1EEPCHK (5.9.4.8)

4) To verify that the table is working, go to RPA mode (number 6), using procedure CISMODECHG (6.5.1.8).

6.5.2.9. Procedure: CIS1_SWEEPTHRESH

Purpose: Modification of parameters defining the analyser HV sweep

Description: This procedure modify 13 parameters in EEPROM(base, modifier parameters used to compute the caracteristics of a new sweep for analyser HV and also the parameters used to compute the thresholds for the various ion species). At the end the new value of the parameters is stored in the table. After a mode change, computation is executed and a new sweep is generated and replace the old one in RAM. Thresholds are updated.

Constraints: This procedure can be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".

These procedure shall not be used when the telemetry mode is housekeeping because verification necessitate science data.

Initial conditions: Nominal mode, initial analyser HV sweep, initial thesholds.

Final conditions: At the end, analyser HV sweep is the new one defined by the new parameters and thresholds are replaced by the new ones.

** For each one of the 15 modes of operation two tables are available in EEPROM, each one containing 13 parameters. The first table is relative to the nominal sweep and the second table is relative to the alternate sweep. This adresses of these tables are contained in the operating table relative to each mode of operation (word N°1 and 2). Every table contains 13 parameters that are used to compute on board the analyser HV sweep and the thresholds for the various ion species. Every time the command ZEC1ECMOD,$modnum is received by CIS a new operating table is loaded and the sweep tables and thresholds are recomputed, even if the mode number is the current mode running.

So, the modification of the HV sweep in nominal mode can only be performed by loading the new 13 parameters using a block command .

The procedure is the following:

1) Upload the new 13 parameters (or more if more than 1 table should be modified) by using block command (IPCH file).

2) Dump the memory area starting at address C136 hex, one page to verify that uploading is correct, using procedure CIS1_MDUMP (6.5.2.3).

3) After verification, recompute EEPROM checksum table, using procedure 1EEPCHK (5.9.4.8)

4) To verify that the table is working, go to the operating mode where this table is used , using procedure CISMODECHG (6.5.1.8).

6.5.2.10. Procedure: CIS1MEMWR1W

Purpose: Writes 1 word in CIS1 RAM

Description: This procedure will be used to write 1 word in RAM. It can be used to modify fix tables in ram, for example to change the speed of HV rising when HVs are decreased.

Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".

Initial conditions: Old word in RAM .

Final conditions: New word in RAM at the defined address.

Henceforth parameters

Name of parameter	Value CLU #5,6,7,8 (hex)	Comments
$addrmsb	7Fh	Most significant bit of the address
$addrlsb	FFh	Least significant bit of the address
$datamsb	00h	Most significant bit of data
$datalsb	00h	Most significant bit of data

```
**  Write 1 word in RAM memory
00:00:00 send ZEC1ADMS, $addrmsb       -- define MSB address
wait 1s   send ZEC1ADLS, $addrlsb      -- define LSB address
wait 1s   send ZEC1DAMS, $datamsb      -- define MSB of data word
wait 1s   send ZEC1MEMS, $datalsb -- define LSB of data word and write data in RAM
wait 1s
```

** Verification can be made by dumping the memory area

** Total duration: 4s

6.5.2.11. Procedure: CIS2MEMWR1W

Purpose: Writes 1 word in CIS2 RAM

Description: This procedure will be used to write 1 word in RAM. It can be used to modify fix tables in ram, for example to change the speed of HV rising when HVs are decreased.

Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".

Initial conditions: Old word in RAM .

Final conditions: New word in RAM at the defined address.

Henceforth parameters

Name of parameter	Value CLU #5,6,7,8 (hex)	Comments
$header	C000h	header of the block command
$addr	7FFFh	address
$data	0000h	data
$checksum	C001h	checksum

** Write 1 word in RAM memory by block command
00:00:00 send ZEC1LOAD, $header -- header
wait 1s send ZEC1LOAD, $addr -- address
wait 1s send ZEC1LOAD, $data -- data word
wait 1s send ZEC1LOAD, $checksum -- checksum
wait 1s

** Verification can be made by dumping the memory area

** Total duration: 4s

6.5.2.12. Procedure: CIS1_SCRATCHOFF

Purpose: Switches scratch memory OFF
Description:
Constraints: This procedure willl be used during the nominal operation phase. . It will also be used during the commissioning phase in "Nominal or Partial operation modes".
Initial conditions: Scratch memory ON
Final conditions: Scratch memory OFF

**
send ZEC1SCRF
wait 1s

** Verification
after 20s verify scratch memory status and voltage:
ECP1BPWR = OFF
ECCAVSCR = ~0 volt

Total duration: 1s + 20s for verification

6.5.2.13. Procedure: CIS1_SCRATCHON

Purpose: Switches scratch memory ON
Description:
Constraints: This procedure willl be used during the nominal operation phase. . It will also be used during the commissioning phase in "Nominal or Partial operation modes".
Initial conditions: Scratch memory OFF
Final conditions: Scratch memory ON

**
send ZEC1SCRN
wait 1s

** Verification
after 20s verify scratch memory status and voltage:
ECP1BPWR = ON
ECCAVSCR = ~4.44O volt

Total duration: 1s + 20s for verification

6.5.2.14. Procedure: CIS1_SCRATCHTST

Purpose: Test of scratch memory
Description:
Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal operation modes".
This test takes about 12060s
Initial conditions: Scratch memory OFFN, nominal operation
Final conditions: Scratch memory ON but cleared

**
send ZEC1SCRS
wait 60s
-- Test is possible only in the EEPROM nominal mode (command ZEC1SCRS only valid in nominal mode and echoed only at the end of a successful test). At the beginning, the scratch memory is switched ON. Then, a test sequence is executed (duration about 2 minutes). When the test is finished, the scratch memory is switched off. If an error occurs then an error is issued type "1A", the scratch memory is immediatly switched OFF and the command ZEC1SCRS is not echoed.

-- start of the test sequence

send ZEC1SCRS

-- wait until scratch memory goes ON (10 seconds maximum)

check ECP1BPWR = "BPWR ON"

--then check scratch memory voltage

4.2 volt < ECAVSCR < 4.7 volt

-- wait until end of test (duration about 2 minutes)

check ECP1BPWR = "BPWR OFF"

--Verify that scratch memory test is successfully completed : command echoed, last error issued different from type 1A.

if ECP1CMDW = 0x0345 and ECP1ETYP # 0x1A then test successful

else test wrong.

** Verification
after 60s test of scratch memory is finish. An error word A is issued when an error occurs during the memory test.

Total duration: 12060s

6.5.2.15. Procedure: CIS1_SPINPHADJ

Purpose: Adjust the phase of the begining of measurement of CIS1 relatively to the sun reference pulse

Description:

Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal operation modes".

Initial conditions: Old value of spin phase

Final conditions: New value of spin phase

Henceforth parameters

Name of parameter	Value CLU #5	Value CLU #6	Value CLU #7	Value CLU #8	Comments
$spinphase1	4Bh 75d (26.367°)	4Bh 75d (26.367°)	4Bh 75d (26.367°)	4Bh 75d (26.367°)	Spin phase value adjusted by 1/1024th of spin: 8bits - range 0-255

**
send ZEC1SPAS, $spinphase1
wait 1s

** Verification:Check ECP1CONF, word N°06h (see section 2.2.9)
In the science data the position of the beams is shifted.

** In the solar wind modes (modes N° 0 to 5), the analyser high voltage sweep is modified around the solar wind. If the phase is modified, the begining of the alternate sweep relatively to the solar wind is modified accordingly by the sofware (see section 6.4.4.3).

Total duration: 1s

6.5.2.16. Procedure: CIS2_SPINPHADJ

Purpose: Adjust the phase of the begining of measurement of CIS2 relative to sun reference pulse

Description:

Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal operation modes".

