CLUSTER / ASPOC

INSTRUMENT USERS MANUAL

Issue 3.3

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Change Record Sheet

Iss/Rev	Pages	Date	Status
1/0	all	1993 Jul 30	First full release
1/1	all	1994 Mar 05	editorial changes
	7		cross-section of emitter module
	14,15		summary description of modes
	15ff		internal hot standby mode renamed into feedback
	21		functional diagram added
	22		column "sampling" added to table
			wait status; description of timeouts updated
	33ff		state diagrams updated
	48		watch-dog description
	91		possible macrocommands mentioned
	139ff		responsibilities for recovery actions defined
	151ff		commissioning procedures revised
	Sect 5-8		major updates
2/0		1994 Dec 30	
	24		more explanation for "hot standby"
	25,29-31		mode changes (mainly editorial)
	12,49		DPU is reset by watch-dog
	47		feedback wait status added for completeness
	61,184		on-board monitoring proposal
	84		EAWISSDW definition
	158ff		need for other exp. during commissioning added
	many		new telecommands
	162		inter-experiment tests at least in 2 regions
	163		remote access to EGSE
	164		transition from commissioning to NOMOP
	181		cycling between emitters detailed
	184		monitoring list revised
	185		JSOC monitoring params specified
	187ff		command sequences added
	193		strategy in perigee crossings

Iss/Rev	Pages	Date	Status
2/1	64	1995 Feb 01	statement about identical limits on all units
	65ff		parameter limits given in engineering units
	66,67		EAFILIMP, EAFILTEM moved from settings table to monitor table
	69,70		calibration table edited
	89		editorial
	97ff,106		parameters of commands ZEAEXPMS, ZEABAKMS,
	114,121		ZEAFILMS, ZEAMODUS changed
	143,146ff		new commands ZEASTESS and ZEASTELS replace commmand ZEASTEPS
	162ff		commissioning phase: several clarifications
	163		procedure QEADCHAR inserted into commissioning
	164ff		emitter cycling sequence during commissioning specified
	189		calibration sweep requested once per orbit
	193ff		on-board monitoring concept updated
	196-198		JSOC monitoring re-defined
	199-202		list of CSEQ's updated
	230		list of procedures updated
	233		procedure QEADCHAR edited
	241		new procedure QEAEMOPT defined
	273		procedure QEANORMP defined
	278		procedure QEARCHAR edited

Iss/Rev	Pages	Date	Status
2/2	11	1995 May 30	7 or 8 emitters per instrument
	45		description of parameter EAEXPMOD
	67,68		parameter limits and the ends of the calibration curves deleted
	69,70		calibration curve for EAPEAOFF modified, curve 25 deleted
	78		list of valid emitter selections is provided
	96		redundancy concept is clarified
	96		new section on command timing
	119,120,122		restrictions to emitter selection by TC
	131		anomaly with hot standby mode (HOTS)
	200		CSEQ ASPBAKSET edited
	201,233ff		ZEASTDBS replaced by ZEAEXPMS,0
	203		CSEQ ASPTECHS: cmd ZEATECHS replaced
	203		CSEQs ASPMODAS and ASPMODBS deleted
	231ff		ZEAITOTS replaced by ZEAEXPMS,1
	231ff		ZEAIIONS replaced by ZEAEXPMS,2
	231ff		ZEAHOT_S replaced by ZEAEXPMS,4
	231ff		ZEAT&C_S replaced by ZEAEXPMS,5
	231ff		ZEATECHS replaced by ZEAEXPMS,6
	231ff		ZEAFEFWS replaced by ZEAEXPMS,3
	231ff		ZEAFPEAS replaced by ZEAEXPMS,7
	231ff		CSEQ ASPEeMmCHG replaced by ASPEMCHG
	231ff		restrictions to emitter selection in procedures
	249,253,289		hex value of 20 uA beam current edited
	284,285		TBD in QEASTART removed
	all		editorial changes

Iss/Rev	Pages	Date	Status
2/3	246-247 264-265 196ff,265, 292,293 201,202 201ff 160	1995 Sep 04 1995 Oct 24 1996 Jan 21	QEAEFAID revised after comments by ESOC QEAHLEAK revised after comments by ESOC Numbering error in section headings 6.2.12 corrected Caveat for CSEQ ASPEMCHG added, Internal timing of CSEQs defined details on the duration of emitter start-up given
3/0	 19 26-35 209	1999 Apr 07	Update for Cluster-II Annexes with HK, TC, and control file databases removed "Cluster" replaced by "Cluster-II" description of "emitter cleaning" implications of cleaning summarised modified or new parameters: EAHVTHRE, EATIMOT4, EAFILERR, EACLNACT, EACLNDSB, EACLNHWL, EASTEPL_, EASTEPS_, EAWISTAB, EAWISCO1 EAFILSLD new or modified TCs: ZEAHVTHR, ZEAWHISS, ZEASTELS, ZEASTESS, ZEAFIL_E, ZEAHV__E, ZEAHVSUS modification of command sequences ASPEMCHG and ASPSETINIT in section 6.3 caveat on command sequence ASPEMCHG removed sequence ASPHVSUS replaced by ASPHVTHR procedures using ASPEMCHG or ASPSETINIT modified
3/1		2000 Jan 28	Revision after meeting with ESOC Editorial changes Flight model ID's updated for Cluster-II ID's of bad emitters set to known values or TBD (will be fully known after refurbishment) Ignition timeout period increased from 10 to 20 min Duration of startup is 25 min (typ). and 33 min (max.) description of mode commands updated (enable/disable status of high voltage and filaments) timing of procedures containing a start-up modified to reflect longer start-up time

Iss/Rev	Pages	Date	Status
3/2		2000 May 07	Revision after delivery of refurbished instruments
	1, 200		Editorial changes
	69		EAHVMON_ upper limit set to 8.5 kV (avoids out-of-limit warnings during start-up)
	81, 125-128		ID's of bad emitters are given
	93		hex default value of EAHVTHRE changed
	172, 273ff, 278ff		timing of initial high voltage turn-on modified (longer duration), in QEAHVTST and QEAINITH
	203		monitoring limit of EATOTC0_ increased to 90 µA
	204		monitoring by ESOC extended by 4 parameters also checked by JSOC
	206		monitoring of EAHVMON_ by JSOC slightly modified
	248ff		Procedure QEADCHAR modified
	256, 300		Procedures QEASTART and QEAEMOPT modified (ZEAHVTHR inserted)
	281ff		Procedures QEAINTCA and QEAINTFR deleted
	294ff		Procedure QEARCHAR modified
	254ff		Procedures QEAEMCYC, QEAEMOPT, QEAEMTRY, QEAFPYRO, QEAFTEFW, QEAFTPEA, QEASHECL, QEAWHIFB, modified (ZEAHVTHR inserted)
	256ff		Procedure QEAEMOPT modified (emitter cleaning inserted at end of procedure)
	261ff		Procedure QEAFPYRO: remark on exchanged pyro harness for S/C FM7 added
	20,100,209		on-board macros will not be used (not reasonable because too short)
	209,243,244		nevertheless for consistency the "enable" commands in macros were deleted (not needed in Cluster-II)

Iss/Rev	Pages	Date	Status
3/3	all	2008 July 15	Re-formatting to current version of MS Word Update contact information Add embeddede figures Editorial changes

1. Instrument Description

1.1 Experiment Overview

1.1.1 Scientific Objectives

The primary objective of this investigation is to insure effective, complete measurement of the ambient plasma distribution functions by active spacecraft potential control (ASPOC). Additional benefits may be found in improved data for the long wire electric field measurement (EFW), and the electron beam probe for electric fields (EDI).

Typical floating potentials for magnetospheric satellites of up to +50 V obscure, or render impossible the measurement of the core of the ion distribution function, which has a thermal energy comparable to the satellite potential. This problem was indicated by discrepancies in density calculations from satellites such as GEOS-1. The densities inferred from ion spectrometers, for example, did not agree with the total electron density measurements obtained from wave techniques. Measurements in eclipse, made on ATS-6, SCATHA, and DE-1 have shown the appearance of previously 'hidden' ion populations, invisible in sunlight.

Other fundamental problems occur in the measurement of the anisotropic distributions outside the plasmasphere, such as the field aligned flows which make up the polar wind. The bulk of the distribution is lost due to the satellite potential, and it is not possible to obtain fundamental parameters such as density, temperature, and flow velocity for H^+. Such flows have been observed at the inner edge of the plasma sheet, at the equator, during an eclipse on one occasion, when the S/C potential was near zero.

Also electron measurements gain by satellite potential control: Usually, the low energy portion of the electron spectra is contaminated by photo-electrons from the satellite surface, trapped by the positive satellite potential. Such effects can cause substantial errors in interpreting electron spectra. The ambient distribution is distorted by the satellite sheath, so that high order moments of the distribution function are not determined correctly. Automatic calculation of these moments, in particular, is made more difficult.

Deleterious effects of S/C charging also extend to electric field measurements. The double probe technique for electric field measurements can respond to the local electric field induced by the satellite charge. This is one motivation for extending the booms to substantial distances from the satellite. By reducing the positive potential of the satellite and on the conductive long wire booms, supporting the electric field probes, the local field perturbation should be reduced, enhancing the electric field measurement.

The electron beam technique for electric field measurements is also somewhat sensitive to satellite potential. If the beam energy is 1 keV and the S/C potential is 10 V, the perturbation to the measurement is about 1 %. The disturbance should be kept to low values in order to be able to use the full capability of the beam technique to measure small electric fields.

Apart from providing a highly improved environment for other experiments as described above, scientific investigations of the photoelectric characteristics, dependence of the S/C potential on plasma parameters, and of S/C charging in different plasma environments will be carried out. In accordance with the scientific community the ion current will be varied in a defined way for a short time to enable the co-operating plasma experiments to calibrate their response to S/C potential variations. Such experiments will be carried out at large, regular intervals, preferably in sections of the orbit which are not of prime interest to the mission as a whole.

1.1.2 Program of Activities

The activities are basically independent of separation, phase, or time.

The main objective of keeping S/C potential constant at low value is the same in all regions along the orbit. The importance of active control, however, is increasing with the value of the uncontrolled potential, which depends on the ambient plasma characteristics. The highest uncontrolled potentials are expected within thin and cold plasma environments.

Active experiments with the ion beam as a secondary objective should be carried out over a very small fraction of total time distributed over all regions of the orbit. There is a preference for performing these active experiments in regions with stable ambient plasma conditions throughout the duration of the experiment. This normally excludes all kinds of boundary crossings in the magnetosphere.

1.2 Areas of Interest

Area of Interest	Mode	Interest
all regions, quasi-continuous	feedback or stand-alone: (modes FEFW, FPEA, IION, ITOT) (depending on technical constraints, e.g. IEL status, rather than on scientific value)	to provide a controlled, low spacecraft potential
all regions, in samples, including short eclipses	test and commissioning: (modes T&C, IION, ITOT)	to investigate the current-voltage characteristics of the spacecraft, to calibrate instruments w.r.t. ion beam effects to investigate on spacecraft charging problems to support ion beam plasma physics investigations

1.3 Instrument Description

1.3.1 Operating Principle

The basic approach to the active control of spacecraft potential involves the emission of charges from the S/C sufficient to balance the excess of charge accumulating on the vehicle from the environment. For the case of primary concern here, where photo-emission of electrons drives the

S/C potential positive relative to the plasma potential, it is necessary to emit positive ions. By adjusting the positive emission current, the spacecraft potential can thus be adjusted to near zero.

Hence, the output of the instrument is an energetic ion beam with known energy and controlled current.

The ion emitter is a "solid needle" - type liquid metal ion source, previously described in the literature using indium as charge material. A solid needle, usually made of tungsten (W), with a tip radius between 2 and 15 µm is mounted in a heated reservoir with the charge material. A potential of 4 to 8 kV is applied between the needle and an extractor electrode. If the needle is well wetted by the metal, the electrostatic stress at the needle tip pulls the liquid metal towards the extractor electrode. This stress is counteracted by the surface tension forces of the liquid. One of the equilibrium configurations the liquid surface can assume is that of a Taylor-cone with a total tip angle of 98.6°. The apex of the Taylor-cone in practice reaches a diameter of 1 to 5 nm. The field evaporation of positively charged metal atoms in the strong apex field leads to emission of a high brightness external ion beam from this cone apex with a beam brightness of the order of 10^6 A cm^{-2} sr^{-1} at maximum beam energy.

Since the emission zone is in the liquid state, ions leaving the surface can be continuously replenished by hydrodynamic flow of liquid metal from the reservoir to the needle apex so that a stable emission can be maintained.

Indium has been chosen as ion source charge material because of its low vapour pressure, preventing contamination of the source insulators and ambient S/C surfaces. On the other hand, the melting point is high enough that melting of an unheated source charge cannot occur even at the maximum expected elevated environmental temperature.

1.3.2 Design of Emitter Module

Four individual ion emitters are contained in one ion emitter "module" and are operated one at a time (Fig. 1). The individual emitters are of cylindrical geometry. The indium reservoir and the needle sitting on top are kept at high voltage. The LMIS's are individually and indirectly heated from below by a PT100 wire resistor embedded into a ceramic insulator tube. This scheme enables the source to be heated from a grounded power supply and the tip itself still being kept at high voltage. The individual emitters are mounted in a slab of porous ceramic with extremely low heat conduction. The thermal isolation of the source has an immediate effect on the heater power consumption which is below 0.6 W. The mass of an individual emitter is 1.2 g including the heater. The reservoir contains 200 mg of indium which suffices for about 2000 hours operation per emitter. Three emitters are more than sufficient to achieve the design goal of 5000 hours per module. The fourth emitter serves as a backup. In fact, three or four emitters per module, or 7 to 8 emitters per instrument are operational in the final configuration of the flight units. A list of non-operational emitters is provided in Section 2.2.11.

All emitters have a common extraction- and focusing lens arrangement consisting of a grounded extractor electrode, a focusing electrode at beam potential and a second ground electrode. These three electrodes constitute a unipotential lens with the tip apex located in one focal point. The divergent ion beam (opening angle ca. 30°) emitted from the tip is focused by this lens into a nominally parallel beam. The cold secondary side of the high voltage supply is connected to the extraction and outer electrodes of the focusing lens and to metal tubes around the heater elements. These tubes protect the heaters and their power supply, which is connected to ground, from disastrous high voltage strokes. With this grounding scheme all possible paths for high voltage flashes are confined within the high voltage loop.

The relevant currents flowing in this system are:

- the current carried by the emitted ion beam. This current loop is closed via the spacecraft surface by the ambient plasma. This current is referred to as ion current or beam current.

- the total current delivered by the high voltage supply to the emitter. This current includes the beam current and internal loss currents (e.g. the current to the extraction and beam focusing electrodes), and is therefore always larger than the beam current. The percentage of loss currents within the total current is small (<10 to 20%) for small to medium currents and may increase to 30 to 50% near the maximum total current (about 65 µA).

In order to avoid oxidation of the indium in the liquid metal ion source it should never become exposed to air or water vapour. An almost hermetically closed volume has been designed where the emitters can be stored in a protective gas atmosphere. It will be opened after launch and after a reasonable outgassing of the satellite has taken place. The cover system consists of a hinged plate which tightens the LMIS module on an O-ring. The cover plate is held down and locked by a special hook, which is held in position by a helically wound bending spring. For opening the cover a pyrotechnic piston actuator, mounted perpendicular to one of the faces of the hook, is actuated. A pin pushes the hook away from its locking position and the spring-loaded cover plate will open.

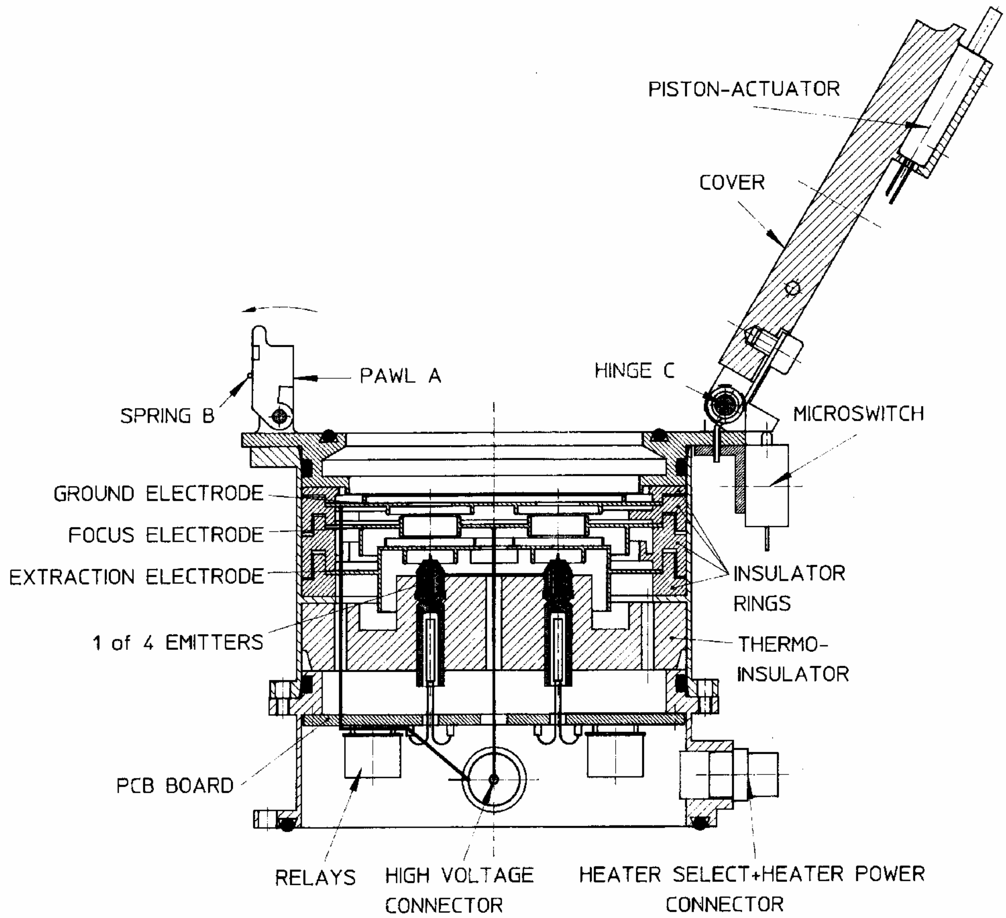


Fig. 1 Cross-section of emitter module

Because of the small volume of gas and the inevitable leakage the initial internal overpressure of 0.1 bar would disappear within about one year during storage on the ground and cause air to enter from outside, contaminating the indium. As the delivery time of the ASPOC flight units is about 1.5 to 2.5 years before the launch date, a two-step solution has been implemented. For the initial deliveries the flight units are equipped with dummy emitter modules to be used during most of the test activities before launch. They are identical to real emitters except that no indium is present and the beam current paths are simulated by electrical resistors. These dummies are replaced by the real emitter modules in the late exchange period before the S/C are shipped to the launch site.