Initial conditions: Old value of spin phase

Final conditions: New value of spin phase

Henceforth parameters

Name of parameter	Value CLU #5	Value CLU #6	Value CLU #7	Value CLU #8	Comments
$spinphase2	4Bh 75d (26.367°)	4Bh 75d (26.367°)	4Bh 75d (26.367°)	4Bh 75d (26.367°)	Spin phase offset adjusted by 1/1024th of spin: 8bits - range 0-255; 0.353°/bit

If $spinphase2 = 0 →185 then the phase shift is positive relatively to the nominal value: 0 → 0°; 185 → +65.3°

If $spinphase2 = 186 -> 255 then the phase shift is negative relatively to the nominal value: 186 → -0.353°; 255 → -24.706°

```
**
send ZEC2SPAS, $spinphase2
wait 1s

** Verification in the science data
```

** In the solar wind modes (modes N° 0 to 5), the analyser high voltage sweep is modified around the solar wind. If the phase is modified, the begining of the of the modified sweep is also tilted relatively to the solar wind. If this phase shall also be corrected, it is necessary to modify operating table, word n°3 (see section 6.4.5.3) and table Op_Chg_Md_T in EEPROM. Check with A.Di Lellis for the correct value to put in these tables. A description of these tables and of the way the phase is used is included in the CIS2 document "FM Normal Operation Software" which is annexed.

** In solar wind modes, it is better to use only small phase shifts. Large phase shifts can be exercised in calibration mode (mode 15).

Total duration: 1s

6.5.2.17. Procedure: CIS2_DISCRISET

Purpose: CIS2 discriminator levels adjustement
Description: This procedure modify the current discrimator level setting.
Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".
Initial conditions: CIS2 discriminators level are at the nominal level.
Final conditions: At the end, discriminator levels are set to the new value.

Henceforth parameters

Name of parameter	Value CLU #1 (dec)	Value CLU #2 (dec)	Value CLU #3 (dec)	Value CLU #4 (dec)	Comments
$disc1lvlnew	160	160	160	160	Discriminator level, high sensitivity section. Level used for nominal operations (~3,0volt)
$disc2lvlnew	160	160	160	160	Discriminator level, low sensitivity section. Level used for nominal operations (~3,0volt)

**Discriminator levels are set to the new value.
send ZEC2DL1S, $disc1lvlnew
wait 1s
send ZEC2DL2S, $disc2lvlnew
wait 10s
after ~30s verify discriminator levels
ECHADIS1 ~ new value (volt)
ECHADIS2 ~ new value (volt)

Total duration: 11s + 30s for verification

6.5.2.18. Procedure: CIS1_ACCHVFAST

Purpose: Writes 1 word in CIS1 RAM in order to decrease Acceleration HV quickly
Description: This procedure will be used to write the word defining the HV rising speed in CIS1 RAM fix table. when HVs are decreased.
Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".
Initial conditions: Old speed.
Final conditions: New word speed.

Henceforth parameters

Name of parameter	Value CLU #1,2,3,4	Comments
$addrmsb	12h	Most significant bit of the address of PACC HV rate of change
$addrlsb	82h	Least significant bit of the address of PACC HV rate of change
$datamsb	01h	Most significant bit of data of PACC HV rate of change
$datalsb	F4h	Most significant bit of data of PACC HV rate of change

** Current address is BOO9h and data -> 0,5s -> 500d = 01F4h

Use CIS1_MEMWR1W with the above parameters (see section 6.5.2.10)

When the new value is uploaded, the checksum of the current fix table is not correct. It is not possible to save the current fix table in the default fix table (EEPROM) without recomputing the checksum. An error (11h) is then issued until the checksum is correct (tbc).

6.5.2.19. Procedure: CIS1_MCPFAST

Purpose: Writes 1 word in CIS1 RAM in order to decrease MCP HV quickly

Description: This procedure will be used to write the word defining the HV rising speed in CIS1 RAM fix table. when HVs are decreased.

Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".

Initial conditions: Old speed.

Final conditions: New word speed.

Henceforth parameters

Name of parameter	Value CLU #1,2,3,4	Comments
$addrmsb	12h	Most significant bit of the address of MCP HV rate of change
$addrlsb	80h	Least significant bit of the address of MCP HV rate of change
$datamsb	01h	Most significant bit of data of MCP HV rate of change
$datalsb	F4h	Most significant bit of data of MCP HV rate of change

** Current address is BOO7h and data -> 0,5s -> 500d = 01F4h

Use CIS1_MEMWR1W with the above parameters (see section 6.5.2.10)

When the new value is uploaded, the checksum of the current fix table is not correct. It is not possible to save the current fix table in the default fix table (EEPROM) without recomputing the checksum. An error (11h) is then issued until the checksum is correct (tbc).

6.5.2.20. Procedure: CIS2_MCPFAST

Purpose: Writes 1 word in CIS2 RAM in order to decrease MCP HV quickly

Description: This procedure will be used to write the word defining the HV rising speed in CIS2 RAM fix table. when HVs are decreased.

Constraints: This procedure willl be used during the nominal operation phase. It will also be used during the commissioning phase in "Nominal or Partial operation modes".

Initial conditions: Old speed.

Final conditions: New word speed.

Henceforth parameters

Name of parameter	Value CLU #1,2,3,4 (dec)	Comments
$header	C000h	header of the block command
$addr	00A3h	Current address is B804h
$data	00C8h	data -> 0,5s -> 200d = 00C8h
$checksum	3E95h	checksum

Use CIS2_MEMWR1W with the above parameters (see section 6.5.2.11)

When the new value is uploaded, the checksum of the current fix table is not correct. The checksum can be recomputed by sending a command which modify one word of the fix table (ZEC2DIS1 for exemple). No error is issued even if the checksum of the fix table is not correct (tbc).

6.5.2.21. Procedure: RPA_ON

Purpose: RPA voltages switched ON
Description: This procedure switch RPA deflection voltages ON (-153V , -247V, -110V, +220V and RPA cut-off voltage)
Parameter: No parameter
Constraints: This procedure will be used during the operational phase.
Initial conditions: RPA is OFF
Final conditions: RPA is ON

** Verify that CIS1 is in partial mode and RPA deflection voltage at ~ 0volt
verify: ECP1MOD=7
verify: ECCRN100< 1volt
verify: ECCRN247< 1volt
verify: ECCRN153< 1.5volt
verify: ECCRP220< 1volt

** Switch RPA ON
send ZEC1RPAN
wait 10s

** When RPA is ON, verify parameters. RPA cut-off voltage is normally set to 0volt
verify: -103volt<ECCRN100< -97volt
verify: -250volt<ECCRN247< -244volt
verify: -156volt<ECCRN153< -150volt
verify: +217volt<ECCRP220< +223volt

Total duration: 10s

6.5.2.22. Procedure: RPA_OFF

Purpose: RPA voltages switched OFF
Description: This procedure switch RPA deflection voltages OFF(-153V , -247V, -110V, +220V and RPA cut-off voltage)
Parameter: no parameter
Constraints: This procedure will be used during the operational phase.
Initial conditions: RPA is ON
Final conditions: RPA is OFF

** Verify that CIS1 is in partial mode and RPA is ON
verify: ECP1MOD=7

verify: -270volt<ECCRN247< -190volt
verify: -180volt<ECCRN153< -100volt
verify: +217volt<ECCRP220< +248volt

** Switch RPA OFF
send ZEC1RPAF
wait 10s

** When RPA is OFF, verify parameters
verify: ECCRN100< 1volt
verify: ECCRN247< 1volt
verify: ECCRN153< 1.5volt
verify: ECCRP220< 1volt

Total duration: 10s

6.5.2.23. Procedure: HS/LS_SEL

Purpose: Select data from HS or LS section
Description: *Parameter:* Parameter 0-> Low sensitivity section data selected
Parameter 1-> High sensitivity section data selected
Constraints: This procedure will be used during the operational phase.
Initial conditions:
Final conditions: Data transmited are coming from the selected section

** selection of section used.
send ZEC1SHLS,$sens
wait 10s

**Verify
if $sens=0 then ECCDSENS=LS
if $sens=1 then ECCDSENS=HS
else no meaning

** Default value
Henceforth parameter:
$sens=1

Total duration: 10s

6.5.2.24. Procedure: ANY_CMD

Purpose: Send one command to CIS (any command)
Description: This procedure can send any command to CIS. To be use carefully because there is no verification by ESOC of the validity of the command.
Parameter: Parameter is the hex value of the command
Constraints: This procedure will be used during the nominal phase.
Initial conditions:
Final conditions: Command is executed