1.3.3 Electronics

The instrument utilises a microprocessor for controlling the experiment and for data handling. It basically operates and controls the ion emitting system (high voltage and heater power), performs the start-up procedure of the emitters, and serves the interfaces to the on-board data handling and telecommand units, the electric field instrument and low energy electron spectrometer (EFW and PEACE) providing S/C potential data in real-time. Special attention is paid to the monitoring and safety of the high voltage unit.

Because of the low data rate (108 bit s^{-1}) both housekeeping and science data are transmitted through the housekeeping channel. Complete status information is given every 10.3 s (a part of the status telemetry is subcommutated 1:2).

Figure 1b shows an electrical block diagram of ASPOC with emphasis on the DPU. The program is downloaded from PROM into CMOS RAM when the instrument is turned on. The processor is a 80C85. A large part of the logic circuits that are not interfacing the S/C is contained in a programmable gate array.

The DC converter and the high voltage unit consume one printed circuit board each. The DC converter provides three fixed voltages (+5 V, +13.5 V, -5 V) and a variable output for the heater elements in the emitters. The high voltage unit can power one of the two emitter modules at a time in voltage or current controlled modes. Analogue monitors of the high voltage, the total output current at high voltage, and the effective ion beam current are provided. The latter measurement necessitates a special grounding concept for the emitter supply unit. The power consumption consists of an almost constant component of ca. 1.5 W for the DPU and the heating of one emitter filament and a variable part which is largely proportional to the emitted ion current. While 3 W peak primary power can be reached by design, this value should not be sustained for longer periods because of lifetime limiting effects on the ion emitters. An average value of 2.7 W primary power complies both with a technically optimum value for the emitters and the requirements on the ion current for S/C potential control in the expected plasma environment.

The DPU has a watch-dog timer. If a counter is not reset regularly by the program running in the DPU, it will perform a full reset of the DPU and a re-load of the programme from the PROM into the RAM after 8 seconds. The impact on telemetry is a reset of all parameters to the power-on state, a loss of data for up to 18 seconds, followed by standby operation of the instrument.

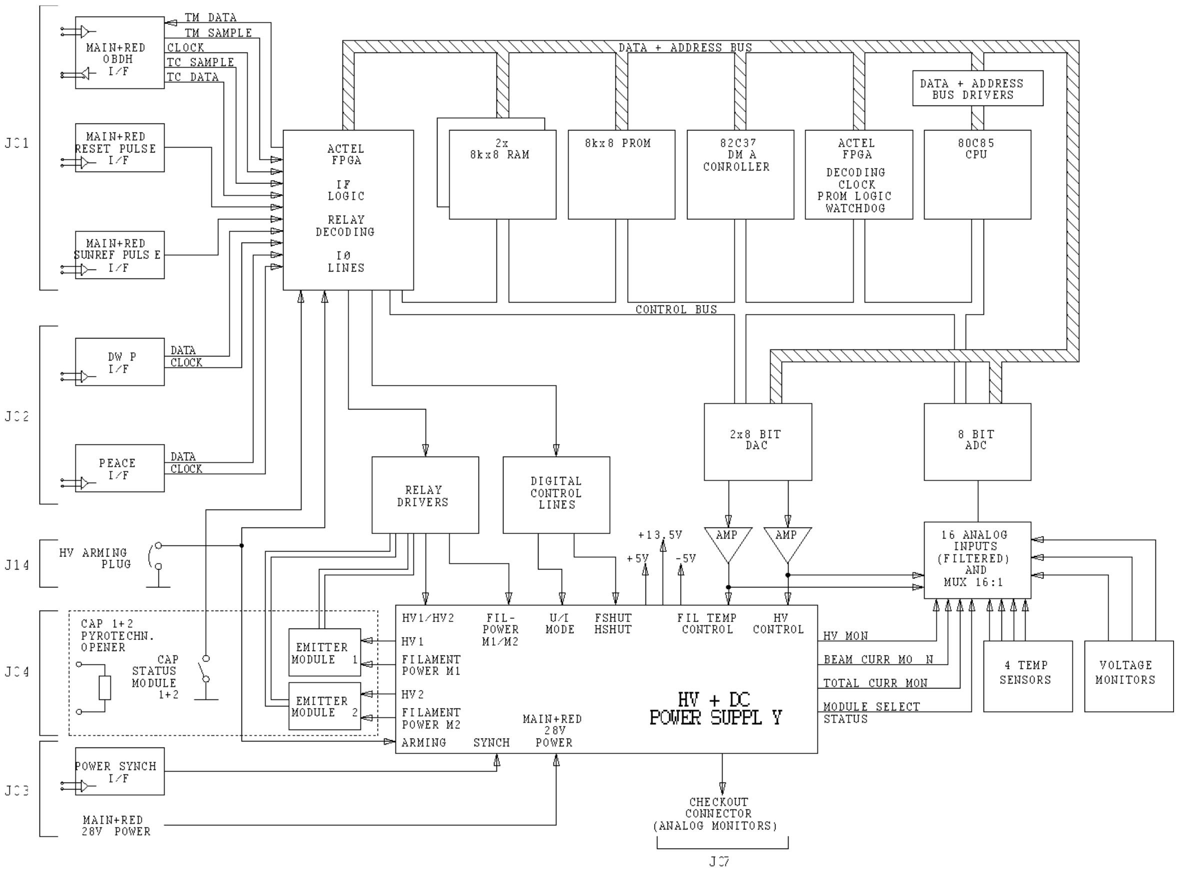


Fig. 1b Electrical block diagram of ASPOC

1.3.4 Operational Modes

1.3.4.1 Overview

Feedback modes. In the basic operation mode a measurement of the S/C potential is supplied to ASPOC by either the electric field experiment (EFW) or the electron analyser (PEACE) and this information is then used to adjust the emission current sufficient to reduce the S/C potential to some predetermined value in a closed-loop scheme. This mode is called feedback mode (mode "FEFW" or mode "FPEA", respectively). The measurements of the S/C potential are updated once every spin and sent to ASPOC via dedicated serial, digital IEL interfaces. Data from EFW consist of the voltage measured between one pair of spheres and the S/C body when operating in voltage mode. The value is sampled every second and sent to the Digital Wave Processor (DWP) instrument, which combines it with operating mode information of the WHISPER instrument and transmits the product to ASPOC. The instrument PEACE attempts to calculate S/C potential from the distribution function of electrons in the range below about 25 V and transmits a value if the calculation was successful.

Test and commissioning mode. For calibration and "active experiment" purposes a test and commissioning mode (mode "T&C") has been defined covering instrument operations which are not related to the maintenance of constant spacecraft potential. From a considerable amount of previous experience the current-voltage characteristics of typical S/C are already well-known, but the necessity for a measurement of this characteristic for each Cluster-II S/C at the beginning of the mission, and occasional re-measurements to account for changes in the photo-emission properties of the surface remains. This measurement is simply carried out by sweeping the ion emission current in incremental steps over some convenient range, allowing simultaneous measurements of the S/C potential. The length of each step is 8 or 16 seconds, the total duration of this mode is a few minutes depending on the emission current range, which will be adjusted to meet the scientific objectives of the particular measurement.

Apart from providing a highly improved environment for other experiments, scientific investigations of the photoelectric characteristics, dependence of the S/C potential on plasma parameters, and of S/C charging in different plasma environments can be carried out in a so-called active mode. In accordance with the scientific community the ion current can be varied in a defined way for a short time to enable the co-operating plasma experiments to calibrate their response to S/C potential variations. Such experiments will be carried out at large, regular intervals, preferably in sections of the orbit which are not of prime interest to the mission as a whole. Stepping through different current levels must occur in synchronism with scans, sampling intervals, etc. of other experiments.

Stand-alone modes. In case no signal from EFW or PEACE is available, a stand-alone mode of operation involves setting the ion emission current to some constant value based on the S/C current-voltage characteristics and experience gained in flight (mode "IION"). This value can be set by ordinary time-tagged commands to vary according to the expected plasma environment along the orbit. A maximum of 4 different currents per orbit should be sufficient. At the same time the current level must be sufficiently low to insure that the S/C potential is not driven negative. The control of potential would not be as good in this case as in the feedback mode described before, but could still be used to reduce the S/C potential to a few volts positive relative to the ambient plasma potential according to the steeper part of the photo-emission characteristic.

There is another stand-alone mode where the total current fed into the ion emitter (rather than the ion beam current) is kept constant. The purpose of this mode (mode "ITOT") is to provide a fallback solution in case of electromagnetic interference problems with the beam current monitor on board. The measurement of the total current is probably less sensitive to electromagnetic interference than the measurement of the beam current, the latter being closed over a huge loop through the ambient plasma and the spacecraft structure.

Hot standby mode. The ion beam emission may have to be turned off during time intervals varying from a few seconds up to fractions of hours or more, depending largely on the ambient plasma conditions. During such pauses the ion emitter may be kept at elevated temperature to ensure immediate re-start capability in changed plasma conditions. The mode associated with pre-programmed emission pauses is called hot standby mode (mode "HOT"). A typical application for this mode is the interruption of ion beam emission for a few minutes enforced by some operational reasons.

It is worth mentioning here that a similar state of the instrument (emitters heated, but the ion beam turned off) is reached when it is forced to turn off the ion beam temporarily due to some conditions in one of the feedback modes. This state was called "internal hot standby mode" in previous documentation. It is now called "feedback wait status" ("WAIT").

Standby mode. The standby mode (mode "STDB") leaves the instrument in a completely passive state: high voltage and ion beam emission and the heater filaments of the emitters are turned off. The instrument only serves the interfaces to the spacecraft and the IEL and produces housekeeping data.

Standby mode is the power-on mode and the contingency mode in case of problems with the ion beam emission.

The instrument does not have permanent memory. Standby mode is therefore useful to keep parameters in internal memory, which would have to be uplinked again after power-off. Standby mode should be used between data taking periods within one orbit in which ASPOC ion beam operations are scheduled. ASPOC should be turned off during passes of the radiation belts.

Other instrument states. Apart from the main operating modes described above there are a few special instrument states (previously called "internal modes") which reflect either failure conditions (e.g. an unexpected absence of spacecraft potential data in feed-back mode) or technical constraints (e.g. start-up of an emitter). The possible failure conditions are described elsewhere in detail. They may be grouped into three categories:

1. Failure of one of the inter-experiment links from the instruments EFW/DWP or PEACE

2. Instrument WHISPER in active mode

3. Failure of the ion emitter

Precautions for WHISPER active modes. It is anticipated that the WHISPER instrument in its active sounding modes may have a large effect on the measurements of the S/C potential and the potential itself, despite the fact that many instruments including EFW and PEACE have implemented blanking periods during the sounder pulses. The presence of any effects will be established during the test and commissioning phase at the beginning of the mission. If it is found necessary to discard the S/C potential by EFW or PEACE, or to turn off the ion beam altogether, the ASPOC instrument can be commanded to switch into a suitable backup mode set by telecommand whenever WHISPER is operating in a mode which has been found disturbing. This is accomplished by transmitting a three-bit WHISPER operating mode information in every spin period through DWP to ASPOC. ASPOC software reacts according to a decision table which has been set by time-tagged command. Constant ion beam current mode (IION) or standby (STDB) mode are possible backup modes. The optimum configuration will be determined in the commissioning phase.

If any interruption of the control loop with S/C potential data occurs while ASPOC is in feedback mode, the ion emission is kept at the last value for a few spin periods before ASPOC reacts on this timeout condition either by turning off the ion current or by setting it to a constant value, which has been pre-set by time-tagged command. In terms of operating modes this is a transition into standby, hot standby or one of the stand-alone modes.

Start-up mode. The description of modes would be incomplete without the start-up mode (mode "STRT"). As will be shown below the ion emitters must be heated during operation. Depending on the ambient temperature it takes about 14 to 33 minutes to reach a temperature inside the emitters which is sufficient to ignite the ion beam. The period from the beginning of the heating until a few seconds after the ignition of the beam is defined as start-up period. Whenever ASPOC is commanded into a mode involving ion beam emission, the instrument begins a start-up cycle for an ion emitter. After ignition of the ion beam and immediately after the emission has become stable the instrument performs according to the commanded operating mode.

Technical mode. The instrument features a technical mode (mode "TECH"). In this mode some additional low-level commands for the control of the emitter filaments, for the internal DA converter, for switching between emitter modules and others are enabled. This mode is suitable for low level check-out of the instrument after an anomaly has been detected. This mode should be avoided in orbit under normal conditions.

Shutdown. Turning off the ion beam is accomplished by switching into standby mode, which does not require any special procedures and can be commanded at any time. Shutdown goes into effect immediately.

Cleaning. If the active emitter is contaminated (e.g. by sputter products) the high voltage starts to increase. When a certain threshold is exceeded, an automatic cleaning of the emitter may be initiated by on-board software. The cleaning consists of a short-term (up to 60 seconds) emission of a high current, which very likely removes contamination layers at the emitter. All parameters of the cleaning can be enabled or set by commands: the cleaning option can be enabled or disabled altogether, the threshold value to trigger cleaning can be set, the action after exceeding the threshold can be selected (either triggering of cleaning or switching into standby mode), and the duration and current of the cleaning cycle can be selected between two options.

The same cleaning effect can also be achieved by time-tagged commands or procedures for short-time, high-current operation (see e.g. procedure QEACLEAN). It can also be carried out as a preventative measure.

1.3.4.2 Technical details of modes

MODE:	**FEFW**
CODE:	0x1300
NAME:	feedback mode from EFW
FUNCTION:	Updates ion beam current whenever valid spacecraft potential data from EFW are received.

REMARKS:
Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS	filament selection, with x = 1...4 or M
ZEAMODxS	module selection, with x = A or B or U
ZEAFIL_E	filament enable
ZEAHV__E	high voltage enable

When valid spacecraft potential data are received, the beam current update calculation is performed.

The data-received-flags EAEFWRX1 or EAEFWRX2 are set and the new data are written into the telemetry frame only if the newly received spacecraft potential data word differs by more than one digit from the previous value.

Only one or two values per reset pulse interval can be stored.

The calculated new ion beam current (Ibeam) and the total high voltage output current (Itotal) necessary to achieve this beam current are constrained by software to the following conditions:

$$\text{Ibeam} \geq \text{EATOTCLL} * 0.5$$
$$\text{Ibeam} \leq \text{EATOTCUL} * 0.5$$
$$\text{Itotal} \geq \text{EATOTCLL}$$
$$\text{Itotal} \leq \text{EATOTCUL}$$

The factor 0.5 has been introduced as a crude estimate of the current efficiency of the emitters which is the ratio between Ibeam and Itotal. Thereby the two parameters EATOTCLL and EATOTCUL can be used to limit both Ibeam and Itotal. If the real efficiency, E, is better than 0.5, then the upper beam current limit is Ibeam = EATOTCUL*0.5 and the lower limit is Ibeam = EATOTCLL*E, if the real efficiency is lower than 0.5, then the upper limit is Ibeam = EATOTCUL*E and the lower limit EATOTCLL*0.5.

Valid spacecraft potential data are identified by bit number 15 in the data word from DWP being set. Other validity considerations related to the inter-experiment link can be found in section 1.3.6.

The formula for the ion current update is given in the software section (1.4.2.2.).

The total high voltage current requested from the supply is calculated in an inner control loop. See mode IION for details.

MODE: **FPEA**
CODE: 0x1700

NAME: feedback mode from PEACE

FUNCTION: Updates ion beam current whenever valid spacecraft potential data from PEACE are received.

REMARKS:
Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS	filament selection, with x = 1...4 or M
ZEAMODxS	module selection, with x = A or B or U
ZEAFIL_E	filament enable
ZEAHV__E	high voltage enable

When valid spacecraft potential data are received, the beam current update calculation is performed and the data-received-flags EAPEARX1 or EAPEARX2 are set.

Only one or two values per reset pulse interval can be stored.

The calculated new ion beam current (Ibeam) and the total high voltage output current (Itotal) necessary to achieve this beam current are limited by the following conditions:

Ibeam ≥ EATOTCLL * 0.5
Ibeam ≤ EATOTCUL * 0.5
Itotal ≥ EATOTCLL
Itotal ≤ EATOTCUL

Valid spacecraft potential data are identified by lying within the range 1 ... 127 (raw). A value of 0 indicated a "trying" status of PEACE, values ≥128 shall be ignored (equivalent to potentials above 25.6 V). Other validity considerations related to the inter-experiment link can be found in section 1.3.6.

The formula for the ion current update is given in the software section.

The total high voltage current requested from the supply is calculated in an inner control loop. See mode IION for details.

MODE: **IION**
CODE: 0x1200

NAME: constant beam current mode

FUNCTION: Updates total current of the high voltage power supply to maintain a constant ion beam current

REMARKS:
Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS	filament selection, with x = 1...4 or M
ZEAMODxS	module selection, with x = A or B or U
ZEAFIL_E	filament enable
ZEAHV__E	high voltage enable

In order to compensate the varying efficiency of the emitters and the high voltage supply, the ion beam current is controlled in a fast loop, which in case of additional spacecraft potential control serves as an inner control loop.