**
send ZEC1PARS,$anycmd
wait 10s

verify echo: ECP1CMDW=$anycmd

** Default value
Henceforth parameter:
$anycmd= 0x0300 (CIS1 cover actuator off)
Total duration: 10s

6.5.2.25. Procedure: CIS2ON

Purpose: The purpose of this procedure is to switch CIS2 ON, and to verify that the status reached is the correct one.
Description:
Initial conditons: CIS2 is OFF
Final Conditions: CIS2 is ON in nominal mode with the dialog established with CIS1

**** CIS2 ON**
send ZEC1PWRN
wait 4s
**** Reset CIS2 processor after CIS2 powered ON**
If primary lpc interface selected then
send ZECLPC2A -- CIS2 reset
else
send ZECLPC2B -- CIS2 reset
endif
wait 4 formats

**** Verification of CIS2 status after switch ON**
Verification: ECL2PWRS=ON

** Verification of low power voltages and current
+4.8V <ECL2VP5_< +5.2V -- CIS2 LPC +5V
+11.7V <ECL2VP12< +12.3V -- CIS2 LPC +12V
-12.3V <ECL2VN12< -11.7V -- CIS2 LPC -12V

75mA <ECL2ITOT< 95mA -- CIS2 total current (nominal 85mA)

6.5.2.26. Procedure: CIS2OFF

Purpose: The purpose of this procedure is to switch CIS2 OFF, and to verify that the status reached is the correct one.

Description:

Initial conditons: CIS2 is in survival mode

Final Conditions: CIS2 is OFF

**** CIS2 OFF**

send ZEC1PWRF
wait 5s

Verification: ECL2PWRS=OFF

Total duration: 5s

6.5.2.27. Procedure: CIS1I/OWR1W

Purpose: Writes 1 I/O word in CIS1
Description: This procedure will be used to write 1 I/O word in CIS1.
Constraints: This procedure willl be used during the nominal operation phase in "Nominal or Partial operation modes".
Initial conditions: None
Final conditions: New I/O word written at the defined address.

Default values

Name of parameter	Value CLU #1,2,3,4 (hex)	Comments
$io1addrmsb	FFh	Most significant bit of the address
$io1addrlsb	FFh	Least significant bit of the address
$io1datamsb	00h	Most significant bit of data
$io1datalsb	00h	Most significant bit of data

** Write 1 I/O word
00:00:00 send ZEC1ADMS, $io1addrmsb -- define MSB of I/O address
wait 1s send ZEC1ADLS, $io1addrlsb -- define LSB of I/O address
wait 1s send ZEC1DAMS, $io1datamsb -- define MSB of of I/O data word
wait 1s send ZEC1IOWS, $io1datalsb -- define LSB of of I/O data word and write data wait 1**s**

** Verification is difficult and depend of what is written and where.

** Total duration: 4s

6.5.2.28. Procedure: CIS2I/OWR1W

Purpose: Writes 1 I/O word in CIS2
Description: This procedure will be used to write 1 I/O word in CIS2.
Constraints: This procedure willl be used during the nominal operation phase in "Nominal or Partial operation modes".
Initial conditions: None
Final conditions: New I/O word written at the defined address.

Default values

Name of parameter	Value CLU #1,2,3,4 (hex)	Comments
$io2addrmsb	FFh	Most significant bit of the address
$io2addrlsb	FFh	Least significant bit of the address
$io2datamsb	00h	Most significant bit of data
$io2datalsb	00h	Most significant bit of data

** Write 1 I/O word
00:00:00 send ZEC2ADMS, $io2addrmsb -- define MSB of I/O address
wait 1s send ZEC2ADLS, $io2addrlsb -- define LSB of I/O address
wait 1s send ZEC2DAMS, $io2datamsb -- define MSB of of I/O data word
wait 1s send ZEC2IOWS, $io2datalsb -- define LSB of of I/O data word and write data wait 1**s**

** Verification is difficult and depend of what is written and where.

** Total duration: 4s

6.2.2.29. Procedure: HSLS_ONOFF

Purpose:	To switch CODIF low and/or high sensitivity sections of the electronics of CODIF, ON or OFF.
Description:	This procedure command CODIF low sensitivity and high sensitivity electronics OFF or ON by writing the right value I/O address @=0290h.
Constraints:	This procedure can be used in "Nominal operation modes" for some specific tests.
Initial conditions:	CODIF low sensitivity or high sensitivity section initial status.
Final conditions:	At the end, CODIF low sensitivity and high sensitivity sections are in the commanded status. Monitor CIS1 total current

```
** Record CIS1 current
record ECL1ITOT

** Switch low sentivity and/or high sensitivity section electronics ON or OFF
send ZEC1ADMS,0x02        -- Select MSB address
wait 1s
send ZEC1ADLS,0x90        -- Select LSB address
wait 1s
send ZEC1DAMS,0x00        -- Data MSB=0
wait 1s
send ZEC1IOWS, stathsls   -- Data LSB=stathsls and write
wait 1s

** Monitor CIS1 current value
verify that ECL1ITOT  decreases or increase by 20 or 40mA depending of the requested transition
verify that ECCAVP5 decreases from ~4.6 volt to 4.0 volt when both sections are switched off.
```

<u>Values of stathsls:</u>

HS OFF and LS OFF: stathsls = 0
HS OFF and LS ON: stathsls = 1
HS ON and LS OFF: stathsls = 2
HS ON and LS ON: stathsls = 3

Default value: stathsls=3

Total duration: 4s.

6.2.2.30. Procedure: CIS1_HOTRST

Purpose: CIS1 hot reset.
Description: This procedure send a hot reset to CIS1.
Constraints: This procedure will be used if a default is detected in CIS1 operations, or if we wish to restart from a default status.
Initial conditions: Some default detected in CIS1 operations.
Final conditions: CIS1 1 restart in EEPROM with the status defined in the fix tables (default fix tables if ram errors or ram fix tables if

** CIS1 hot reset
If CIS1 primary low power command interface selected then
send ZECLPC1A -- hot reset
else (redundant low power command interface selected)
send ZECLPC1B -- hot reset
wait 10s

**verify that frame counter testart at 1

Total duration: 10s.

6.2.2.31. Procedure: BLCK_CMD

Purpose: Send a block command to CIS.
Description: This procedure could be used to modify fix tables in RAM or EEPROM for exemple, without using IPCH files
Constraints: This procedure is limited to send a few words (in any case less than 21). It is normaly followed by a memory dump of the written area.
Initial conditions: None.
Final conditions: Data written in memory.

** Send n succesives commands 1<n<21 as a block command

for i=1 to n
send ZEC1PARS, $wordi
send 3 dummy commands
end for
wait 10s
verify echo: ECP1CMDW=$word1

** Default value

Total duration: 10s.

Cluster - CIS

User Manual for CIS Flight Operations

7. CRITICAL OPERATIONS

7.1 SHORT ECLIPSES (less than 50 minutes)

During short eclipses, CIS is operating in nominal mode or in CODIF reduced power mode, according to the available power. This is done by switching off the electronics detector part which is not used (LS or HS). It will save about 2 watts. Use procedure HS/LS_ONOFF with parameter = 1 or 2.

7.1.1 Preparation of CIS before the eclipse

If the available power imposes reduced power mode switch part of CODIF OFF using procedure HS/LS_ONOFF with parameter = 1 or 2..
Set the eclipse flag for CIS2 by writing 1 at address B809h in EEPROM or 00A8h in RAM when is in Nominal mode.
To write in RAM, the content is : C000 hex, 00A8 hex, 0001 hex and 3F57 hex
To write in EEPROM the content is : C000 hex, B809 hex, 0001 hex and 87F6 hex

If address B809h is used, the software will go in Partial mode. In this case, 2EEPCHK has to be used to jump back to Nominal mode.

7.1.2 Monitoring of activities

No modification to the normal monitoring.

7.1.3 Conditioning after the eclipse

Being outside the eclipse :
- if the CODIF reduced power mode had been switched, return to the normal power mode Use procedure HS/LS_ONOFF with parameter = 3.