As fast as processor speed allows the beam current is measured and an updated total current is calculated.

The calculated new total high voltage output current (Itotal) necessary to achieve the beam current is limited by the following conditions:

Itotal ≥ EATOTCLL
Itotal ≤ EATOTCUL

The formula for the ion current update is given in the software section.

MODE: **ITOT**
CODE: 0x1100

NAME: constant total current mode

FUNCTION: reads every second the parameter EATOTCSV and outputs this current value to the high voltage power supply

REMARKS:
Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS	filament selection, with x = 1...4 or M
ZEAMODxS	module selection, with x = A or B or U
ZEAFIL_E	filament enable
ZEAHV__E	high voltage enable

MODE: **STDB**
CODE: 0x1000

NAME: standby mode

REMARKS:
Resets the enable flags for filaments and high voltage:

EAFILENB	filament enable
EAHVSWEN	high voltage software enable
EAHVSHEN	hshut line enable

Also resets the validity of any previous filament and module selection (so the selection has to be repeated if necessary), but the parameter values of the selection (EAFILSEL and E EAMODULE) remain unchanged. One of the following parameters has to be set again before any active command can be commanded:

EAFILSEL by command ZEAFILxS (x=1 ... 4 or M)

EAMODULE by command ZEAMODxS (x=A or B or U)

MODE:	**T&C**
CODE:	0x1500
NAME:	test and commissioning mode
FUNCTION:	operates the ion emitter in a step function for the total current

REMARKS:
Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS	filament selection, with x = 1...4 or M
ZEAMODxS	module selection, with x = A or B or U
ZEAFIL_E	filament enable
ZEAHV__E	high voltage enable

The initial current value is the value of the parameter EATOTCSV (the total current set value).

The direction (sign) of the steps, when the command is sent, continues from the status when the mode has been left previously. The initial status after power-on is positive (increasing current).

The current range is limited by the total current limits EATOTCLL and EATOTCUL. Starting from the initial value the current is increased or decreased, but the direction is reversed before one of the limits would be exceeded.

The total current set value parameter (EATOTCSV) is overwritten during this mode. After the end of the operation in this mode this parameter contains the last current value of the step function.

MODE:	**TECH**
CODE:	0x1600
NAME:	technical mode
FUNCTION:	allows low level check-out operations

REMARKS:
The experimenter team has to constantly log the status of the instrument. He must take care to reset all relays etc. which have been set.

1.3.4.3 Functional Diagram

Figure 1c shows a functional diagram of the instrument.

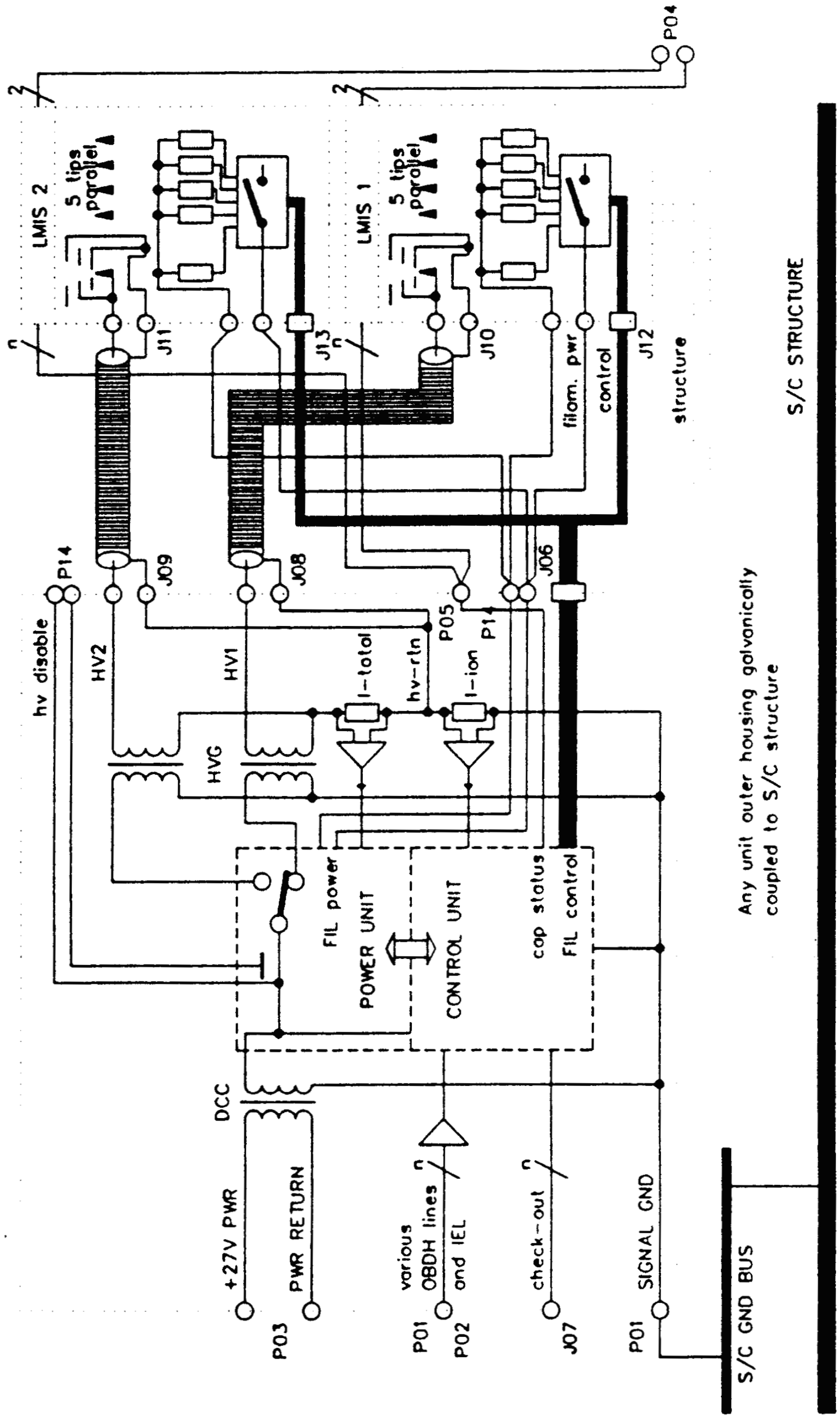


Fig. 1c Functional diagram of ASPOC

1.3.5 Parameters

The most important parameters are:

NAME	DESCRIPTION	RELEVANT MODE	SAMPLING
EAHVMON_	high voltage	all active modes	10.3 s
EATOTC0_ through EATOTC9_	total high voltage current	all active modes	0.5 s
EAIONC0_ through EAIONC9_ and EAHRION0 through EAHRION9	ion beam currents	all active modes	0.5 s 40 ms
EAFILTEM	temperature of active emitter	all active modes	10.3 s
EAEFWPT1 EAEFWPT2	S/C potential from EFW	feedback modes	4 s
EAPEAPOT EAPEAPT2	S/C potential from PEACE	feedback modes	4 s
EACOEFKV EACOEFTV	control loop characteristics	feedback modes	10.3 s

1.3.6 Mode and Parameter Changes

1.3.6.1 Parameter changes

All parameter changes are via individual telecommands.

There is no keep-alive memory.

1.3.6.2 Mode changes

Modes changes may be initiated by telecommand. These changes are reflected in the experiment mode status word in the telemetry.

Some other instrument status changes occur autonomously by the instrument, mainly dictated by failure conditions. Such changes generally only temporarily determine the mode of the instrument. They are also reflected in the experiment mode word in the telemetry. It can be distinguished from a commanded mode change by the respective timeout flags. In order to get a complete picture of the experiment status it is therefore necessary to look at the experiment mode and the various additional flags (EABKMODE="backup mode", EABK_ACT="backup mode active flag", EASU_ACT="start-up active flag", EAEXPMOD="experiment in active mode flag", 6 different timeout flags: EATIMOT2, EATiMOUT with i = 1 to 5). See section on state diagrams (1.3.6.4) and parameters defining the instrument state (1.3.6.5) for more details.

An exception is the autonomous change into standby mode caused by the total failure of an emitter, or after the high voltage threshold for cleaning has been exceeded and automatic cleaning was either disabled or unsuccessful. This condition sets the instrument permanently into standby mode, until commands to correct the problem have been issued.

Autonomous status changes can occur in abnormal conditions:

IGN	no ignition during emitter start-up
I=0	no current
ENV	EFW data not valid
PNV	PEACE data not valid
INV	calculated ion current out of range
V<0	negative S/C potential
FWX	maximum feedback wait period exceeded
THR	no recovery from cleaning threshold condition

The start-up (heating of the emitters to operating temperature) is another special case of a temporary instrument status. It cannot be commanded as an operating mode. It can be regarded as a wait state which the instrument temporarily assumes whenever a command for an active ion emission mode is encountered after a new emitter or a new module has been selected. The duration of the start-up depends on ambient temperature and on the initial temperature conditions. It can take up to 33 minutes: see Section 4.4.1.3 (internal mode timing) for details.

The hot standby mode turns off high voltage, leaving the emitters at operating temperature. It only makes sense to command hot standby mode from one of the active ion emission modes, not from standby.

The technical mode is a mode in which some commands directly addressing instrument hardware are permitted which in all other modes would be performed in a programmed sequence. Also no further enable commands are required, with the exception of high voltage enable. The technical mode is ended by any other mode command. Care must be taken not to leave the instrument in an undesired state, i.e. the reverse commands for all settings must be given before entering another mode.

Backup mode and feedback wait status

There are two major methods of failure handling:

1. A subset of failures on the IEL links (e.g. no data from EFW during EFW feedback mode) causes the instrument to enter a previously commanded backup mode.

2. The rest of failures (usually the more severe ones) cause the instrument to enter one of the standby modes without ion emission.

Permitted commanded and autonomous status changes, respectively, are summarized in the following matrices, where different matrices have been defined also for backup modes and the feedback wait status.

Indicators for "feedback wait status"

The following flags are set during feedback wait status:

1. EATIMOT2 (HOT). This flag is the main indicator of the feedback wait status

2. A second flag may be set, indicating the reason why the instrument has got into feedback wait status:

   a) Condition "INV"; parameter EAT5MOUT. Calculated ion current in feedback mode out of range (less than minimum permitted value).

   b) Condition "V<0"; no dedicated parameter available, but condition can be derived from polarity of EFW spacecraft potential data EAEFWPT1. Spacecraft potential sent by EFW is negative.

   c) No second flag is set if the reason for feedback wait status was the detection of a WHISPER mode matching the WHISPER mode conditions.

These conditions are also described in section 1.3.6.3.

Difference between "Hot Standby Mode" and "feedback wait status"

1. Hot Standby Mode lasts for indefinite time, until the next operating mode command.

   Feedback Wait Status does not last indefinitely, if it has been caused by a WHISPER mode matching the WHISPER mode conditions.

2. in Hot Standby Mode the experiment operating mode parameter (EAOPMODE) is EAOPMODE=4

   in Feedback Wait Status the experiment operating mode parameter remains the one set by the last operating mode command (one of the feedback modes, EAOPMODE=3 or 7).

Mode Change Matrices

1. Legend

ENV	EFW data not valid
FEFW	feedback from S/C pot. measured by EFW
FPEA	feedback from S/C pot. measured by PEACE
FWX	maximum feedback wait period exceeded
HOT	hot standby
I=0	no current
IGN	no ignition during emitter start-up
IION	constant ion beam current
INV	calculated ion current out of range
ITOT	constant total HV current
OFF	power off
PNV	PEACE data not valid
POFF	change by power off
PON	change by power on
STDB	standby
STRT	start-up
T&C	test and commissioning
TC	change by telecommand
TECH	technical
THR	no recovery from cleaning threshold condition
V<0	negative S/C potential
WAIT	feedback wait status

The mode change matrices must be read: The initial mode is given in the left column. It changes into the mode given in the top row by an event indicated in the matrix.

2. Commanded Mode Changes (Complete List)

This matrix lists all technically possible mode changes without respect to their actual relevance. The changes are executed by the instrument and do not put the instrument in an irrecoverable state.

TO: FROM	OFF	STDB	ITOT	IION	FEFW	FPEA	HOT	T&C	TECH
OFF	-	PON	-	-	-	-	-	-	-
STDB	POFF	TC	TC	TC	TC	TC	-	TC	TC
ITOT	POFF	TC	TC	TC	TC	TC	TC	TC	TC
IION	POFF	TC	TC	TC	TC	TC	TC	TC	TC
FEFW	POFF	TC	TC	TC	TC	TC	TC	TC	TC
FPEA	POFF	TC	TC	TC	TC	TC	TC	TC	TC
HOT	POFF	TC	TC	TC	TC	TC	TC	TC	TC
T&C	POFF	TC	TC	TC	TC	TC	TC	TC	TC
TECH	POFF	TC	TC	TC	TC	TC	TC	TC	TC

3. Commanded Mode Changes (relevant changes only)

This table lists scientifically and technically relevant mode changes. It is a subset of table 2. It does not contain:

- changes into the same mode again,
- changes from technical mode in any other mode than standby. These changes are not recommended because of the arbitrary condition the instrument may have after a technical mode session.

TO: / FROM	OFF	STDB	ITOT	IION	FEFW	FPEA	HOT	T&C	TECH
OFF	-	PON	-	-	-	-	-	-	-
STDB	POFF	-	TC	TC	TC	TC	-	TC	TC
ITOT	POFF	TC	-	TC	TC	TC	TC	TC	TC
IION	POFF	TC	TC	-	TC	TC	TC	TC	TC
FEFW	POFF	TC	TC	TC	-	TC	TC	TC	TC
FPEA	POFF	TC	TC	TC	TC	-	TC	TC	TC
HOT	POFF	TC	TC	TC	TC	TC	-	TC	TC
T&C	POFF	TC	TC	TC	TC	TC	TC	-	TC
TECH	POFF	TC	-	-	-	-	-	-	-

4. Autonomous Permanent Mode Changes

This table contains possible autonomous and permanent mode changes due to failure conditions. The destination mode is always standby.

This table includes the case that standby mode has been defined as the backup mode for IEL failures.

TO:	OFF	STDB	Reasons
OFF	-	-	
STDB	-	-	
ITOT	-	FAI	IGN,I=0
IION	-	FAI	IGN,I=0
FEFW	-	FAI	IGN,I=0,ENV
FPEA	-	FAI	IGN,I=0,PNV
HOT	-	FAI	IGN,I=0,FWX
T&C	-	FAI	IGN,I=0
TECH	-	FAI	IGN,I=0
THR	-	FAI	THR

5. Autonomous Temporary Mode Changes into Backup Mode

In this table the left column represents the commanded originating modes, all other columns are temporary modes resulting from an autonomous mode change into a predefined (by command) backup mode, caused by a subset of IEL failures. The resulting modes, including the hot standby mode, are backup modes.

TO: / FROM	ITOT	IION	FEFW	FPEA	HOT	T&C	TECH
ITOT	-	-	-	-	-	-	-
IION	-	-	-	-	-	-	-
FEFW	ENV	ENV	-	ENV	ENV	-	-
FPEA	PNV	PNV	PNV	-	PNV	-	-
HOT	-	-	-	-	-	-	-
T&C	-	-	-	-	-	-	-
TECH	-	-	-	-	-	-	-

6. Recovery from Autonomous Backup Mode

In this table the left column represents the temporarily assumed backup mode resulting from a previous IEL failure as listed in table 5. The other columns are the regular modes which were active before the backup mode was entered. The changes occur when a previous failure condition indicated in the matrix has ceased to be true. This table is the inverse of table 5.

TO: / FROM	ITOT	IION	FEFW	FPEA	HOT	T&C	TECH
ITOT	-	-	ENV	PNV	-	-	-
IION	-	-	ENV	PNV	-	-	-
FEFW	-	-	ENV	-	-	-	-
FPEA	-	-	-	PNV	-	-	-
HOT	-	-	ENV	PNV	-	-	-
T&C	-	-	-	-	-	-	-
TECH	-	-	-	-	-	-	-

7. Other Autonomous Temporary Mode Changes

In this table the left column represents the commanded originating modes, the right column is a temporary state of the instrument resulting from an autonomous change other than the execution of the backup mode. In particular, this is the change in the feedback wait status.

TO: / FROM	WAIT
ITOT	-
IION	-
FEFW	ENV,INV,V<0
FPEA	PNV,INV
HOT	-
T&C	-
TECH	-

8. Recovery from Other Autonomous Temporary Mode Changes

In this table the left column represents temporary internal states resulting from a previous failure as listed in table 7 (only feedback wait state is relevant). The other columns are the modes which were active before the feedback wait status was entered. The changes occur when a previous failure condition indicated in the matrix has ceased to be true. This table is the inverse of table 7.

TO: / FROM	ITOT	IION	FEFW	FPEA	HOT	T&C	TEC
ITOT	-	-	-	-	-	-	-
IION	-	-	-	-	-	-	-
FEFW	-	-	-	-	-	-	-
FPEA	-	-	-	-	-	-	-
WAIT	-	-	ENV,INV,V<0	PNV,INV	-	-	-
T&C	-	-	-	-	-	-	-
TECH	-	-	-	-	-	-	-

9. Failure During Backup Mode

Failures during backup mode are treated as failures during normal modes, except that temporary changes to backup mode are replaced by permanent changes into standby mode. In table 9 the left column represents an active backup mode already caused by some failure (see table 5). Additional failures within backup mode cause changes to modes in the right columns.

TO: FROM	OFF	STDB	ITOT	IION	FEFW	FPEA	WAIT		T&C	TEC
OFF	-	-	-	-	-	-	-		-	-
STDB	-	-	-	-	-	-	-		-	-
ITOT	-	I=0	-	-	-	-	-		-	-
IION	-	I=0	-	-	-	-	-		-	-
FEFW	-	I=0	-	-	-	-	ENV,INV,V<0		-	-
FPEA	-	I=0	-	-	-	-	PNV,INV		-	-
HOT	-	-	-	-	-	-	-		-	-
T&C	-	-	-	-	-	-	-		-	-
TECH	-	-	-	-	-	-	-		-	-
WAIT	-	FWX	-	-	-	-	-	-	-	-

1.3.6.3 Failure conditions

The failure conditions in more detail:

IGN **no ignition during emitter start-up:**

Condition: HV = on, but no ignition (beam current < 2.3 µA) at emitter occurred during 20 minutes.
Result: standby mode
Monitor: EATIMOUT, bitmask 01 (= EAT1MOUT)
EAOPMODE=0 (standby)
Recovery: by the next operation mode command

I=0 **no current**

Condition: measured total current was less than the lower limit EATOTCLL (default value: 2 µA) during 255 sec
Result: standby mode
Monitor: EATIMOUT, bitmask 02 (= EAT2MOUT)
EAOPMODE=0 (standby)
Recovery: by the next operation mode command

ENV **EFW data not valid**

Condition: EFW failed or has been invalid over 40 sec.
(no data, or data disabled by WHISPER)
EFW negative is treated differently.

Results:

a) If "no data", the instrument goes into the mode defined as "backup mode".
Monitor: EATIMOUT, bitmask 04 (= EAT3MOUT)
EABK_ACT=1

b) If "data disabled by WHISPER" and "source change flag" is set, the instrument goes into the mode defined as "backup mode".
Monitor: EABK_ACT=1
EAWISSOR=1

c) If a) or b) are true and the instrument is already in backup mode, then it goes to standby mode.
Monitor: EATIMOUT, bitmask 04 (= EAT3MOUT)
EAOPMODE=0 (standby)

d) If "data disabled by WHISPER" and "WHISPER shutdown flag" is set, the instrument goes into "feedback wait status".
Monitor: EAWISSDW=1
EATIMOT2=1 (feedback wait status)

Recovery: 1) after 40 s of valid data have been received, and the target mode was not standby. There is no recovery from standby mode.
2) by the next operation mode command

PNV **PEACE data not valid**

Condition: PEACE failed or has been invalid over 40 sec. (no data, data invalid, data out of range, or data disabled by WHISPER)

Results:

a) If "no data", "data invalid", "data out of range" the instrument goes into the mode defined as "backup mode".
Monitor: EATIMOUT, bitmask 08 (= EAT4MOUT)
EABK_ACT=1

b) If "data disabled by WHISPER" and "source change flag" is set, the instrument goes into the mode defined as "backup mode".
Monitor: EABK_ACT=1
EAWISSOR=1

c) If a) or b) are true and the instrument is already in backup mode, then it goes to standby mode.
Monitor: EATIMOUT, bitmask 08 (= EAT4MOUT)
EAOPMODE=0 (standby)

d) If "data disabled by WHISPER" and "WHISPER shutdown flag" is set, the instrument goes into "feedback wait status".
Monitor: EAWISSDW=1
EATIMOT2=1 (feedback wait status)

Recovery: 1) after 40 s of valid data have been received, and the target mode was not standby. There is no recovery from standby mode.
2) by the next operation mode command

INV **calculated ion current out of range**

Condition: calculated total current in one of the feedback modes has been less than 50% of the minimum total current parameter setting, during 40 seconds: instrument had to switch into "feedback wait status". No further switching into standby mode.
Result: feedback wait status
Monitor: EATIMOUT, bitmask 10 (= EAT5MOUT)
EATIMOT2=1 (feedback wait status)
Recovery: after 40 s of valid data have been calculated, or by the next operation mode command

V<0 **negative S/C potential**

Condition: measured S/C potential by EFW is negative.
Result: immediately into feedback wait status. No further switching into standby mode.
Monitor: sign bit of EFW potential
EATIMOT2=1 (feedback wait status)
Recovery: after 40 s of valid, positive data have been received, or by the next operation mode command

FWX **maximum feedback wait period exceeded**

Condition:	"feedback wait status" has been active for more than 30 minutes, and the reason for feedback wait status was the detection of a disturbing WHISPER mode with the WHISPER shutdown flag having been set.
Note:	Feedback wait status caused by conditions "negative S/C potential (V<0)" or "calculated ion current out of range (INV)" has no time limit.
Result:	standby.
Monitor:	EATIMOT2, bitmask 01 EAOPMODE=0 (standby)
Recovery:	by the next operation mode command

THR **no recovery from cleaning threshold condition**

Condition:	high voltage EAHVMON_ has exceeded the threshold value EAHVTHRE during more than 20 seconds, and automatic cleaning was disabled (EACLNDSB=1) or automatic cleaning has been performed but was unsuccessful.
Result:	standby.
Monitor:	EATIMOT4=1 EAOPMODE=0 (standby)
Recovery:	by the next operation mode command

1.3.6.4 State diagrams

The following series of 10 state diagrams visualises the mode switching concept. Generally time-out counters are activated when a necessary condition becomes false.

Constant total current mode (ASPSTATE): refers to the conditions that
a) the emitter does not ignite properly (IGN), or
b) the total current drawn by the emitter falls below a threshold (I=0).

Constant beam current mode (ASPSTAT1): also refers to the conditions that
a) the emitter does not ignite properly (IGN), or
b) the total current drawn by the emitter falls below a threshold (I=0).

EFW feedback mode (ASPE1STA): refers to the condition that both
a) the IEL source change flag has not been set by telecommand, and
b) the calculated beam current for maintaining constant spacecraft potential falls below a given minimum.

EFW feedback mode (ASPENSTA): refers to the condition that both
a) the IEL source change flag has not been set by telecommand, and
b) the measured spacecraft potential falls below zero.

EFW feedback mode with WHISPER shutdown (ASPE2STA): refers to the condition that both
a) the WHISPER shutdown flag has been set by telecommand, and
b) the WHISPER status transmitted via the DWP interface matches one of the WHISPER condition flags also previously set by telecommand

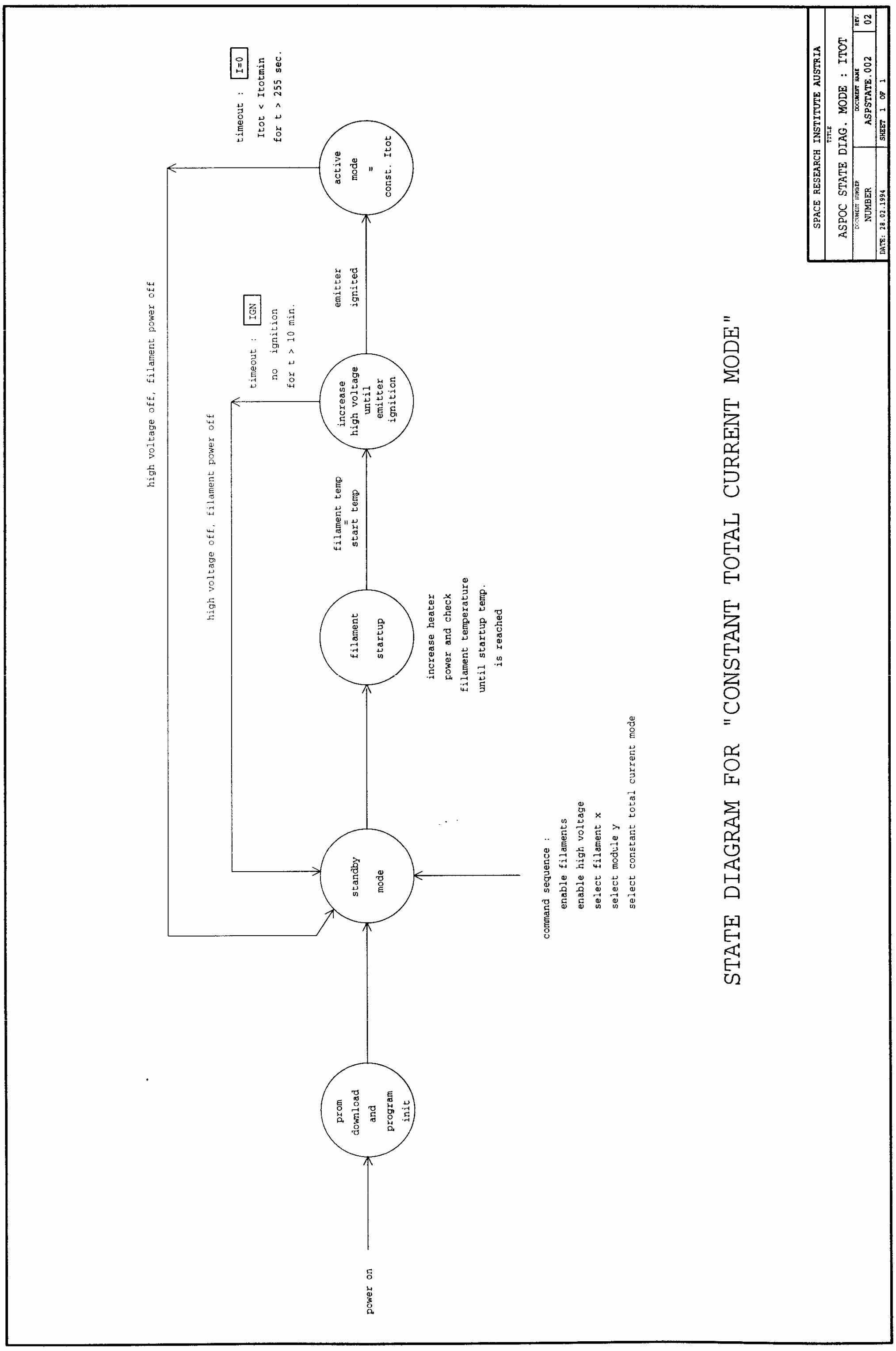
EFW feedback mode with source change condition (ASPESTAT): refers to the condition that both
a) the IEL source change flag has been set by telecommand, and
b) EFW spacecraft potential data become invalid or unavailable

PEACE feedback mode (ASPP1STA): refers to the condition that both
a) the IEL source change flag has not been set by telecommand, and
b) the calculated beam current for maintaining constant spacecraft potential falls below a given minimum.

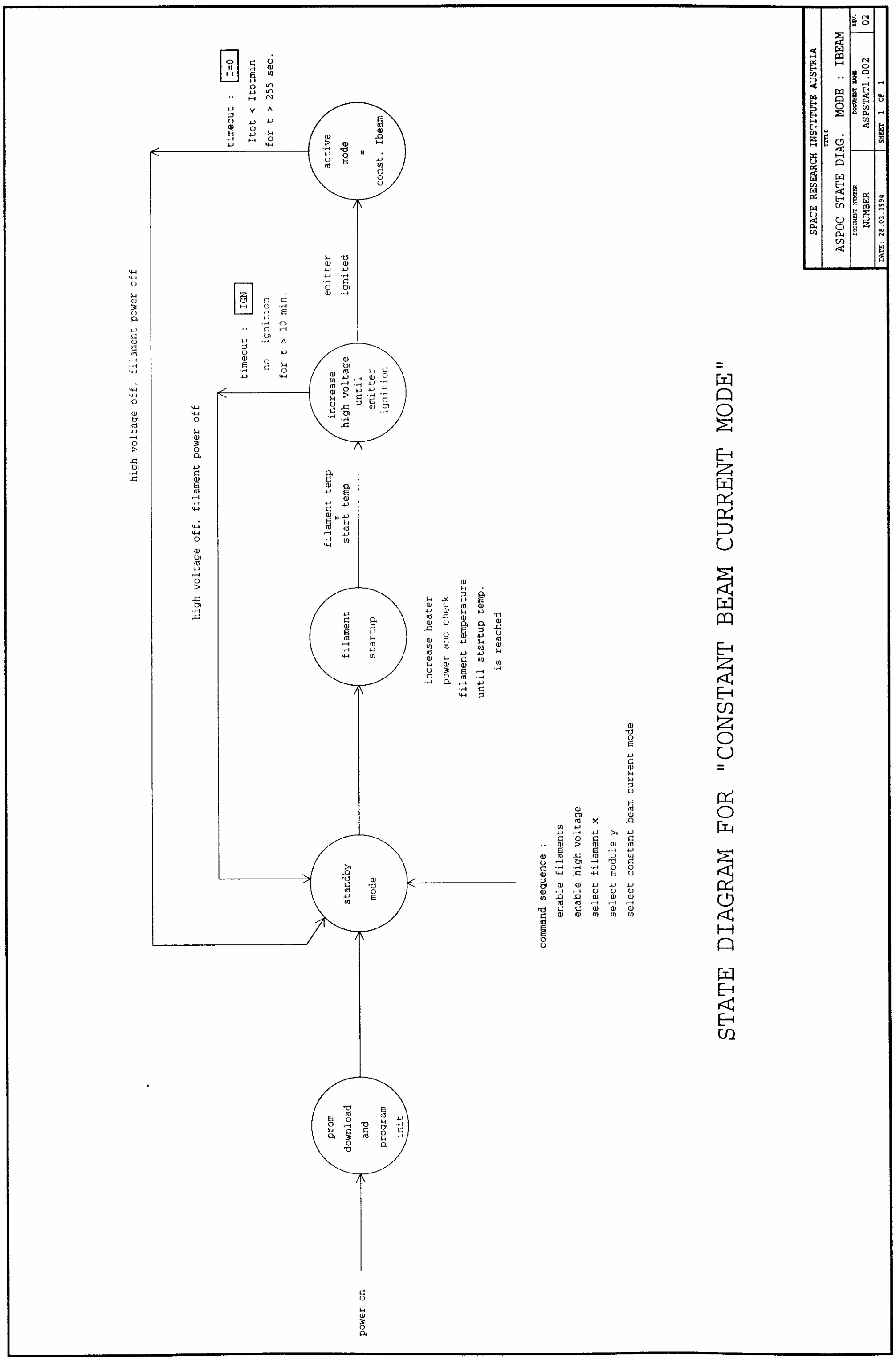
PEACE feedback mode with WHISPER shutdown (ASPP2STA): refers to the condition that both
a) the WHISPER shutdown flag has been set by telecommand, and
b) the WHISPER status transmitted via the DWP interface matches one of the WHISPER condition flags also previously set by telecommand

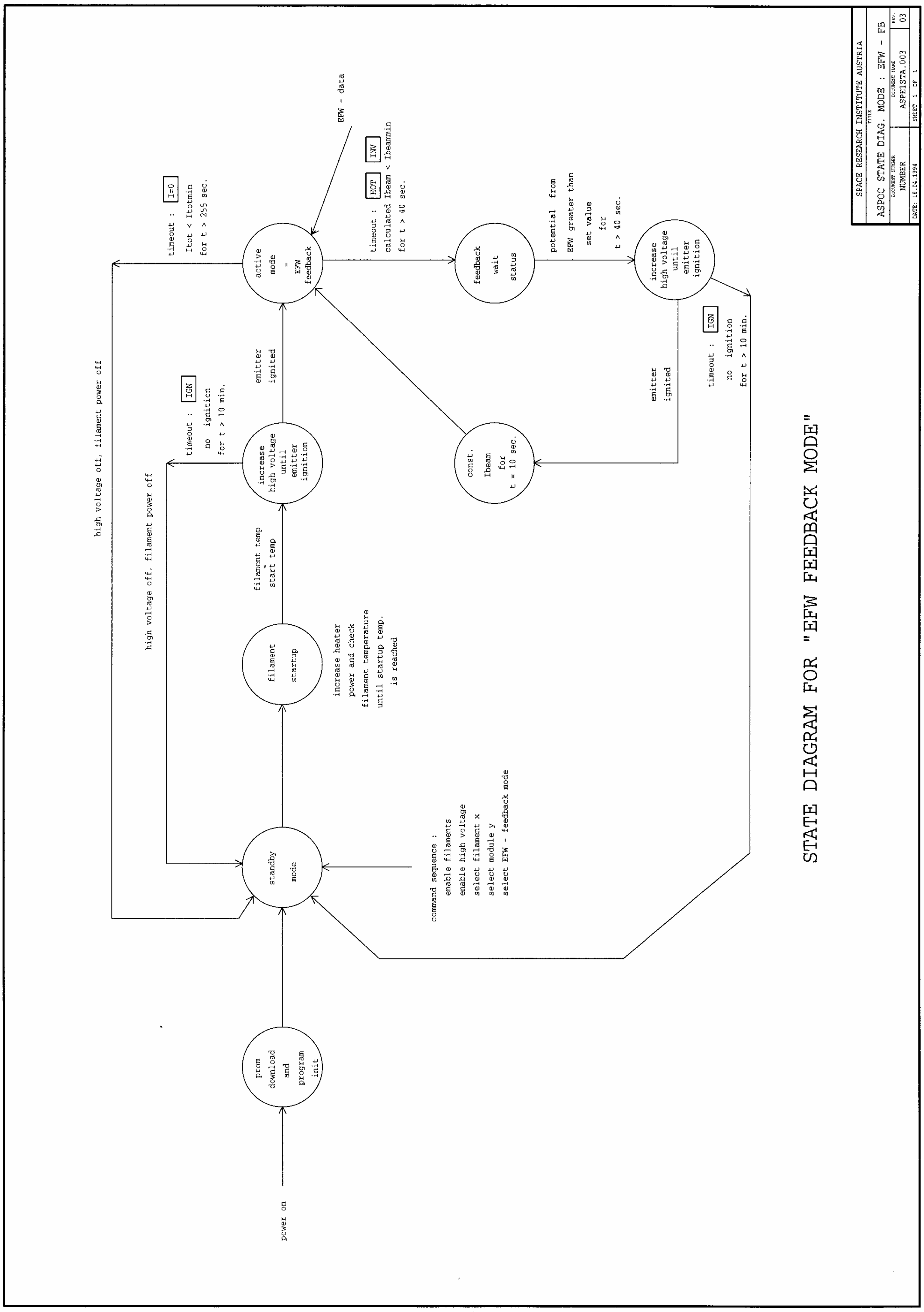
PEACE feedback mode with source change condition (ASPPSTAT): refers to the condition that both
a) the IEL source change flag has been set by telecommand, and
b) PEACE spacecraft potential data become invalid or unavailable

Hot standby mode (ASPHSTAT): refers to the transitions by the mode command "hot standby".