Disable the eclipse flag for CIS2 by writing 0 at address B809h in EEPROM or 00A8h in RAM when is in Nominal mode. This is done in both cases by using a block of commands
To write in RAM, the content is : C000 hex, 00A8 hex, 0000 hex and 3F58 hex.
To write in EEPROM the content is : C000 hex, B809 hex, 0000 hex and 87F7 hex

7.1.4 Constraints

All CIS data acquisition is synchronised to the Sun Reference Pulse. Since this one is not available to the instruments during eclipses, CIS data acquisition cycles are controlled by the CIS processor timer. They become thus asynchronous to the spacecraft spin, an effect that introduces a degradation in the data timing precision.

7.1.5 Resources

CODIF reduced power mode during short eclipses will be commanded only if the available spacecraft power resources necessitate it.

7.1.6 Procedures

cf. 7.1.1 and 7.1.3.

7.2 LONG ECLIPSES (50' < duration < 4h30')

During long eclipses CIS will be switched Off.

7.2.1 Preparation of CIS before the eclipse

The procedure for switching Off CIS is :

Switch off CIS1 analyser using procedure 1ANLOF

Switch off CIS2 analyser using procedure 2ANLOF

HIA MCP HV slowly down to zero. Use procedure 2MCPSET with parameter 0.

Decrease CODIF MCP HV slowly down to zero. Use procedure 1MCPSET with parameter 0.

wait 150s

Decrease CODIF Acceleration HV slowly down to zero . Use procedure 1ACCSET with parameter 0.

wait 250s

HS/LS_ONOFF with parameter 0

Then the instrument can be switched Off.

If the available power resources allow it, the heaters will be switched On during the eclipse.

7.2.2 Monitoring of activities

CIS monitoring is limited to monitoring of the temperature of the two boxes.

7.2.3 Conditioning after the eclipse

After the eclipse the instrument is switched On, following the CISON procedure described in 6.5.1.1

7.2.4 Constraints

None_

7.2.5 Resources

If the available power resources allow it, the heaters will be switched On during the eclipse.

7.2.6 Procedures

cf. 7.2.1 and 7.2.3.

7.3 PERIGEE PASSAGES

MCPs High Voltages are lowered during the perigee passages, to avoid acceleration of gain fatigue due to high counting rates.

7.3.1 Preparation of CIS before perigee

The procedure for preparation is:

Switch off CIS1 analyser using procedure 1ANLOF

Switch off CIS2 analyser using procedure 2ANLOF

HIA MCP HV slowly down to 1500 volts. Use procedure 2MCPSET with parameter 110 dec.

Decrease CODIF MCP HV slowly down to 1500 volts. Use procedure 1MCPSET with parameter 84 dec.

wait 200s

HS/LS_ONOFF with parameter = 0

7.3.2 Monitoring of activities

No modification to the normal monitoring.

7.3.3 Conditioning after perigee passage

This procedure is executed just before the first observation period, following perigee, and it includes:

HS/LS_ONOFF with parameter = 3

Increase CODIF MCP HV slowly up to pre-passage value. Use procedure 1MCPSET

Switch on CIS1 analyser using procedure 1ANLON

Increase HIA MCP HV slowly up to pre-passage value. Use procedure 2MCPSET

Switch on CIS2 analyser using procedure 2ANLON

7.3.4 Constraints

_None

7.3.5 Resources

7.3.6 Procedures

cf. 7.3.1 and 7.3.3.

7.4 MANOEUVRES

The procedures followed for manoeuvre preparation are similar to those followed for perigee passages, except that the high voltages are decreased to a lower value.

7.4.1 Preparation of CIS before manoeuvres

The procedure for preparation is:

Switch off CIS1 analyser using procedure 1ANLOF

Switch off CIS2 analyser using procedure 2ANLOF

HIA MCP HV slowly down to 1000 volts. Use procedure 2MCPSET with parameter 73 dec.

Decrease CODIF MCP HV slowly down to 1500 volts. Use procedure 1MCPSET with parameter 56 dec.

wait 200s

HS/LS_ONOFF with parameter = 0

7.4.2 Monitoring of activities

No modification to the normal monitoring.

7.4.3 Conditioning after manoeuvres

This procedure is executed just before the first observation period, following the manoeuvre, and it includes:

HS/LS_ONOFF with parameter = 3

Increase CODIF MCP HV slowly up to pre-manouvre value. Use procedure 1MCPSET

Switch on CIS1 analyser using procedure 1ANLON

Increase HIA MCP HV slowly up to pre-manoeuvre. Use procedure 2MCPSET

Switch on CIS2 analyser using procedure 2ANLON

HS/LS_ONOFF with parameter 3

7.4.4 Procedures

cf. 7.4.1 and 7.4.3.

7.5 PATCHING SOFTWARE

CIS software patching will use multiple word commands that are described in section 3.2.3 (" Multiple Word Commands "). It is necessary to distinguish different cases for patches:

A - Patches to CIS1 (in EEPROM-CODE) use 1CRITICALPATCH

B - Patches to CIS1 (in RAM or EEPROM-DATA) use 1PATCH

C - Patches to CIS2 (in EEPROM) use 2CRITICALPATCH

D - Patches to CIS2 (in RAM) use 2PATCH

7.5.1 Preparation of CIS for patch

In case of patch to CIS1-EEPROM-CODE, the high voltages of CIS1 and CIS2 should be switched off because CIS1 should go in Survival mode.

In case of patch to CIS2-EEPROM, the high voltages of CIS2 should be switched off because CIS2 should go in partial mode.

7.5.2 Monitoring of patching

When CIS1 is in *survival* mode during the patch, each block accepted has the number of data word received in a block, minus 1, that is echoed in the *frame counter*. When there is many blocks, we built the IPCH files in order to have alternate length of blocks. So, the frame counter will change alternatively from 62 to 64. It is a way to monitor the progress of the patch.

When CIS1 is in *partial op.* mode during the patch, each block accepted has its first word, that is echoed in the *command register*. When there is many blocks, we manage to have alternate length of blocks in order that the command register change alternatively for each block successfully received. It is a way to monitor the progress of the patch.

7.5.3 Conditioning after patch

After verification of patch it is assume that, for critical patches, a small time will be used for commissioning the uplinked software (new features, new configuration tables or bugs correction).

7.5.4 Constraints

Telemetry rate can be housekeeping or NM1 for patching and NM1 for verification (dump) due to the necessity for science products (dump, ...)

7.5.5 Resources

Power dissipated by the experiment is reduced during the patch because CIS high voltages are OFF.

For large patches, the amount of commands to uplink can be large and most of the uplink capability will be used.

7.5.6 Procedures

7.5.6.1. 1CRITICALPATCH

Purpose: Used to perform large patches to CIS1 EEPROM-CODE

Description: Configure CIS1 in survival mode then perform the patch.

Constraints: CIS1 in survival operation mode

Initial conditions: CIS1 is running in Normal mode 1.

Final conditions: Patch to CIS1 is performed and verified. CIS1 is ready for nominal operation.

1 - Configure CIS1 for survival mode

Switch off CIS1 analyser using procedure 1ANLOF

Switch off CIS2 analyser using procedure 2ANLOF

HIA MCP HV slowly down to zero. Use procedure 2MCPSET with parameter 0.

Decrease CODIF MCP HV slowly down to zero. Use procedure 1MCPSET with parameter 0.

wait 150s

Decrease CODIF Acceleration HV slowly down to zero . Use procedure 1ACCSET with parameter 0.

wait 250s

HS/LS_ONOFF with parameter 0

- Execute procedure **CIS12_SURVIVAL**

2 - Perform the requested patch.

CIS1, in survival mode, do not accept patch at full speed, so it is necessary to introduce 3 dummy commands to the S/C, in order to increase the delay between 2 successives commands. During the patch, each block accepted has the number of data word received in a block, minus 1, that is echoed in the frame counter. When there is many blocks, we built the IPCH files in order to have alternate length of blocks. So, the frame counter will change alternatively from 62 to 64. It is a way to monitor the progress of the patch.

3 - Go to partial operation mode.

- Execute procedure **1EEPPART**

4 - Verification of patch

- Execute procedure **CIS1_MDUMP** with the begining address and the number of pages to dump as parameters.