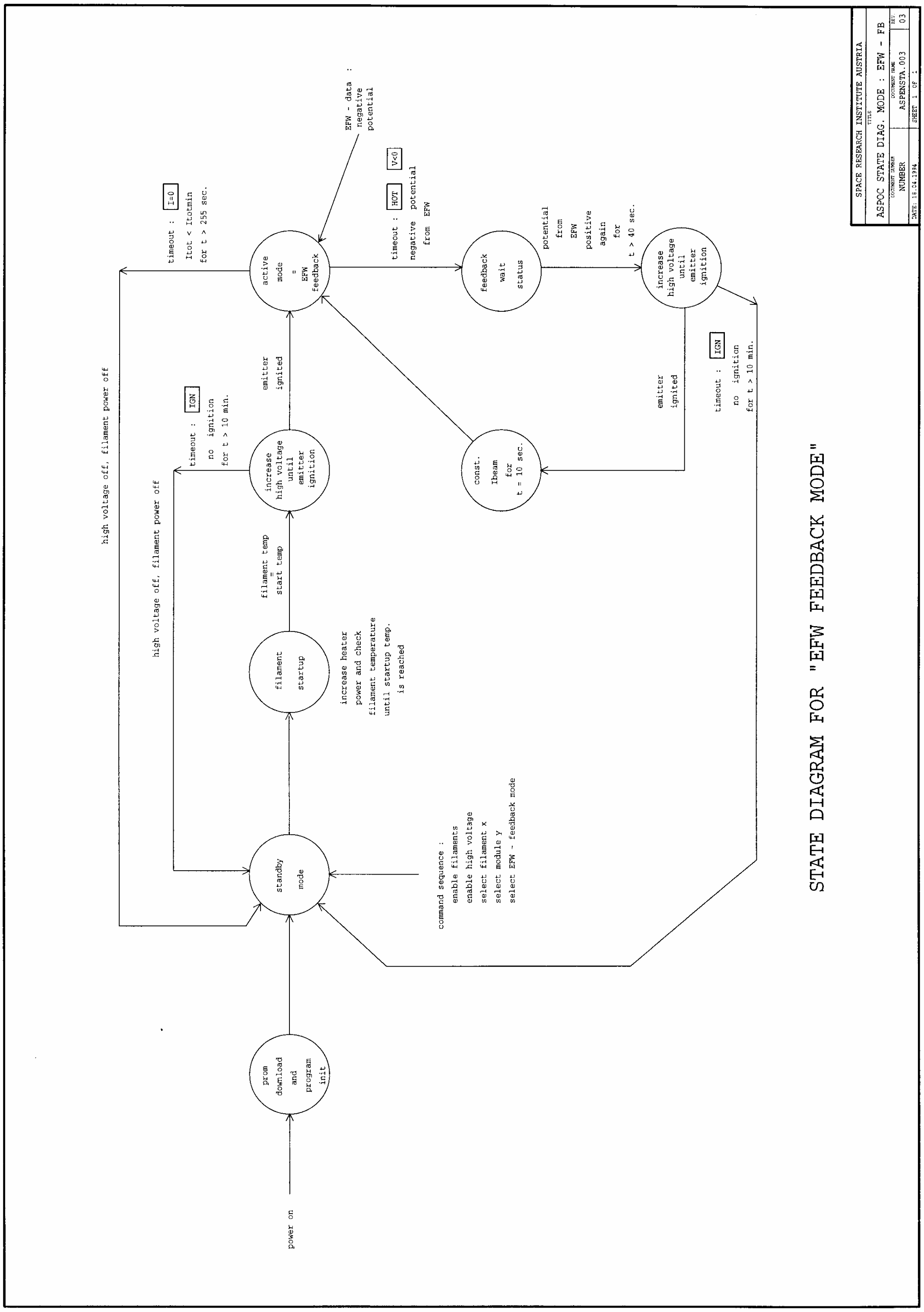


STATE DIAGRAM FOR "CONSTANT TOTAL CURRENT MODE"

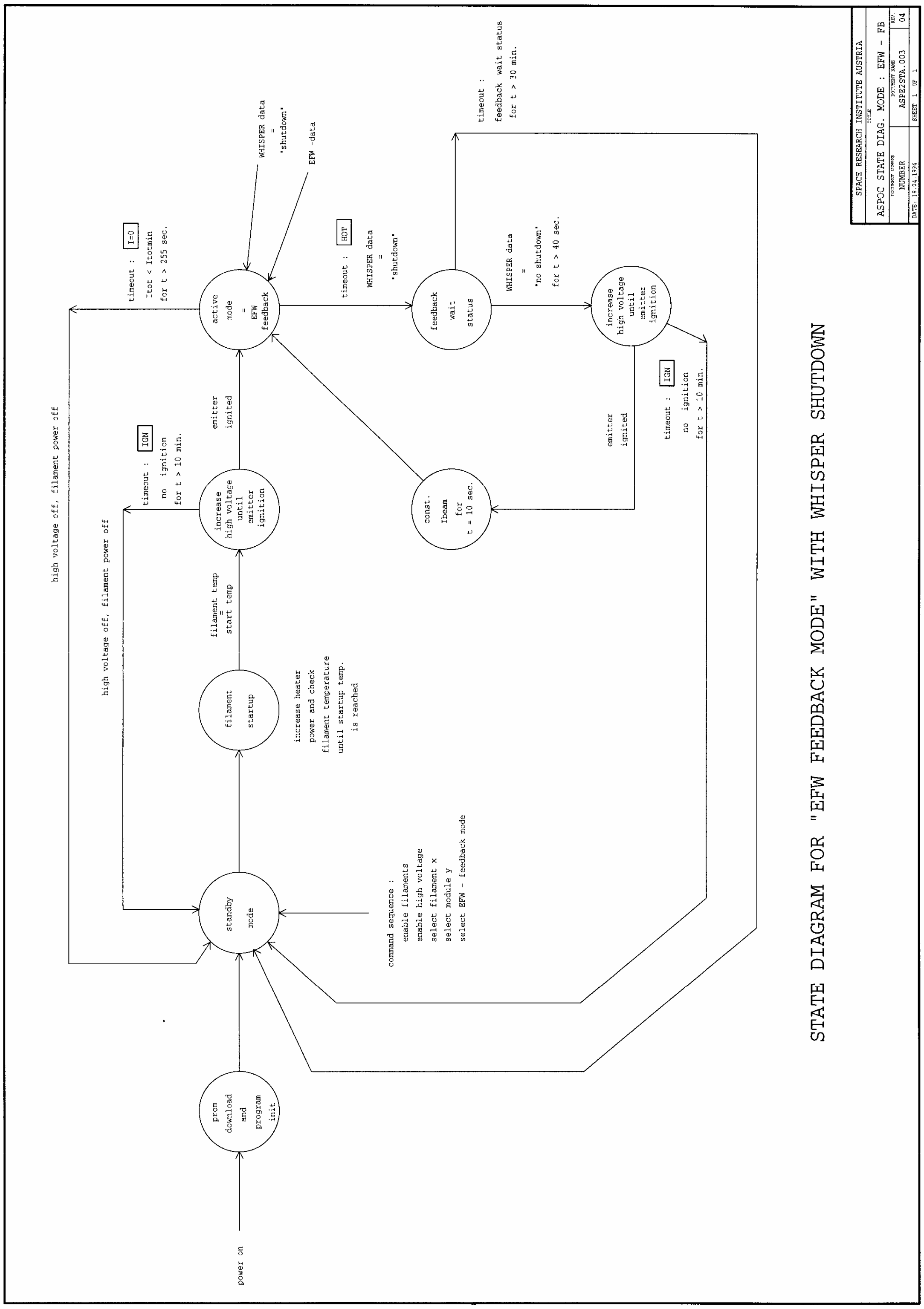

power on
prom download and program init
standby mode
filament startup
filament temp = start temp
increase high voltage until emitter ignition
emitter ignited
active mode = const. Ibeam
timeout : Itot < Itotmin for t > 255 sec.
I=0
timeout : no ignition for t > 10 min.
IGN
high voltage off, filament power off
high voltage off, filament power off
increase heater power and check filament temperature until startup temp. is reached
command sequence :
enable filaments
enable high voltage
select filament x
select module y
select constant beam current mode
STATE DIAGRAM FOR "CONSTANT BEAM CURRENT MODE"
SPACE RESEARCH INSTITUTE AUSTRIA
ASPOC STATE DIAG. MODE : IBEAM
NUMBER
ASPSTAT1.002
02
DATE: 28.02.1994
SHEET 1 OF 1

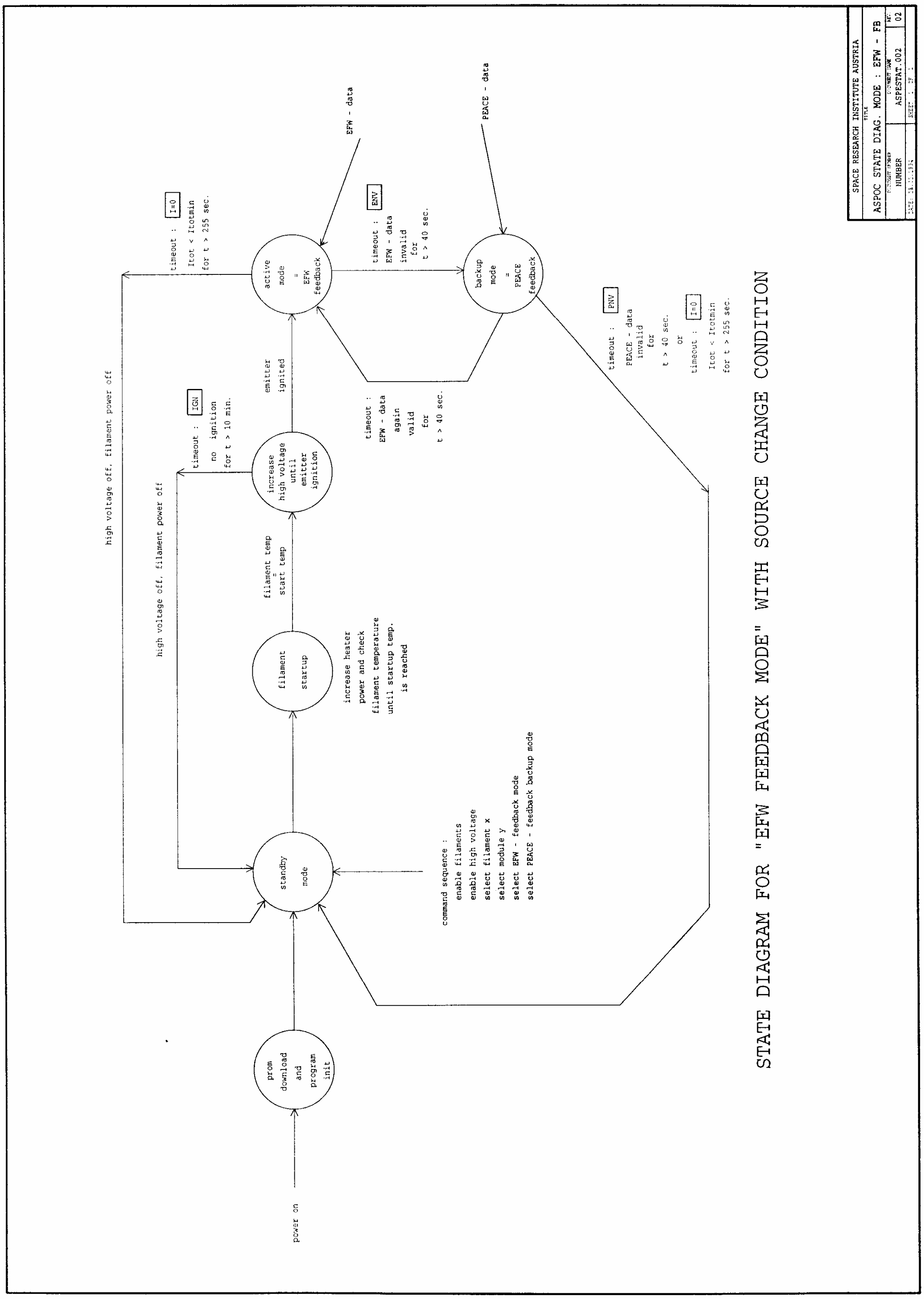


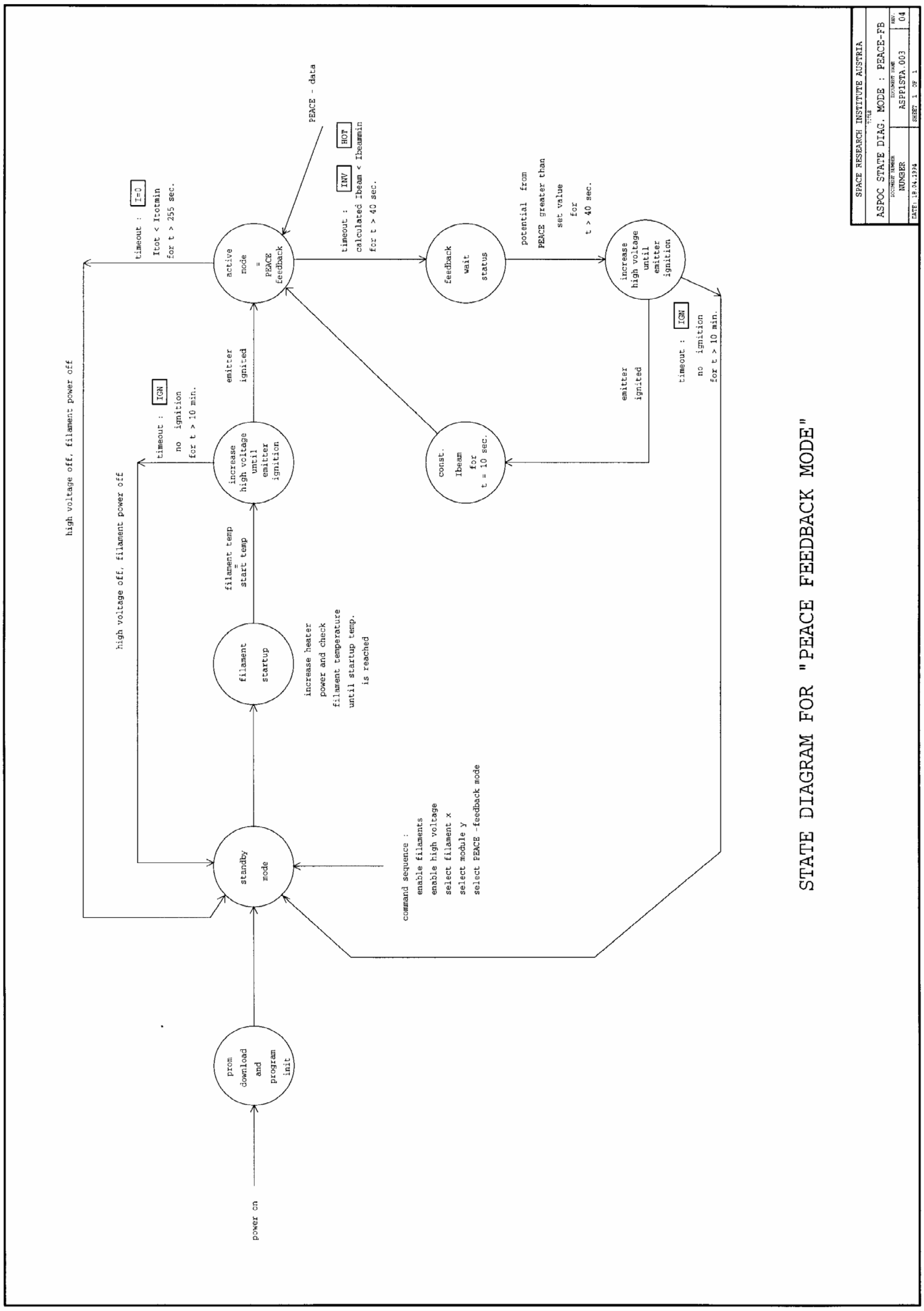
STATE DIAGRAM FOR "EFW FEEDBACK MODE"



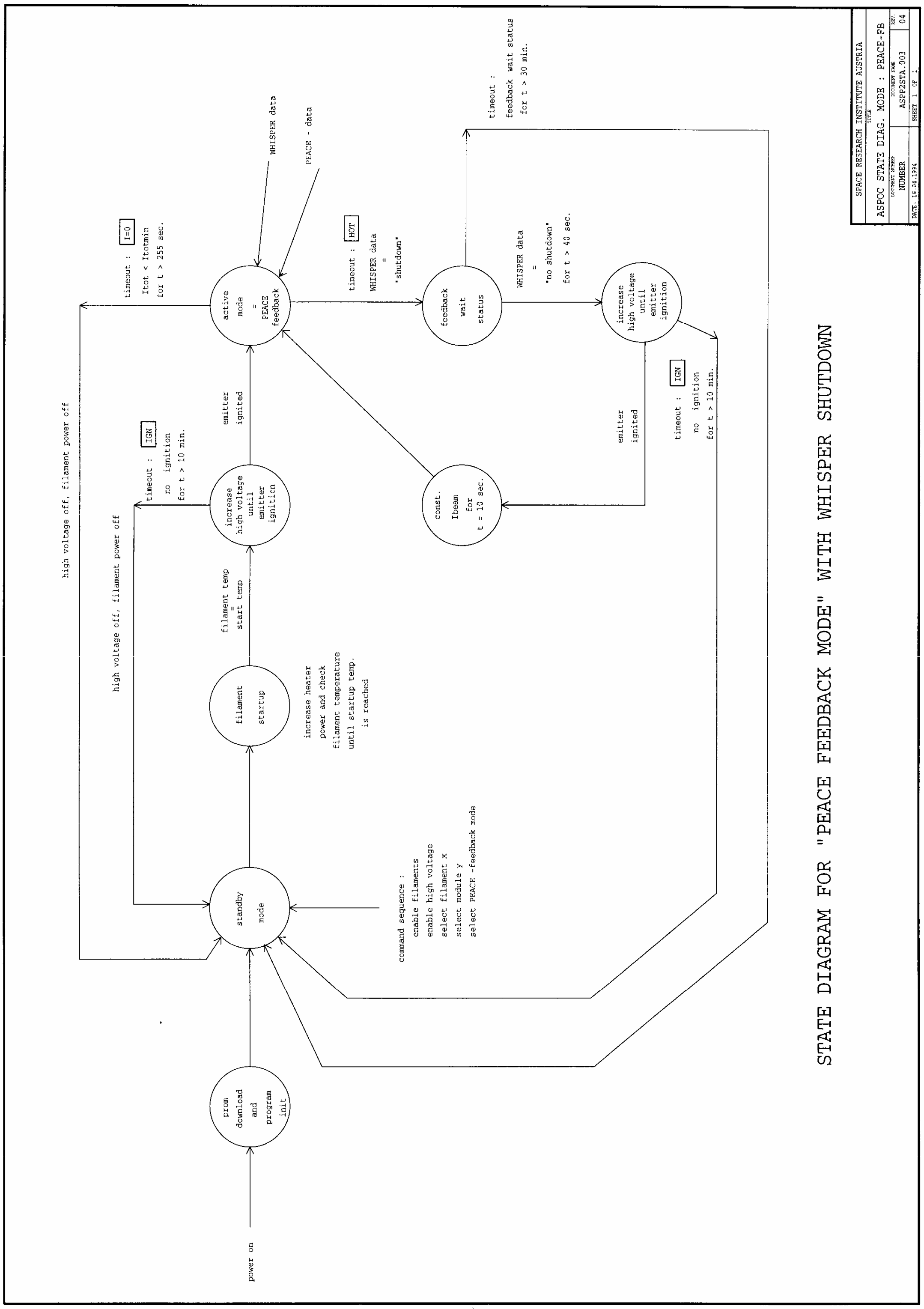
STATE DIAGRAM FOR "EFW FEEDBACK MODE"


STATE DIAGRAM FOR "EFW FEEDBACK MODE" WITH WHISPER SHUTDOWN
SPACE RESEARCH INSTITUTE AUSTRIA
ASPOC STATE DIAG. MODE : EFW - FB
ASPE2STA.003
04
power on
prom download and program init
standby mode
filament startup
increase high voltage until emitter ignition
active mode = EFW feedback
feedback wait status
increase high voltage until emitter ignition
const. Ibeam for t = 10 sec.
command sequence : enable filaments enable high voltage select filament x select module y select EFW - feedback mode
increase heater power and check filament temperature until startup temp. is reached
filament temp = start temp
emitter ignited
timeout : IGN no ignition for t > 10 min.
timeout : I=0 Itot < Itotmin for t > 255 sec.
high voltage off, filament power off
WHISPER data = 'shutdown'
EFW -data
timeout : HOT WHISPER data = 'shutdown'
timeout : feedback wait status for t > 30 min.
WHISPER data = 'no shutdown' for t > 40 sec.

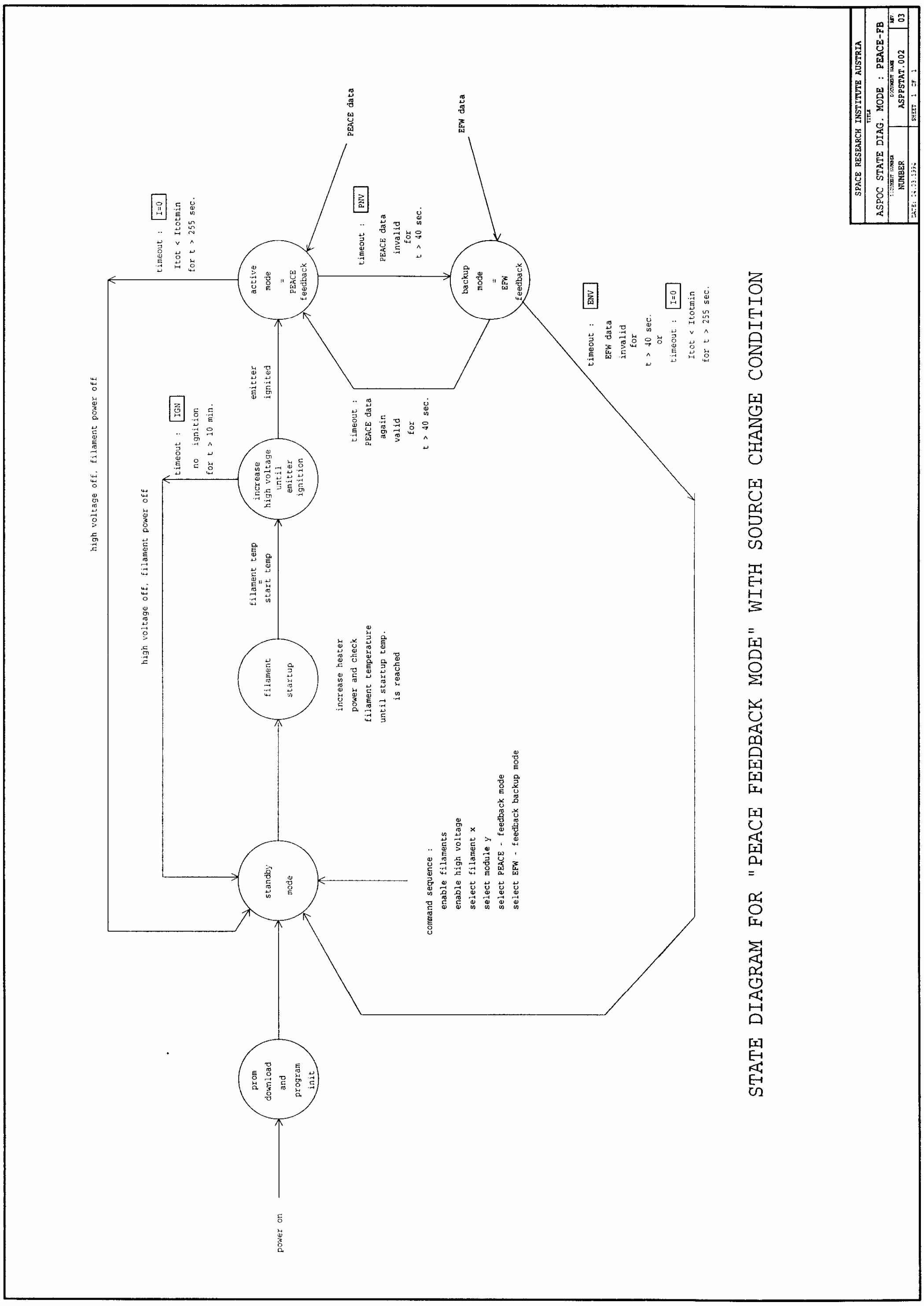

power on
prom download and program init
standby mode
filament startup
increase heater power and check filament temperature until startup temp. is reached
filament temp = start temp
increase high voltage until emitter ignition
timeout : IGN
no ignition for t > 10 min.
emitter ignited
active mode = EFW feedback
EFW - data
timeout : I=0
Itot < Itotmin for t > 255 sec.
timeout : ENV
EFW - data invalid for t > 40 sec.
backup mode = PEACE feedback
PEACE - data
timeout : EFW - data again valid for t > 40 sec.
timeout : PNV
PEACE - data invalid for t > 40 sec.
or
timeout : I=0
Itot < Itotmin for t > 255 sec.
high voltage off, filament power off
high voltage off, filament power off
command sequence :
enable filaments
enable high voltage
select filament x
select module y
select EFW - feedback mode
select PEACE - feedback backup mode
STATE DIAGRAM FOR "EFW FEEDBACK MODE" WITH SOURCE CHANGE CONDITION
SPACE RESEARCH INSTITUTE AUSTRIA
ASPOC STATE DIAG. MODE : EFW - FB
NUMBER
ASPSTAT.002
02



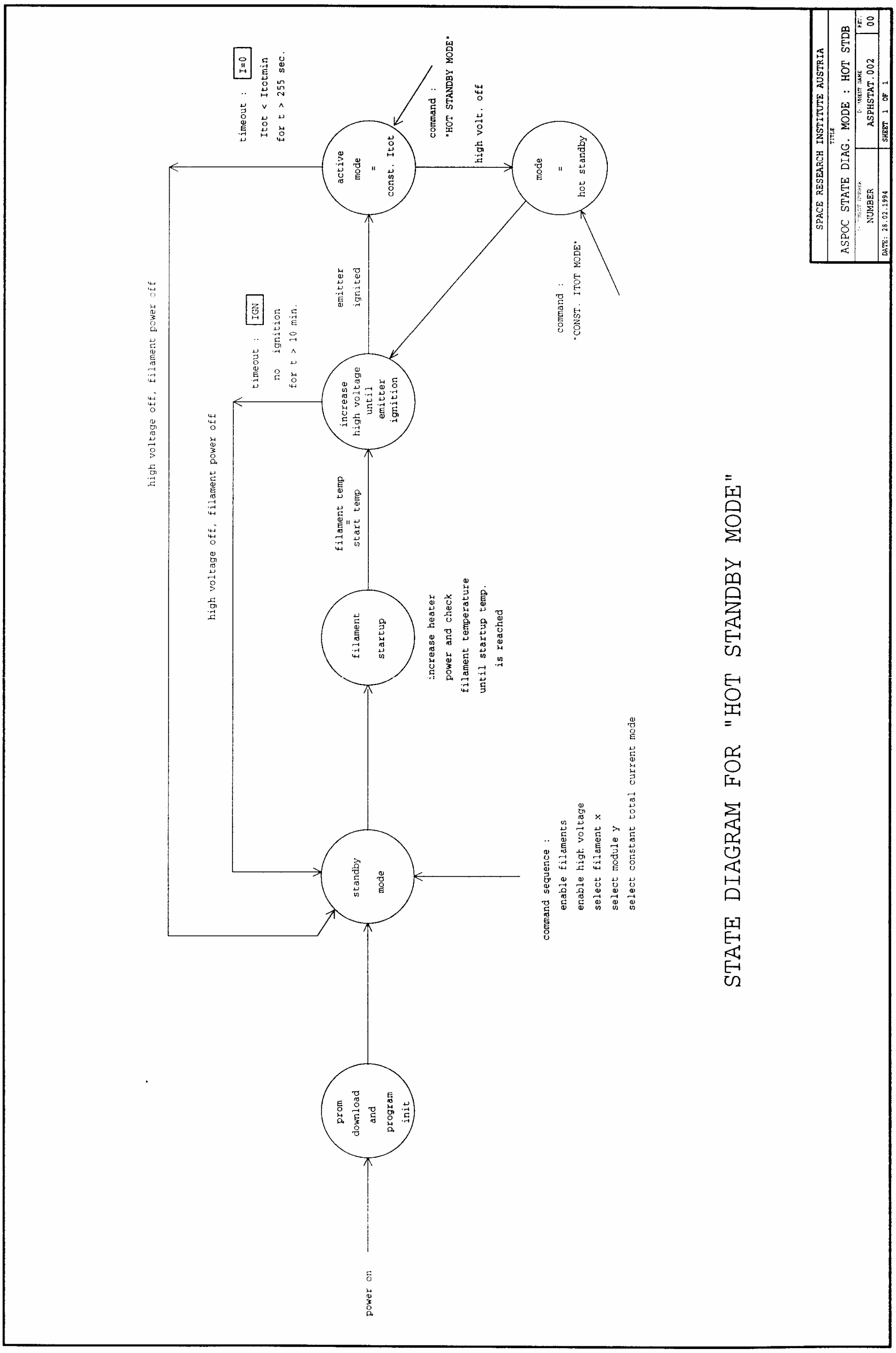
STATE DIAGRAM FOR "PEACE FEEDBACK MODE"



STATE DIAGRAM FOR "PEACE FEEDBACK MODE" WITH WHISPER SHUTDOWN



STATE DIAGRAM FOR "PEACE FEEDBACK MODE" WITH SOURCE CHANGE CONDITION


STATE DIAGRAM FOR "HOT STANDBY MODE"
power on
prom download and program init
standby mode
filament startup
increase high voltage until emitter ignition
active mode = const. Itot
mode = hot standby
command sequence :
enable filaments
enable higt voltage
select filament x
select module y
select constant total current mode
increase heater power and check filament temperature until startup temp. is reached
filament temp = start temp
emitter ignited
timeout : IGN
no ignition
for t > 10 min.
timeout : I=0
Itot < Itotmin
for t > 255 sec.
high voltage off, filament power off
high voltage off, filament power off
command : "HOT STANDBY MODE"
high volt. off
command : "CONST. ITOT MODE"
SPACE RESEARCH INSTITUTE AUSTRIA
ASPOC STATE DIAG. MODE : HOT STDB
NUMBER
ASPHSTAT.002
00
DATE: 28.02.1994
SHEET 1 OF 1

1.3.6.5 Parameters defining the instrument state

The previous chapter has described transitions between instrument states. Now the parameters that determine the operation at any moment are described. There are 3 relevant parameters:

EAOPMODE operating mode

This is the basic operating mode. Even after transitions into backup modes this parameter always describes the present operation with two exceptions:

1. EATIMOT2=1 (error condition "FWX", "feedback wait status")

   Under this condition the high voltage generator is turned off, regardless of the operating mode.

2. EASU_ACT=1 (start-up is active)

   Under this condition the start-up process of an emitter is in progress. The high voltage may not yet have been turned on, although the operating mode is an active one.

There are also some redundant parameters which are maintained to improve visibility:

EABK_ACT "backup mode is active" flag

This parameter gives a possible reason why the actual operating mode (EAOPMODE) is unequal to the commanded mode.
The information can also be derived from the fact that the current operating mode (EAOPMODE) is different from the commanded mode.

EAEXPMOD experiment in active mode flag

This flag, if set, indicates that the instrument has successfully entered into one of the active experiment modes. As a necessary condition the selection and enabling of emitters and emitter modules must have been commanded prior to the active mode command itself.

EAPOT_SR S/C pot. source used

Indicates the data source (EFW or PEACE) for the spacecraft potential which is used for the beam current control during feedback mode.
This parameter is fully defined by the experiment mode (EAOPMODE).

The timeout flags give the reason for a mode transition which has occurred.

EATIMOT2 feedback wait status

Indicates that a timeout condition has caused the experiment to switch into feedback wait status.

EATIMOT4 cleaning timeout flag

Indicates that the instrument has entered standby mode after the high voltage has exceeded the threshold value for cleaning.

EAT1MOUT timeout, no ignition

Indicates that an emitter has failed to ignite within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

EAT2MOUT timeout, no beam current

Indicates that the beam current has dropped to zero and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

EAT3MOUT timeout, EFW failure

Indicates that the data transmission from EFW has been stopped and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

EAT4MOUT timeout, PEACE failure

Indicates that the data transmission from PEACE has been stopped and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

EAT5MOUT timeout, ion current set below limit

Indicates that the beam current calculated on board during feedback mode has dropped below 50% of the lower HV output current limit, and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

1.4 On-board Software

1.4.1 Requirements

The on-board instrument software has to perform the following functions in the different operational modes:

Mode	Function
all modes	HK data acquisition serve TM serve TC serve IEL
STDB (standby)	no beam current output, no filament heating. load program from PROM if necessary (at switch-on or watchdog action)
ITOT (constant total current)	set a constant output current of the high voltage supply, ion beam current adjusts itself according to the electrical efficiency of the emitter, control the filament temperature
IION (constant beam current)	update regularly the output current of the high voltage supply to maintain a constant ion beam current despite time varying electrical efficiency of the emitter, control the filament temperature
FEFW (feedback from EFW)	outer control loop: update regularly the required ion beam current to maintain a constant spacecraft potential measured by EFW; inner control loop: update the output current of the high voltage supply to achieve the required ion beam current; control the filament temperature
FPEA (feedback from PEACE)	outer control loop: update regularly the required ion beam current to maintain a constant spacecraft potential measured by PEACE; inner control loop: update the output current of the high voltage supply to achieve the required ion beam current; control the filament temperature
T&C (test/commissioning)	set the output current of the high voltage according to a step function, control the filament temperature
HOT (hot standby)	hot standby mode: no output current of high voltage supply, filament temperature is controlled to allow immediate resumption of ion emission without delay for heating up the filaments; to be used for mid-term (up to about 1 hour) "ion beam off" periods with the advantage of immediate resumption of ion beam emission without delay for heating up the filament

TECH (technical)	commands for instrument check-out are enabled
FWS (feedback wait status)	acts on the ion emitters like the hot standby mode. The difference lies in the conditions for entering and leaving the mode: FWS is not an experiment mode which can be commanded on and off, it is rather a temporary state caused by some anomaly with the inter-experiment link data.

On lower level the following tasks are performed:

- acquire housekeeping data:
  4 temperatures
  3 internal voltages
  2 cover status flags
  high voltage generator status
  HV disable connector status

- reset DPU at switch-on and watchdog action
  load software from PROM
  initialise

- read data over IEL
  EFW and WHISPER status via DWP I/F
  PEACE

- read and interpret telecommands

- input OBDH signals (reset, sun ref. pulse)

- output HK TM frames

- control filaments:
  switch between filaments
  read filament current
  control filament voltage
  calculate filament temperature
  run control algorithm for constant filament temperature

- control high voltage generator:
  set control mode (voltage or current mode)
  select emitter module
  read high voltage
  read total high voltage generator current ("= total current")
  read ion beam current
  run control algorithm for total high voltage generator current depending on operational mode:
  a) constant
  b) as a function of the ion beam current
  c) as a function of the spacecraft potential

- mode control:
  switch modes (fall back to backup mode) on certain conditions (flags)

The above list is an overview. For a complete description of switches, timeouts see Section 1.3.