5 - Checksum update

- When the experimenter has verified that the patch was received well, send the command

ZEC1EECS

6 - Verification of CIS1 checksum update by resetting CIS1
- Execute procedure **CIS1_TO_NOMINAL**
- CIS1 should restart in nominal mode (EEPROM) with the default configuration tables

7 - CIS1 is ready for test of the new S/W or the new tables.

8 - Put the experiment back in the configuration it was before the patch.

7.5.6.2. 1PATCH

Purpose:	Used to perform small patches to CIS1 EEPROM-DATA or RAM
Description:	Leave CIS1 in Nominal mode or in Partial mode as is.
Constraints:	
Initial conditions:	Nominal mode (EEPROM) or Partial mode of CIS1 is running.
Final conditions:	Patch to CIS1 is performed and verified. CIS1 is ready for nominal operation.

1 - Perform the requested patch

CIS1, in nominal mode, do not accept patch at full speed, so it is necessary to introduce 3 dummy commands to the S/C, in order to increase the delay between 2 successives commands. During the patch, each block accepted has its first word, that is echoed in the command register. When there is many blocks, we manage to have alternate length of blocks in order that the command register change alternatively for each block successfully received. It is a way to monitor the progress of the patch.

2 - Verification of patch

- Execute procedure **CIS1_MDUMP** with the begining address and the number of pages to dump as parameters.

3 - Checksum update

- When the CIS experimenter has verified that the patch was received well, send the command **ZEC1EECS if the patch was done in EEPROM-DATA AREA ! (address C000h to E500h).**

4 - CIS1 is ready for test of the new tables.

7.5.6.3. 2CRITICALPATCH

Purpose: Used to perform patches to CIS2 EEPROM.
Description: Configure CIS2 in partial op. mode then perform the patch.
Constraints: CIS2 in partial operation mode
Initial conditions: Nominal software (EEPROM) of CIS1 and CIS2 are running.
Final conditions: Patch to CIS2 is performed and verified. CIS2 is ready for nominal operation.

1 - Configure CIS2 for partial op. modes

Switch off CIS2 analyser using procedure 2ANLOF

HIA MCP HV slowly down to 0 . Use procedure 2MCPSET with parameter 0.

- Execute first procedure **CIS2_SURVIVAL then procedure 2SURV_TO_PART**

2 - Perform the requested patch

CIS1, in nominal mode, do not accept commands at full speed, so it is necessary to introduce 3 dummy commands to the S/C between each command of the patch, in order to increase the delay between 2 successives commands. During the patch, each block accepted has its first word, that is echoed in the command register. When there is many blocks, we built IPCH files to have alternate length of blocks in order that the command register change alternatively for each block successfully received. It is a way to monitor the progress of the patch.

4 - Verification of patch

- Execute procedure **CIS2_MDUMP** with the begining address and the number of pages to dump as parameters.

5 - Checksum update

- When the CIS experimenter has verified that the patch was received well, execute procedure **2EEPCHK – CIS2 will restart in Nominal mode.**

6 -CIS2 is ready for test of the new S/W or the new tables

7.5.6.3. 2PATCH

Purpose: Used to perform patches to CIS2 RAM.

Description: Leave CIS1 in Nominal mode or in Partial mode as is.

Constraints:

Initial conditions: Nominal mode or Partial mode of CIS1 and CIS2 are running.

Final conditions: Patch to CIS2 is performed and verified. CIS2 is ready for nominal operation.

1 - Perform the requested patch

CIS1, in nominal mode, do not accept commands at full speed, so it is necessary to introduce 3 dummy commands to the S/C between each command of the patch, in order to increase the delay between 2 successives commands. During the patch, each block accepted has its first word, that is echoed in the command register. When there is many blocks, we built IPCH files to have alternate length of blocks in order that the command register change alternatively for each block successfully received. It is a way to monitor the progress of the patch.

2 - Verification of patch

- Execute procedure **CIS2_MDUMP** with the begining address and the number of pages to dump as parameters.

3 - CIS2 is ready for test of the new tables

7.6 Switching from primary to redundant Interface

As soon as possible after the spacecraft interface change, configure CIS on the right telemetry and telecommand channels.

* Sending any command will switch to the redundant interface.
  - make sure that no block command is in progress !
  - use ZEC1ADLS,0 because it is not a critical command !

* Send ZECLPC2B to configure the LPC interface

7.7 Switching from redundant to primary Interface

As soon as possible after the spacecraft interface change, configure CIS on the right telemetry and telecommand channels.

* Sending any command will switch to the primary interface.
  - make sure that no block command is in progress !
  - use ZEC1ADLS,0 because it is not a critical command !

* Send ZECLPC2A to configure the LPC interface

Cluster - CIS

User Manual for CIS Flight Operations

8. CONTINGENCY OPERATIONS

8-1 Failures analysis

Contingency procedures will be used in case of failure of CIS1 or CIS2 during the operations in flight.

They have to cover :

- internal failures of the instrument,
- failures induced by an external process
- or by a high energy particle.

The internal failures could come from a High voltage malfunctioning or a high voltage discharge.

They could come also from a timing problem occurring in temperature.

Some command can be sent accidentally and can put the instrument in a non desirable state. When using block commands, some word can be lost. It could be not sent or not got by the instrument if they are too close each other or if one on them is arriving too late (time out error). In the last case, the rest of the block command will be seen as a list of normal commands and they can put the instrument in a bad state.

A high energy particle can change the content of a RAM memory location and this can make the software crashing.

If most of the time the internal watchdog reset will restart the instrument, it could occur that the software stays in a loop where the watchdog is reinitialized and in this case no reset will occur.

Failures could occur for CIS1 or for CIS2. The communication between the two instruments can be lost as well.

A gradual (not catastrophic) failure mode that may occur for CIS1 is an increase in the electronic cross talk between the position signals. In the extreme case, if all events had cross talk between the position, the instrument logic would consider all events invalid, and there would be no further science data. A special mode has been developed in case the cross talk reaches an unacceptable level.

8-2 Failures recovery

The survey of the housekeeping parameters and monitor rates will detect failures and will decide the recovery procedure to be used.

We have to distinguish 2 different sets of recovery procedures :
- on-board recovery procedures,
- on-ground recovery procedures.

8-2-1 On-board recovery

In this situation, only specified parameter out of limits could be specified and the recovery procedure will consist in one command sent only.

Hereafter are specified the parameters to be checked under the given limits and the action to be executed in case of out of limits.

These parameters have to be seen out of limits during 6 frames before the action will be initiated. That means that the subcommutated parameters will be refreshed 3 times.

MNEMONIC	ESOC Mnem	FUNCTION	MINA CT1	MAXA CT1	On board action when ot of limits	On ground action when out of limits
EC1LITOT	C_061	Total CIS1 current at primary side of low power converter	90	400	CIS A/B LCL OFF	CIS_OFF_EMER
ECCHIACC	C_075	CODIF 4 - CODIF Acceleration HV current	-1	12	ZEC1ACCF	see 8.3.2.1
ECCHID__	C_071	AHKP15 - CODIF Step HV diode current	-1	10	ZEC1ANLF	see 8.3.2.4
ECCHIMCP	C_077	CODIF MCP HV Current (CODIF 5)	-1	50	ZEC1MCPF	see 8.3.2.2
ECCHVACC	C_070	CODIF 1 - CODIF Acceleration HV monitor	-25000	1	ZEC1ACCF	1ACCOFF
ECCHVANL	C_057	AHKP8 - CODIF Maximum STEP HV analog	-5300	1	ZEC1ANLF	1ANLOF
ECCHVMCP	C_072	CODIF 2 - CODIF MCP HV monitor	-1	2800	ZEC1MCPF	see 8.3.3.1
ECCTANAL	C_059	AHKP9 - CIS1 analog electronics temperature	-50	65	CIS A/B LCL OFF	see 8.3.4.1
ECCTELEC	C_073	CODIF 3 - CODIF electronics temperature	-50	60	CIS A/B LCL OFF	see 8.3.4.1
ECHHID__	C_064	AHKP!@ - HIA Step HV diode current	-1	10	ZEC2ANLF	see 8.3.2.5
ECHHIMCP	C_058	AHKP8 - HIA MCP HV current on the 28V primary	-1	10	ZEC2MCPF	see 8.3.2.3
ECHHVMO_	C_046	AHKP2 - HIA MCP HV voltage, actual	-2600	1	ZEC2MCPF	see 8.3.3.2
ECHTELEC	C_060	AHKP9 - CIS2 Analog electronics temperature	-45	70	ZEC1PWRF	see 8.3.4.2
ECIS1__T	C_???	Experiment CIS 1 internal thermistor powered and read out from S/C as seperate channel	-50	65	CIS A/B LCL OFF	CIS_OFF_EMER