1.4.2 Architecture

1.4.2.1 Overview

After a reset (at power on or watchdog action) the program is loaded from PROM into RAM. This process takes about 1.5 seconds.

Thereafter the software is running in a main loop, performing the tasks under 1.4.1 if required.

The main loop is run through as fast as processor speed permits. If no time-consuming functions are called within the loop, the execution time is about 40 ms.

The fast loop tests if one of the following functions has to be called:

- switch mode into standby
- perform update calculation for total current in order to control the beam current in modes IION, FEFW and FPEA
- perform update calculation for ion beam current in order to control the spacecraft potential. This calculation, if executed, may take less than one second. The condition for this calculation is that the experiment is in a feedback mode (FEFW or FPEA) and valid spacecraft potential data are received, which occurs at a rate of one per second from EFW/DWP or one per spin from PEACE.
- Reset the watch-dog timer (a hardware counter). If this counter is not reset within 8 seconds, a full reset will occur and the instrument will be put in power-on status.

In addition to the above, every second a set of less time-critical functions is performed:

- process timeout counter
- update total current, if the experiment is in constant total current mode (ITOT) or test and commissioning mode (T&C)
- process one command from the command stack at the first full second after a reset pulse.

The impact of a watch-dog reset after malfunction of the DPU on telemetry are:

- about 8 seconds of erroneous or no data
- about 10 seconds without data while the program is loaded from PROM.
- thereafter the instrument will be in standby mode if the failure was temporary.
- reset of all telemetry parameters to the power-on state

1.4.2.2 Spacecraft potential and beam current control

SPACECRAFT POTENTIAL

```
k = Kv/Tp * (- Vnew + Vold - Tv * (Vold - Vset))

ktab = points * (k-kmin) / (kmax-kmin)   (range: 1...80)

Iion,new = Iion,meas * table(ktab-1)

Legend:

Vnew = latest potential data
           (EAEFWPT1 or EAEFWPT2 or EAPEAPOT or EAPEAPT2)
Vold = previous potential data
Vset = EAPOT_SV
Iion,meas = EAIONCx_ with x = 0...9
Iion,new  = new ion current used as input to inner control

Tp = 2.6 V
Kv = EACOEFKV (range 0...8)
Tv = EACOEFTV ( = 255/Tv(raw), range: 1/Tv = 0...1 )
points = 80
kmax = 1.5
kmin = -0.7

"table" contains:

exp (i * (kmax-kmin)/points + kmin)   for i = 0...points-1
```

BEAM CURRENT

```
Itot,new = Itot,meas + Kc * (Iset - Iion,meas) -
           - (1/Tx * Kc * (Iset,prev - Iion,prev))

Legend:

Iset = EAIONCSV (actual value)
Iset,prev = EAIONCSV (value of previous calculation)
Iion,meas = EAIONCx_ with x = 0...9 (actual value)
Iion,prev = EAIONCx_ with x = 0...9
                     (value of previous calculation)
Itot,meas = EATOTCx_ with x = 0...9
Itot,new  = new total current used as output to supply

Kc = EACOEFKC (range 0...4)
Tx = EACOEFTX ( = 256/Tx(raw) )
```

1.4.2.3 Subroutines

The following subroutines are called:

a) C language

GET_MSM_STATUS()	determines the state of the high voltage module selection relay.
PICONTROL(ISET)	controls the high voltage current according to the required beam current ISET.
TEMP_CONTROL()	controls the filament converter output to keep the filament temperature constant.
SWITCH_OFF_EMITTER()	switches "off" high voltage and filament power.
EFW_OK()	checks if EFW-data are available on the EFW-interface channel.
PEACE_OK()	checks if PEACE-data are available and within the range 1 to 7Fh.
TEST_PEACE_RETURNED()	checks if data transmission from PEACE restarts while experiment is running in backup mode.
TEST_EFW_RETURNED()	checks if data transmission from EFW restarts while experiment is running in backup mode.
TEST_FOR_WHISPER_INFO()	test of bit 12 and bit 13 of DWP-data word. Experiment reacts according to the code given by the WHISPER-decision table.
TEST_SOURCE_TIMEOUT()	switches experiment to backup mode if potential transmission from PEACE / EFW fails for more than 40 seconds and set the appropriate timeout bit.
TEST_ITOT_TIMEOUT()	switches experiment to standby mode if measured total current is less than its lower limit for more than 255 seconds and set the appropriate timeout bit.
TEST_IGNORE_TIMEOUT()	tests whether the timeout started by certain WHISPER data is over and a new beam current calculation can resume.
TEST_IION_TIMEOUT()	handles the timeout due to a negative potential from EFW or due to a calculated beam current which is less than the minimum value.
EXIT_INTERN_HOT_STANDBY()	enters the high voltage start-up cycle after experiment was running in an internal hot standby mode (=feedback wait status: filaments are kept on operating temperature ; high voltage is "off").

ENTER_INTERN_HOT_STANDBY()
enters the internal hot standby mode (=feedback wait status). High voltage will be switched "off". Filaments are kept on operating temperature.

MODE_OPERATION(OPMODE)
operating mode selector called in each main loop for time critical routines.

TEST_ACTIVE_STATUS() initialises timeouts and various flags if experiment mode changes from stand by to any active operating mode.

MODE_SELECT_SEC(OPMODE)
operating mode selector called once per second for non time critical routines.

TEST_CMD(CODE_PTR) tests whether a telecommand is in the command table. Set / resets the "command rejected"- flag.

VERIFY_CMD() checks if the current command is valid in the present operating mode.

CALC_NEW_IION_PEA() calculates a beam current as a function of the received PEACE data.

CALC_NEW_IION_EFW() calculates a beam current as a function of the received EFW-data.

MAKE_EXP_TABLE() calculates one value of an exponential table in the main loop.

INIT_FLOAT_VARS() initializes the floating point variables

SET_VSATSET() converts binary set value for S/C-potential into float.

SET_KVSC() converts binary value of control parameter KVSC to float.

SET_TVSC() converts binary value of parameter TVSC to float.

b) 8085 Assembler language:

COPY_PROM copies contents of bipolar PROM to shadow RAM.

COPY_SWITCH copies PROM-switching routine to data RAM

RAMBEG switches "off" PROM. Program is now running in shadow RAM

INIT_DMA initializes DMA controller

CLR_VARS clears variables in data RAM

SET_UCONTROL	switches HV converter to voltage mode
HV_CONV_OFF	switches HV converter "off"
FIL_CONV_OFF	switches filament converter "off"
RESET_DACS	sets both digital to analog converters to zero volt
INIT_VARS	initializes binary variables
SYNCHPULSE	resets counter for PEACE clock pulses
FILSTARTUP	handles heating up of selected filament to the start-up temperature. Applies high voltage to the emitter and tests if it has ignited. A timeout occurs if there is no ignition within 20 minutes.
ADCINT	interrupt with a period of 1.024 ms. Reads the analog channels. Increments the internal software timer. Handles DMA channel for EFW data reception.
RESETINT	interrupt triggered by the reset pulse each 5.15 seconds. Handles initialization of telemetry DMA channel and telecommand DMA channel. Copies telemetry data to frame buffer.
SUNREFINT	interrupt triggered once per 4 seconds by sun reference pulse. Stores time of pulses relative to reset pulses.
PEACEINT	interrupt triggered by PEACE interface. Reads PEACE data and determines time of event.
SERV_FILREL	handles the selection of the filaments. First all filament relays are switched "off" and module A is selected to get a defined state of all relays. Then the appropriate module is selected and the selected filament is switched "on". Each second only one switch cycle is performed.
GET_PYROSTAT	reads the digital input line of the module cap status switches.
CLRWDOG	resets the hardware watchdog
CALCRESIST	calculates the resistance of the filament
SERV_CMD	reads one command per 5.15 seconds from the command ring buffer and handles the buffer pointers. The command code is checked and a call to the appropriate command routine is performed.

1.5 Instrument Physical Characteristics

1.5.1 Location on the spacecraft

The experiment consists of one mechanical unit: an electronics box with two emitter modules mounted on top. The sub-units

- electronics box
- emitter modules

are interconnected by harness between each emitter module and the box.

Inside the electronics box there are four horizontally mounted printed circuit boards (two for the DPU, one for the DC and filament converter, and one for the high voltage converter.

The experiment is not directly mounted on the payload platform, but on a special bracket to elevate the upper surface of the emitter modules flush with the S/C skin.

Figure 2 shows a perspective view of the instrument, For size and shape of the instrument see Fig. 3, which is a copy of the mechanical interface drawing. The physical properties are (c.f. EID-B Table 2.4-1):

```
Mass:         1.90 kg

Envelope dimensions (mm):

              L = 187, W = 157, H = 169.65 (covers closed)
                                 H = 216.29 (covers open)

Centre of mass w.r.t. URF (mm):

              X = 70.7 (covers closed), Y = -69.6, Z = -50.2
              X = 72.0 (covers open)

Moment of inertia w.r.t. CoM (kg m²):

              Ix = 0.0074, Iy = 0.0089, Iz = 0.0058
```

The position on the S/C is given in Fig. 4. The mounting hole positions are (in mm):

```
Xb =  1040.00
Yb = -1330.00
Zb =   375.00

Yu direction from Yb counterclockwise: 161°
```