ECIS2__T	C_???	Experiment CIS 2 internal thermistor powered and read out from S/C as seperate channel from CIS1	-45	70	ZEC1PWRF	CIS2OFF
ECL1ITOT	C_041	Analog housekeeping measurement of the CIS1 current (CIS1 AHKP 10)	90	400	CIS A/B LCL OFF	see 8.3.1
ECL2ITOT	C_042	Analog housekeeping measurement of the CIS2 current (CIS2 AHKP 10)	0	200	ZEC1PWRF	see 8.3.1
???	???	CIS total current at LCL level	0	600	CIS A/B LCL OFF	CIS_OFF_EMER

8-2-2 On-ground recovery

We can distinguish three cases :

- a parameter is out of limits,
- an error number is reported by the instrument in the appropriate housekeeping field,
- all the parameters are frozen putting the instrument out of control.
- the monitor rates show values that are out of limits.

The parameters to be checked are :

- total current,
- individual high voltages current,
- individual level of the high voltages,
- levels of the low voltages,
- temperatures,
- current command,
- configuration words,
- the SEV/SFR ratio from the monitor rates (done by the experimenter).

The error numbers to take care of are :

- CIS1 : 2B - communication lost with CIS2,
- CIS1 : 20 - serial error sending hia command.

8-3 On ground failures recovery procedures

8-3-1 Total currents out of limits

On board, the total power of CIS1 and CIS2 are checked at LCL level. Nevertheless we have to keep the survey of the individual power of CIS1 and CIS2. For example CIS1 could be in low power mode and CIS2 can consume a too big power but the sum of the two can stay under the limit.

CIS2 power > 200 mA

reset CIS2 : send ZECLPC2A or ZECLPC2B according to the interface selected
Wait for 30 s
If the current is still out of limits use procedure CIS2OFF to switch off CIS2.
Wait for 20 s
Switch on CIS2 using procedure CIS2ON
If the current is still out of limits use procedure CIS2OFF to switch off CIS2.

CIS1 power > 400 mA

Reset CIS1 : send ZECLPC1A or ZECLPC1B according to the interface used
Wait for 30s
If the current is still out of limits use procedure CIS2OFF to switch off CIS2 and use procedure CISOFF to switch off CIS1.

Wait for 3 minutes
Switch on CIS1 using procedure CISON
Wait for 10 s
If the current is still out of limits use procedure CISOFF to switch off CIS1,
else switch on CIS2 using procedure CIS2ON.

8-3-2 High voltage currents

8-3-2-1 CIS1 - ACCeleration High Voltage

If Housekeeping parameter ECCHIACC > 12 mA for 6 frames

CIS1 ANL HV OFF using procedure 1ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF
wait for 5 minutes
CIS1 ACC HV ON using procedure 1ACCON
CIS1 MCP HV ON using procedure 1MCPON
CIS1 ACC HV set to the nominal value using procedure 1ACCSET parameter nominal value
wait for 100s
CIS1 MCP HV set to the nominal value using procedure 1MCPSET parameter nominal value
wait for 200s
CIS1 ANL HV ON using procedure 1ANLON

If Housekeeping parameter ECCHIACC is still out of limits :
CIS1 ANL HV OFF using procedure 1ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF

8-3-2-2 CIS1 - MCP High Voltage

If Housekeeping parameter ECCHIMCP > 50 mA for 6 frames
CIS1 ANL HV OFF using procedure 1ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF
wait for 5 minutes
CIS1 ACC HV ON using procedure 1ACCON
CIS1 MCP HV ON using procedure 1MCPON
CIS1 ACC HV set to the nominal value using procedure 1ACCSET parameter nominal value
wait for 100s
CIS1 MCP HV set to the nominal value using procedure 1MCPSET parameter nominal value
wait for 200s
CIS1 ANL HV ON using procedure 1ANLON
If Housekeeping parameter ECCHIMCP is still out of limits :
CIS1 ANL HV OFF using procedure 1ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF

8-3-2-3 CIS2 - MCP High Voltage

If Housekeeping parameter ECHHIMCP> 10 mA for 6 frames

CIS2 ANL HV OFF using procedure 2ANLOF
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 200 s
CIS2 MCP HV OFF using procedure 2MCPOFF
wait for 5 minutes
CIS2 MCP HV ON using procedure 2MCPON
CIS2 MCP HV set to the nominal value using procedure 2MCPSET parameter nominal value
CIS2 ANL HV ON using procedure 2ANLON

If Housekeeping parameter ECHHIMCP is still out of limits
CIS2 ANL HV OFF using procedure 2ANLOF
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 200 s
CIS2 MCP HV OFF using procedure 2MCPOFF

8-3-2-4 CIS1 - Analyser High Voltage

If Housekeeping parameter ECCHID_ > 10 mA for 6 frames
CIS1 ANL HV OFF using procedure 1ANLOF
wait for 5 minutes
CIS1 ANL HV ON using procedure 1ANLON
If Housekeeping parameter ECCHID_ is still out of limits :
CIS1 ANL HV OFF using procedure 1ANLOF

8-3-2-5 CIS2 - Analyser High Voltage

If Housekeeping parameter ECHHID_ > 10 mA for 6 frames

CIS2 ANL HV OFF using procedure 2ANLOF
wait for 5 minutes
CIS2 ANL HV ON using procedure 2ANLON

If Housekeeping parameter ECHHID_ is still out of limits
CIS2 ANL HV OFF using procedure 2ANLOF

8-3-3 High voltage level

8-3-3-1 CIS1 - MCP High Voltage

If Housekeeping parameter ECCHVMCP > 2800 volts for 6 frames
CIS1 ANL HV OFF using procedure 1ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF
wait for 5 minutes
CIS1 ACC HV ON using procedure 1ACCON
CIS1 MCP HV ON using procedure 1MCPON
CIS1 ACC HV set to the nominal value using procedure 1ACCSET parameter nominal value
wait for 100s
CIS1 MCP HV set to the nominal value using procedure 1MCPSET parameter nominal value
wait for 200s
CIS1 ANL HV ON using procedure 1ANLON
If Housekeeping parameter ECCHVMCP is still out of limits :
CIS1 ANL HV OFF using procedure 1ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF

8-3-3-2 CIS2 - MCP High Voltage

If Housekeeping parameter ECHHVMO_ < -2600 volts for 6 frames

CIS2 ANL HV OFF using procedure 2ANLOF
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 200 s
CIS2 MCP HV OFF using procedure 2MCPOFF
wait for 5 minutes
CIS2 MCP HV ON using procedure 2MCPON
CIS2 MCP HV set to the nominal value using procedure 2MCPSET parameter nominal value
CIS2 ANL HV ON using procedure 2ANLON

If Housekeeping parameter ECHHVMO_ is still out of limits
CIS2 ANL HV OFF using procedure 2ANLOF
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 200 s
CIS2 MCP HV OFF using procedure 2MCPOFF

8-3-4 Temperatures

8-3-4-1 CIS1 Temperatures

If Housekeeping parameter ECCTELEC > 60°C
Switch off CODIF using procedure HS/LS_ONOFF with parameter 0

If Housekeeping parameter ECCTANAL > 65°C

CIS1 ANL HV OFF using procedure 1ANLOF
CIS2 ANL HV OFF using procedure 2ANLOF
CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s

CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF
CIS1 MCP HV OFF using procedure 2MCPOFF

Switch off CODIF using procedure HS/LS_ONOFF with parameter 0

Switch off CIS2 using procedure CIS2OFF
Switch off CIS1 using procedure CISOFF

8-3-4-2 CIS2 Temperatures

If Housekeeping parameter ECHTELEC > 70°C

CIS2 ANL HV OFF using procedure 2ANLOF
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 150 s
CIS2 MCP HV OFF using procedure 2MCPOFF

Switch off CIS2 using procedure CIS2OFF

8-3-5 Telemetry locked or lost

8-3-5-1 CIS1 Frame counter

The value of the housekeeping parameter ECP1FNCT (Frame Counter) is incremented every frame. During the telemetry mode changing it could keep the same value during several frames and then makes a jump. During a switch from primary to redundant interfaces or from redundant to primary interfaces it could get some strange value as 0 or 255.

If the housekeeping parameter ECP1FNCT is staying at the same value during more than 8 frames :

- take care that no block of commands are in progress
- reset CIS1 : send ZECLPC1A or ZECLPC1B according to the interface selected
- send ZEC1ADLS,0 to confirm the telemetry interface selected.

wait for 6 frames,

If the frame counter is still locked :

CIS1 ANL HV OFF using procedure 1ANLOF
CIS2 ANL HV OFF using procedure 2ANLOF

CIS1 MCP HV down to zero using procedure 1MCPSET parameter 0
CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0
wait 150 s
CIS1 ACC HV down to zero using procedure 1ACCSET parameter 0
wait 200s
CIS1 MCP HV OFF using procedure 1MCPOFF
CIS1 ACC HV OFF using procedure 1ACCOFF
CIS2 MCP HV OFF using procedure 2MCPOFF

Switch off CODIF using procedure HS/LS_ONOFF with parameter 0

Switch off CIS2 using procedure CIS2OFF
Switch off CIS1 using procedure CISOFF
wait for 200s
Switch on CIS1 using procedure CISON
Switch on CIS2 using procedure CIS2ON

8-3-5-2 CIS1 Error 2Bh

If this error occurs the communication between CIS1 and CIS2 is lost !

Warning : The error value is staying in the error field while a new error is not coming. To check if it is a new error (eventually having the same value), it is necessary to checkthe error counter.

CIS2 ANL HV OFF using procedure 2ANLOF

CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0

wait 150 s

CIS2 MCP HV OFF using procedure 2MCPOFF

Switch off CIS2 using procedure CIS2OFF

Switch on CIS2 using procedure CIS2ON

8-3-5-3 CIS2 Config word

If the housekeeping parameter ECP2CONF is keeping the same value during 8 frames :

reset CIS2 : send ZECLPC2A or ZECLPC2B according to the interface selected
Wait for 30 s
If housekeeping parameter ECP2CONF is still having the same value for 8 frames

CIS2 ANL HV OFF using procedure 2ANLOF

CIS2 MCP HV down to zero using procedure 2MCPSET parameter 0

wait 150 s

CIS2 MCP HV OFF using procedure 2MCPOFF

Switch off CIS2 using procedure CIS2OFF

Wait for 20 s
Switch on CIS2 using procedure CIS2ON

Wait for 30 s
If housekeeping parameter ECP2CONF is still having the same value for 8 frames :

CIS2 ANL HV OFF using procedure 2ANLOF

MCP HV down to zero using procedure 2MCPSET parameter 0

wait 150 s

MCP HV OFF using procedure 2MCPOFF

Switch off CIS2 using procedure CIS2OFF

reset CIS1 : send ZECLPC1A or ZECLPC1B according to the interface selected

Wait for 20 s
Switch on CIS2 using procedure CIS2ON

8-3-5-4 CIS1 Error 20h

If this error occurs the command was not aknowledged by CIS2.

Send again the last command sent to CIS2.

Warning : The error value is staying in the error field while a new error is not coming. To check if it is a new error (eventually having the same value), it is necessary to checkthe error counter.

8.3.6 CIS1 crosstalk out of limits

This procedure should only be run after detailed analysis by scientists has confirmed that the crosstalk has increased permanently to an unacceptable level. If this occurs, then we will go to a mode where events with more than one position signal are accepted into the science data.

** HS procedure to allow adjacent starts

** Step0H - Stimuli: 0000 - Control: 1000

wait 1s send ZEC1ADMS, x02 -- Select MSB address

wait 1s send ZEC1ADLS, x4C -- Select LSB address

wait 1s send ZEC1DAMS, x00 -- Select MSB data

wait 1s send ZEC1IOWS, x00 -- Write HS_stimulation value

wait 1s send ZEC1ADLS, x4D -- Select LSB address

wait 1s send ZEC1DAMS, x10 - Sets HS imm evt mode to 1 (adjacent starts)

wait 1s send ZEC1IOWS, x00 -- Write HS_control register

** LS procedure to allow adjacent starts

** Step0L - Stimuli: 0000 - Control: 1000

wait 1s send ZEC1ADMS, x02 -- Select MSB address

wait 1s send ZEC1ADLS, x48 -- Select LSB address

wait 1s send ZEC1DAMS, x00 -- Select MSB data

wait 1s send ZEC1IOWS, x00 -- Write LS_stimulation value

wait 1s send ZEC1ADLS, x49 -- Select LSB address

wait 1s send ZEC1DAMS, x10 - Sets HS imm edt mode to 1 (adjacent starts)

wait 1s send ZEC1IOWS, x00 -- Write

Cluster - CIS

User Manual for CIS Flight Operations

9. ANNEXES

5.9.1. GENERAL PROCEDURES		
No.	**Procedure**	**Purpose**
5.9.1.1.	**CISON**	Switch CIS ON, configure interfaces according to the one selected (primary or redundant), configure CIS according to the telemetry rate at switch ON time, and verify that the status reached is the correct one
5.9.1.2.	**CISOFF**	Switches CIS OFF
5.9.1.3.	**1CVR OPEN**	CIS1 cover actuator switch ON to open the retractable cover. Normaly be used only once, during the commissioning phase
5.9.1.4.	**CIS2ON_C**	To switch CIS2 ON
5.9.1.5	**CIS2OFF**	Switches CIS2 OFF
5.9.1.6	**CIS_OFF_EMER**	Switches CIS1 and CIS2 quickly in case of emergency

5.9.2. HV OPERATIONS PROCEDURES

No.	Procedure	Purpose
5.9.2.1.	**1ANLON**	CIS1 analyser high voltage switch ON
5.9.2.2	**1ANLOF**	CIS1 analyser high voltage switch OFF
5.9.2.3.	**2ANLON**	CIS2 analyser high voltage switch ON
5.9.2.4	**2ANLOF**	CIS2 analyser high voltage switch OFF
5.9.2.5.	**1ACCON**	Switch CIS1 acceleration HV ON
5.9.2.6.	**1ACCOFF**	Switch CIS1 acceleration HV OFF
5.9.2.7.	**1MCPON**	Switch CIS1 MCP HV ON
5.9.2.8.	**1MCPOFF**	Switch CIS1 MCP HV OFF
5.9.2.9.	**2MCPON**	Switch CIS1 analyser HV ON
5.9.2.10.	**2MCPOFF**	Switch CIS2 MCP HV OFF
5.9.2.11	**1ACCSET**	CIS1 acceleration HV setting.
5.9.2.12	**1MCPSET**	CIS1 MCP HV setting
5.9.2.13	**2MCPSET**	CIS2 MCP HV setting
5.9.2.14.	**CIS1 MCPGAIN CALIB**	Verification of the gain of CODIF MCPs and of the correct setting of MCP high voltage
5.9.2.15.	**CIS2 MCPGAIN CALIB**	Verification of the gain of CIS2 MCPs and of the correct setting of MCP high voltage

5.9.3. CODIF OPERATIONS		
No.	**Procedure**	**Purpose**
5.9.3.1	**CODIF_HS_ON**	Switch ON of the high sensitivity section of the electronics of CODIF
5.9.3.2.	**CODIF_LS_ON**	Switch ON of the low sensitivity section of the electronics of CODIF
5.9.3.3.	**CODIF_HSLS_ON**	Switch ON of the low and high sensitivity sections of the elctronics of CODIF
5.9.3.4.	**CODIF_HSLS_OFF**	Switch OFF of the low and high sensitivity sections of the electronics of CODIF
5.9.3.5.	**CIS1_HS_STIMULI_SHORT**	Short test of the electronics of CODIF (CIS1 sensor), high sensitivity section
5.9.3.6.	**CIS1_LS_STIMULI_SHORT**	Short test of the low sensitivity section of the electronics of CODIF (CIS1 sensor)
5.9.3.7.	**RPA_M247S**	RPA -247V setting
5.9.3.8.	**RPA_M153S**	RPA -153V setting
5.9.3.9.	**CIS1_HS_STIMULI_LONG**	Detailed and long test of the electronics of CODIF (CIS1 sensor), high sensitivity section
5.9.3.10.	**CIS1_LS_STIMULI_LONG**	Detailed and long test of the electronics of CODIF (CIS1 sensor), low sensitivity section
5.9.3.11	**RPA_ON**	RPA voltages switched ON
5.9.3.12	**RPA_OFF**	RPA voltages switched OFF
5.9.3.13	**RPA_SET**	RPA cut-off voltage setting

5.9.4. VARIOUS		
No.	**Procedure**	**Purpose**
5.9.4.1.	**CIS2_SURVIVAL**	CIS2 software will go from nominal or partial mode to survival mode - CIS1 mode not affected
5.9.4.2.	**CIS12_SURVIVAL**	CIS1 and CIS2 softwares will go from nominal or partial mode to survival mode (prom)
5.9.4.3.	**CIS2_TO_NOMINAL**	CIS2 software will go from partial or survival mode to nominal mode.
5.9.4.4.	**CIS1_TO-NOMINAL**	CIS1 software will go from Partial or Survival modes to nominal mode
5.9.4.5.	**2SURV_TO_PART**	CIS2 software will go from Survival mode to PARTIAL mode
5.9.4.6.	**1EEPPART**	CIS1 software will go from survival to partial mode
5.9.4.7.	**1SURV_TO_PART**	CIS1 EEPROM checksum updated
5.9.4.8.	**2EEPCHK**	CIS2 EEPROM checksum update
5.9.4.9.	**1TIMEOUT**	Modify default time-out used by CIS1 for maximum delay between 2 consecutive commands of a block command (1s), in partial operation mode to increase it to 10s (default value in nominal mode)

5.9.2. HV Operations Procedures

5.9.2. HV OPERATIONS PROCEDURES		
No.	**Procedure**	**Purpose**
5.9.2.1.	**1ANLON**	CIS1 analyser high voltage switch ON
5.9.2.2	**1ANLOF**	CIS1 analyser high voltage switch OFF
5.9.2.3.	**2ANLON**	CIS2 analyser high voltage switch ON
5.9.2.4	**2ANLOF**	CIS2 analyser high voltage switch OFF
5.9.2.5.	**1ACCON**	Switch CIS1 acceleration HV ON
5.9.2.6.	**1ACCOFF**	Switch CIS1 acceleration HV OFF
5.9.2.7.	**1MCPON**	Switch CIS1 MCP HV ON
5.9.2.8.	**1MCPOFF**	Switch CIS1 MCP HV OFF
5.9.2.9.	**2MCPON**	Switch CIS1 analyser HV ON
5.9.2.10.	**2MCPOFF**	Switch CIS2 MCP HV OFF
5.9.2.11	**1ACCSET**	CIS1 acceleration HV setting
5.9.2.12	**1MCPSET**	CIS1 MCP HV setting
5.9.2.13	**2MCPSET**	CIS2 MCP HV setting
5.9.2.14.	**CIS1 MCPGAIN CALIB**	Verification of the gain of CODIF MCPs and of the correct setting of MCP high voltage
5.9.2.15.	**CIS2 MCPGAIN CALIB**	Verification of the gain of CIS2 MCPs and of the correct setting of MCP high voltage

6.5.1. Procedures for nominal operations

NOMINAL OPERATIONS PROCEDURES		
no.	Procedure	Purpose
6.5.1.1.	**CISON**	Switch CIS ON, configure interfaces according to the one selected (primary or redundant), configure CIS according to the telemetry rate at switch ON time, and verify that the status reached is the correct one
6.5.1.2	**CISOFF**	Switch CIS OFF
6.5.1.3	**CISAMHVON**	Switch CIS1 acceleration and MCP HVs ON Switch CIS2 MCP HV ON
6.5.1.4	**CISAMHVOFF**	Switch CIS1 acceleration and MCP HVs OFF Switch CIS2 MCP HV OFF
6.5.1.5	**CISANLON**	CIS1 and CIS2 analyser high voltages switch ON
6.5.1.6	**CISANLOFF**	CIS1 and CIS2 analyser high voltages switch OFF
6.5.1.7	**CISHVSET**	CIS1 acceleration and MCP HVs setting and CIS2 MCP HV setting
6.5.1.8	**CISMODECHG**	Scientific modes of operation modification
6.5.1.9	**CISMCPGCAL**	Verification of the gain of CODIF MCPs, of the gain of CIS2 MCPs, and of the correct setting of MCP high voltages.

6.5.2. Technical Adjustement Procedures

TECHNICAL ADJUSTEMENT PROCEDURES		
No.	**Name**	**Purpose**
6.5.2.1	**CIS1TABSAVE**	Save CIS1 fix or/and operating tables from RAM to EEPROM. They becomes the default fix/operating tables
6.5.2.2	**CIS2TABSAVE**	Save CIS2 tables from RAM to EEPROM. They becomes the default tables
6.5.2.3	**CIS1_MDUMP**	Dump of n pages of an area of the CIS1 memory
6.5.2.4	**CIS2_MDUMP**	Dump of n pages of an area of the CIS2 memory
6.5.2.5	**CIS1_STIMULIS**	Test of the electronics of CODIF, high and low sensitivity section
6.5.2.6	**CIS2_AMPTST**	Test of the electronics of CIS2 (amplifiers + counters + DPU)
6.5.2.7	**CIS1_RPADEFL**	Modification of voltages applied to the RPA deflection plates
6.5.2.8	**CIS1_RPASWEEP**	Modification of parameters defining a RPA sweep
6.5.2.9	**CIS1_SWEEPTHRESH**	Modification of parameters defining the analyser HV sweep
6.5.2.10	**CIS1MEMWR1W**	Writes 1 word in CIS1 RAM
6.5.2.11	**CIS2MEMWR1W**	Writes 1 word in CIS2 RAM
6.5.2.12	**CIS1_SCRATCHOFF**	Switches scratch memory OFF
6.5.2.13	**CIS1_SCRATCHON**	Switches scratch memory ON
6.5.2.14	**CIS1_SCRATCHTST**	Test of scratch memory
6.5.2.15	**CIS1_SPINPHADJ**	Adjust the phase of the beginning of measurement of CIS1 relative to sun reference pulse
6.5.2.16	**CIS2_SPINPHADJ**	Adjust the phase of the beginning of measurement of CIS2 relative to sun reference pulse
6.5.2.17	**CIS2_DISCRISET**	CIS2 discriminator levels adjustement
6.5.2.18	**CIS1_ACCHVFAST**	Writes 1 word in CIS1 RAM in order to decrease acceleration HV quickly
6.5.2.19	**CIS1_MCPHVFAST**	Writes 1 word in CIS1 RAM in order to decrease MCP HV quickly
6.5.2.20	**CIS2_MCPHVFAST**	Writes 1 word in CIS2 RAM in order to decrease MCP HV quickly
6.5.2.21	**RPA_ON**	RPA voltages switched ON
6.5.2.22	**RPA_OFF**	RPA voltages switched OFF
6.5.2.23	**HS/LS_SEL**	Select data from HS or LS sections
6.5.2.24	**ANY_CMD**	Send one command to CIS (any command)
6.5.2.25	**CIS2ON**	Switches CIS2 ON

6.5.2.26	**CIS2OFF**	Switches CIS2 OFF
6.5.2.27	**CIS1I/OWR1W**	Writes 1 I/O word in CIS1
6.5.2.28	**CIS2I/OWR1W**	Writes 1 I/O word in CIS2
6.5.2.29	**HS/LS_ONOFF**	Switches CODIF HS or/and LS ON or OFF
6.5.2.3	**CIS1_HOTRST**	CIS1 hot reset
6.5.2.31	**BLCK_CMD**	Send a block comand to CIS