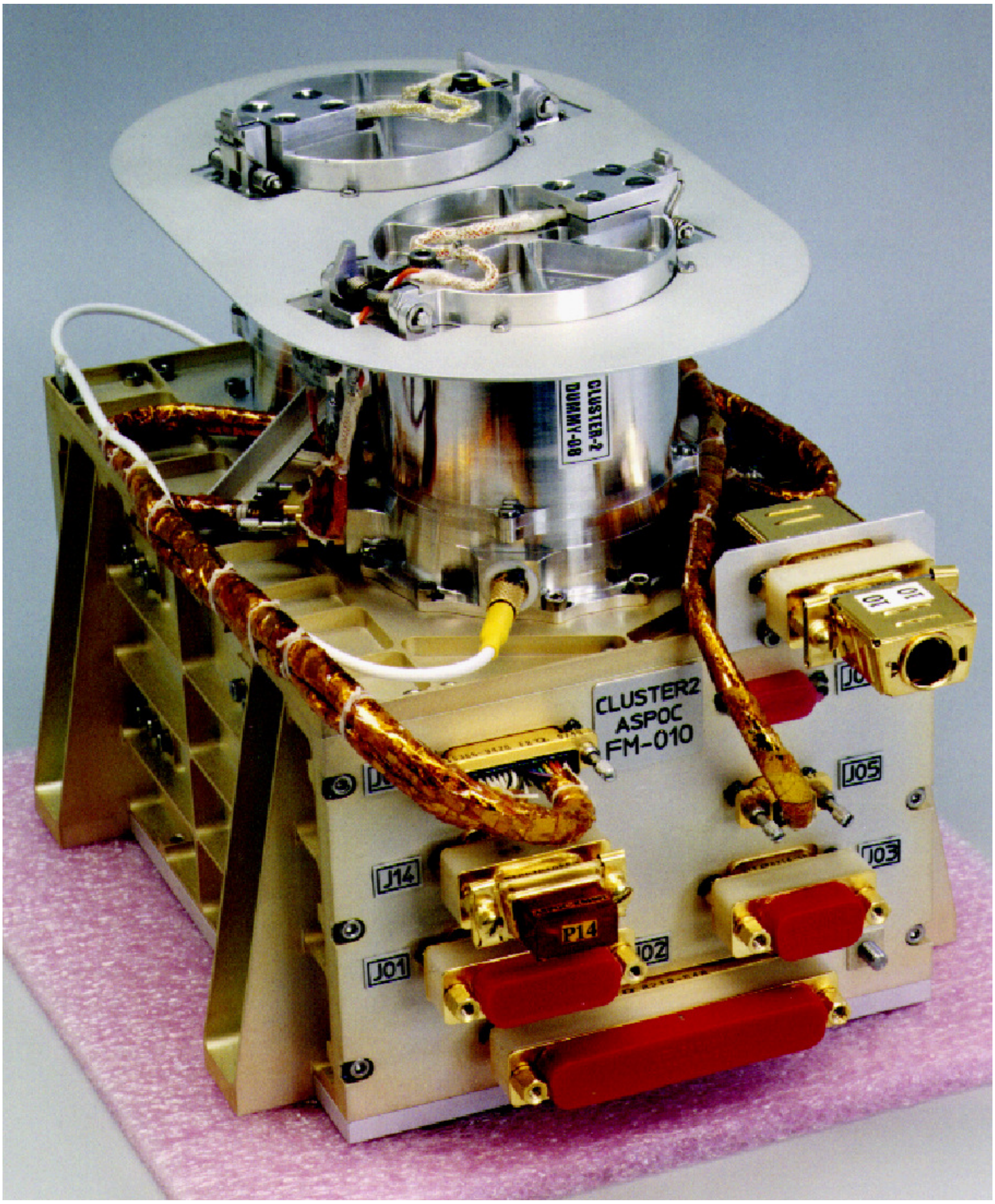


Fig. 2 Perspective view of ASPOC

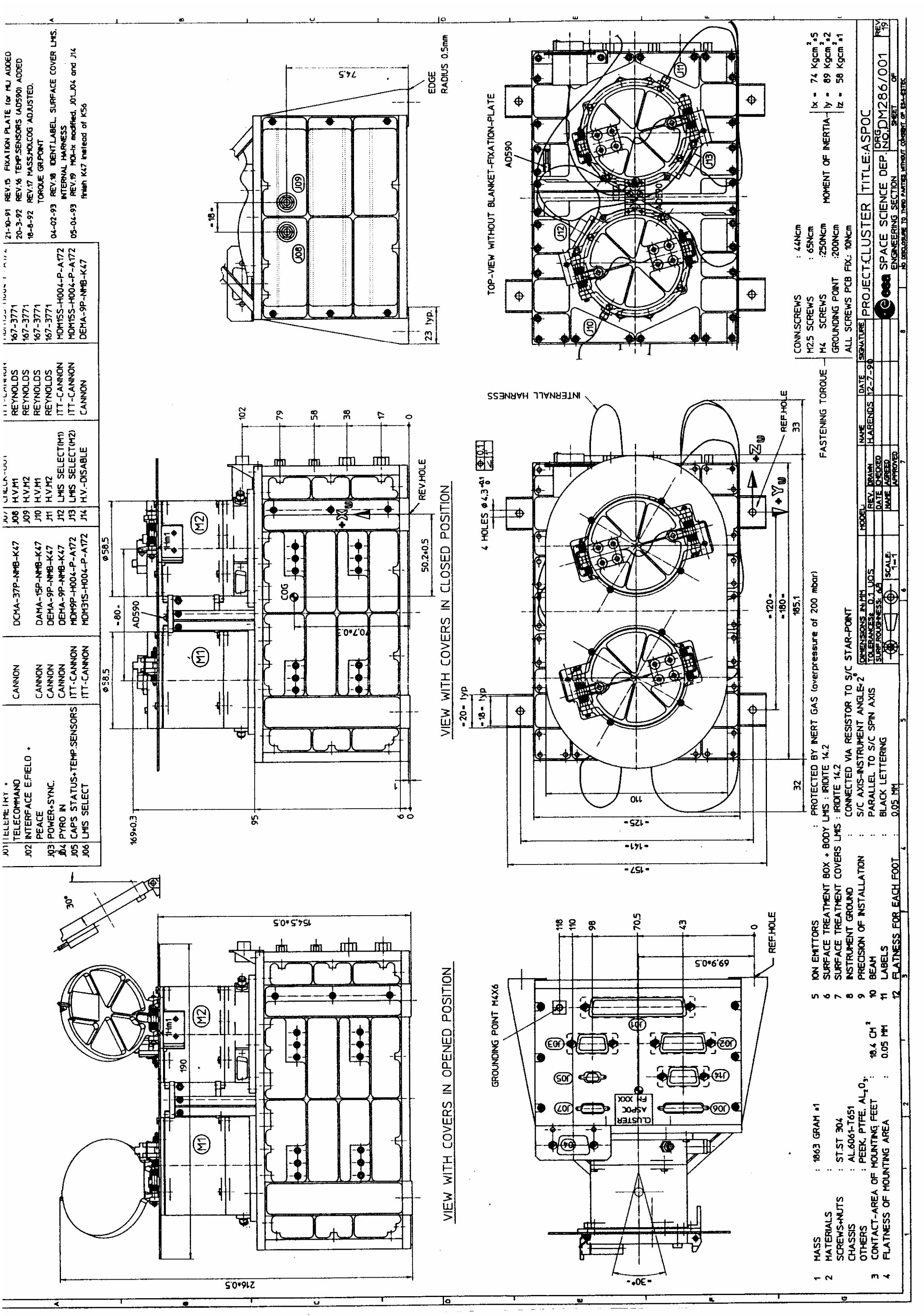


Fig. 3 Mechanical Interface Drawing of ASPOC

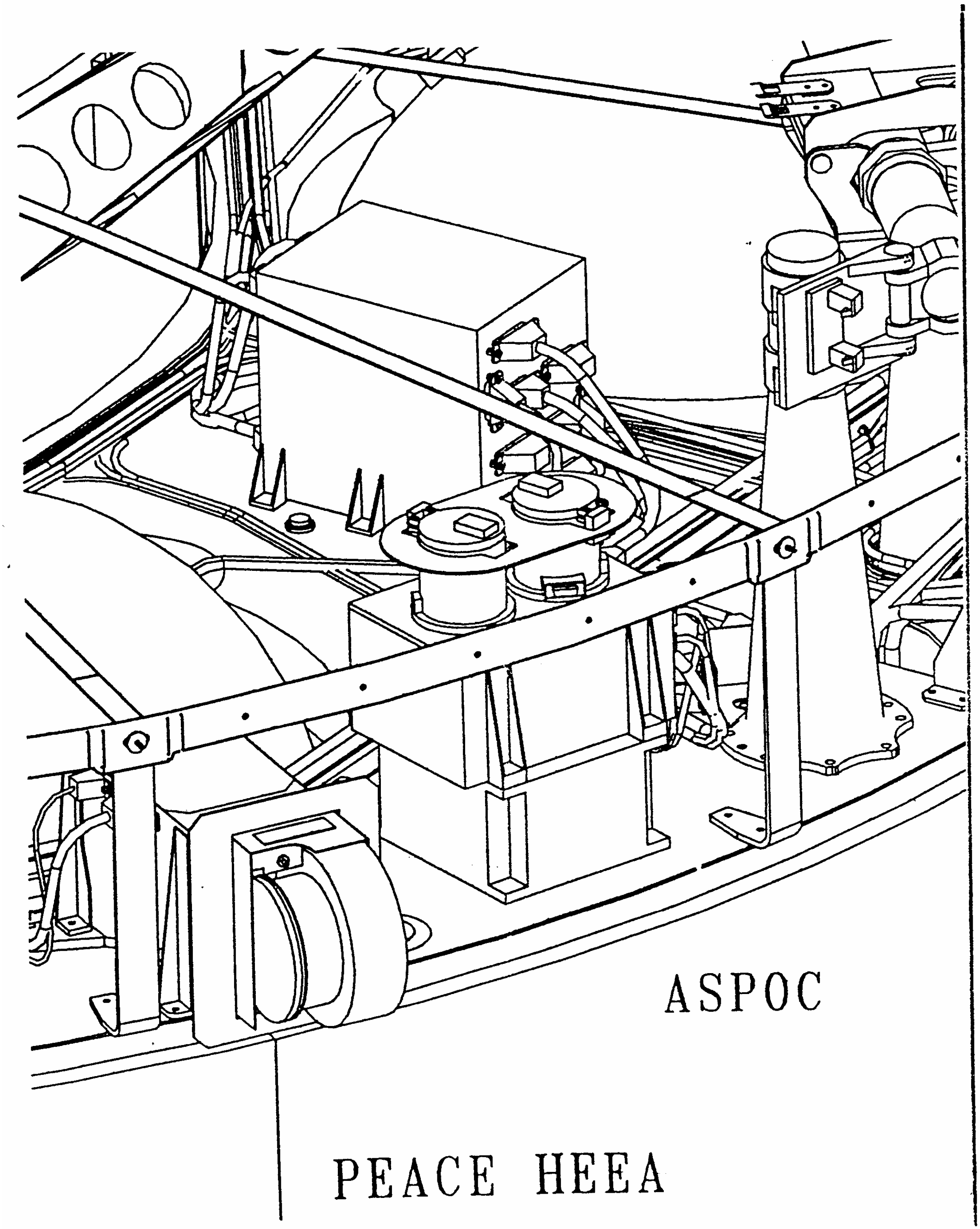


Fig. 4 ASPOC Installation Drawing

The positions of the two ion beam emitters are (boresight and field of view, c.f. EID B table 2.2-3):

```
Module 1

  elevation:       90°

  scientific field of view:
  cone half angle: 15° HWHM
  vertex position:
              X =  117
              Y =  -70.5
              Z = -100

  unobstructed field of view:
  cone half angle: 50°, small obstacles allowed
  vertex position: same as scientific FoV
```

```
Module 2

  elevation:       90°

  scientific field of view:
  cone half angle: 15° HWHM
  vertex position:
              X =  117
              Y =  -70.5
              Z =  -20

  unobstructed field of view:
  cone half angle: 50°, small obstacles allowed
  vertex position: same as scientific FoV
```

1.5.2 Mechanisms

In order to avoid oxidation of the indium in the liquid metal ion sources it should never become exposed to air or water vapour. In-flight deployable covers create almost hermetically closed volumes where the emitters can be stored in a protective gas atmosphere. They will be opened after launch and after a reasonable outgassing of the satellite has taken place. The cover system consists of a hinged plate which tightens the LMIS module on an O-ring. The cover plate is held down and locked by a special hook, which is held in position by a helically wound bending spring. For opening the cover a pyrotechnic piston actuator, mounted perpendicular to one of the faces of the hook, is actuated. A pin pushes the hook away from its locking position and the spring-loaded cover plate will open. Figure 5 shows this mechanism.

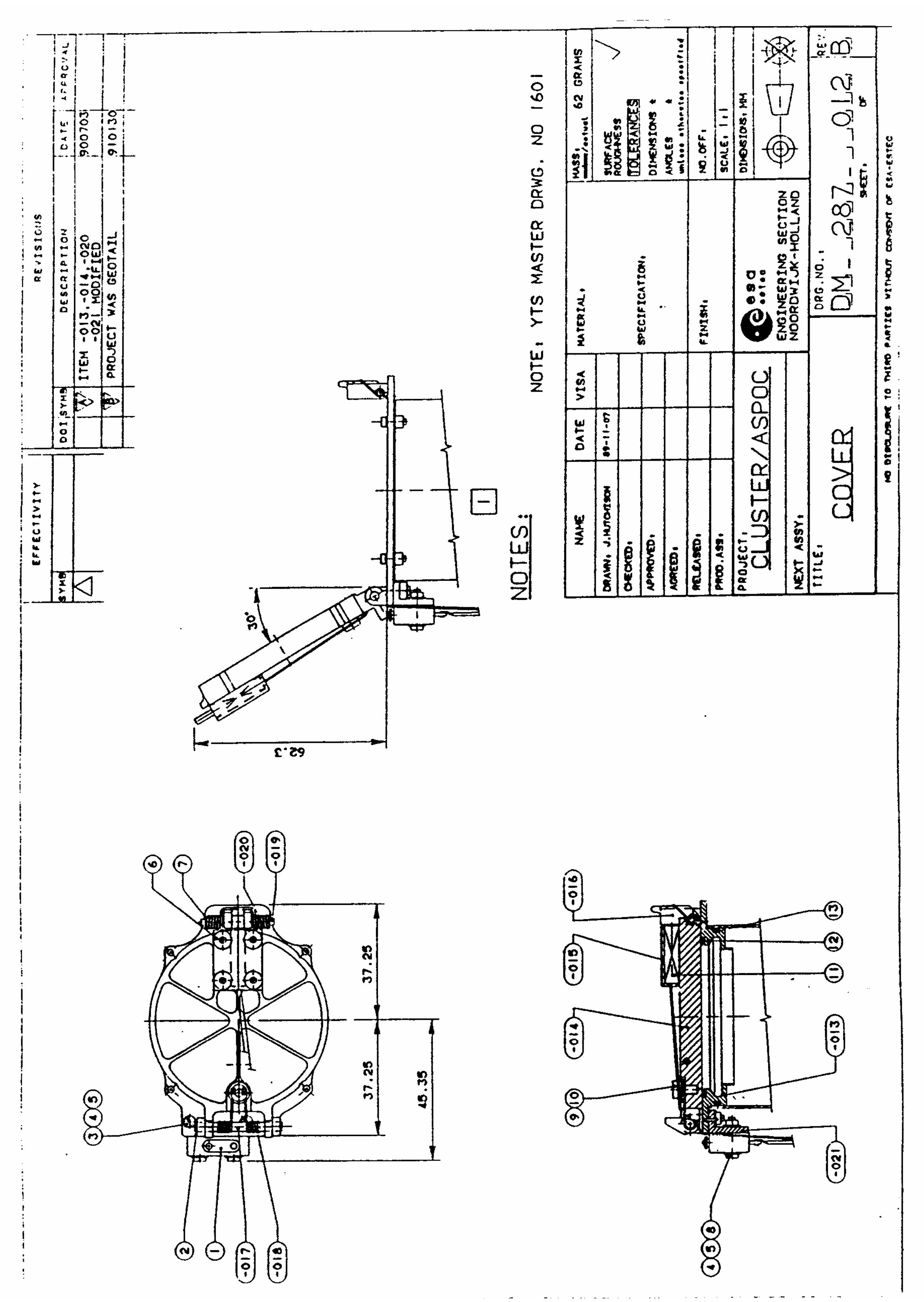


Fig. 5 Opening mechanism of the emitter module

1.5.3 Mass

Without any inter-experiment harness and elevated bracket, but including the connectors and the interconnection harness between the LMIS and the box, the total mass of the experiment is 1900 g.

Part	Mass (kg)
Emitter module 1	0.195
Emitter module 2	0.195
Bridge between emitters	0.050
Electronics box	1.450
Total	1.900 kg

1.5.4 Flight covers

Opening mechanisms for the two emitter modules are implemented as described in 1.5.2.

2. Telemetry

2.1 Monitoring Philosophy

All monitoring is through housekeeping TM via ESOC, JSOC, or the PI.

As pointed out in Sections 6.2.12 and 8.2 (instrument failure recovery) two parameters for automatic on-board recovery procedures could be identified.

The watch-dog timer of the DPU (see Section 1.3.3) does not become active in all possible cases. If, for example, a single event upset crashes the software only partially, the program may still regularly reset the watch-dog timer, but other parts of the software may not work. As there is a large variety of partial software failures, it may not be feasible to detect all, but at least some possible failures by on-board monitoring.

There are no S/C powered thermistors.

Instrument thermistors (see T1-T4 in Fig. 6) are located as follows:

ID	FIGURE	LOCATION	PARAMETER
T1	6	motherboard (inside electronics box)	EATMPBOX
T2	6	DPU board (inside electronics box)	EATMPDPU
T3	7	top plate of electronics box	EATMPMD1
T4	7	bracket interconnecting emitter modules	EATMPMD2

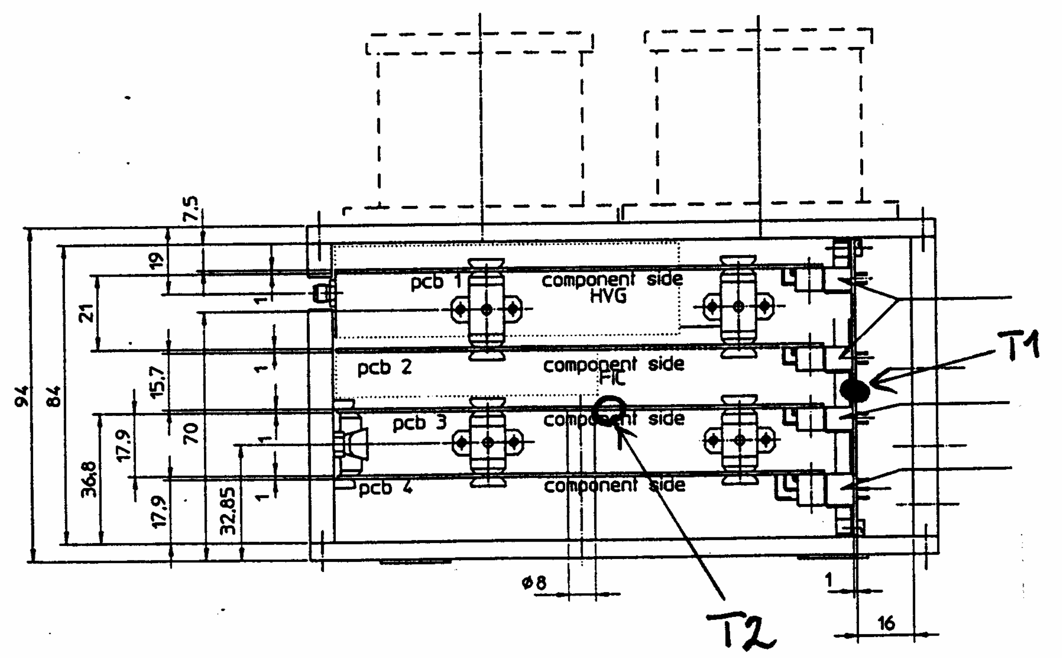


Fig. 6 Location of temperature sensors inside the box

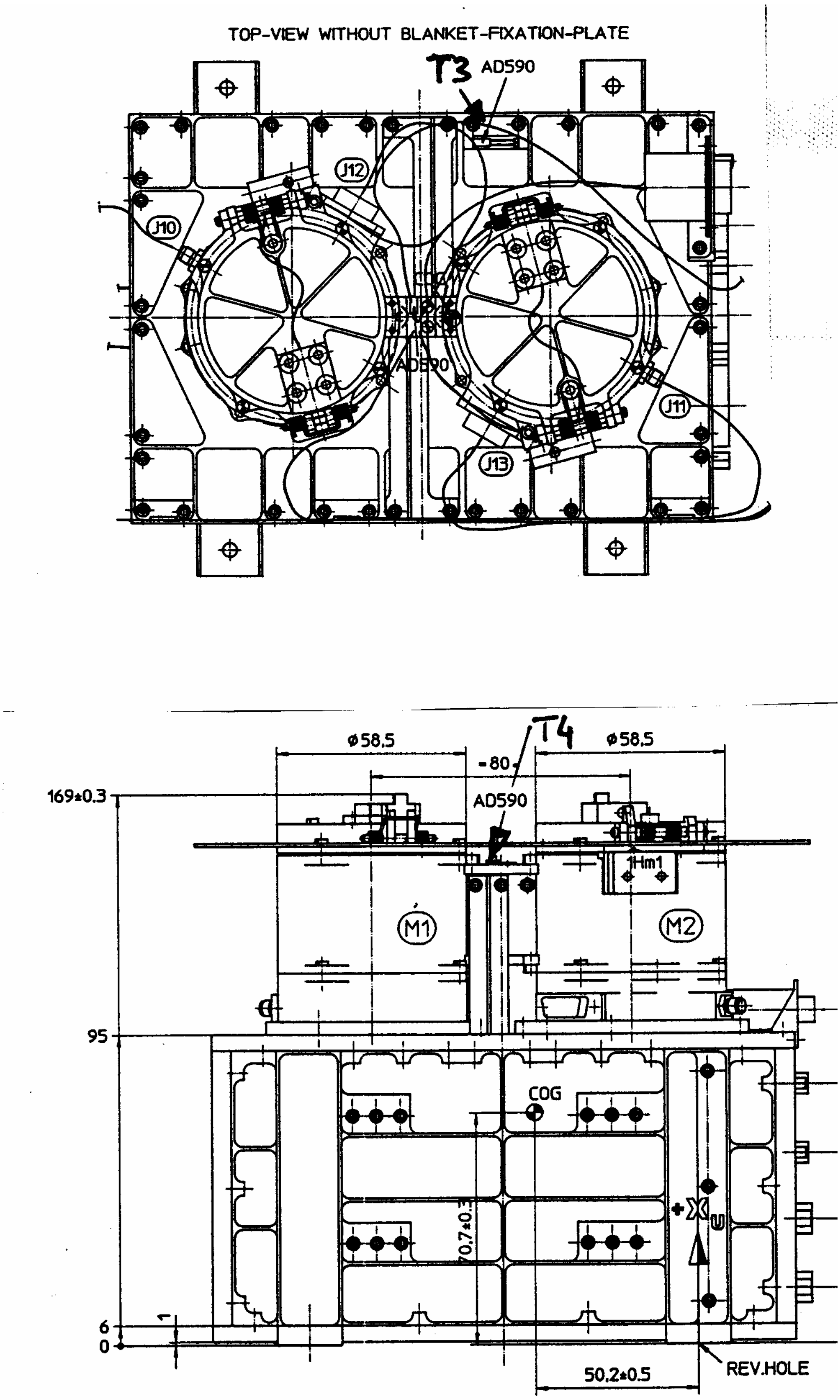


Fig. 7 Location of temperature sensors outside the box

2.2 Housekeeping TM

2.2.1 Introduction

No parameter occurs more than once in one HK frame.

Byte order of 16-bit parameters: The low location contains the low-order byte (LSB first). This is the reverse order as compared to the standard definition for the housekeeping TM.

Analogue parameters are unsigned, one byte long, with the following exceptions:

EALASTCM	2 bytes, LSB first (contains last command)
EAPEAOFF	1 byte, signed integer
EAEFWPT1	12 bit, signed integer, LSB first
EAEFWPT2	12 bit, signed integer, LSB first

Checksums are not used.

The parameter limits are mode-independent. Parameters being out of limits shall result in an alert to the experimenter.

The limits are identical for all ASPOC Flight Units.

Legend

LABEL	Name of parameter in AIT database
LOC	Location in HK frame (0...71)
MASK	Bitmask (hexadecimal) for the byte(s) at location LOC
TYPE	Type of parameter (A=analogue, D=digital)
LINK	Linked to telecommands (yes/no)
MX	Multiplex flag. The parameter occurs only in TM frames where the following condition is true:

N	all TM frames
0	EAMUXID_=0
1	EAMUXID_=1
4	EAEFWRX2=0
5	EAEFWRX2=1
8	EAPEARX2=0
9	EAPEARX2=1

for analogue parameters only:

SIGN	Signed (yes/no)
UNIT	Physical units
CAL	Number of calibration table for this parameter
HIGH	Upper limit of the parameter (engineering value)
LOW	Lower limit of the parameter (engineering value)

2.2.2 Voltage monitors

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EAV13_5_	10	FF	A	N	V	6	14.5	12.5	N	1
EAVN5___	12	FF	A	N	V	7	-4.5	-5.5	N	1
EAVP5___	11	FF	A	N	V	5	5.25	4.75	N	1

2.2.3 Temperature monitors

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EATMPBOX	15	FF	A	N	C	4	55.0	-25.0	N	1
EATMPDPU	13	FF	A	N	C	4	55.0	-25.0	N	0
EATMPMD1	14	FF	A	N	C	4	80.0	-25.0	N	0
EATMPMD2	15	FF	A	N	C	4	80.0	-25.0	N	0

2.2.4 Status/logic

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EABK_ACT	06	80	D	-	-	-	-	-	N	N
EABKMODE	06	70	D	-	-	-	-	-	Y	N
EACAP_A_	08	10	D	-	-	-	-	-	N	N
EACAP_B_	08	20	D	-	-	-	-	-	N	N
EACLNACT	56	20	D	-	-	-	-	-	N	4
EACLNDSB	43	04	D	-	-	-	-	-	Y	0
EACLNHWL	43	08	D	-	-	-	-	-	Y	0
EACMDREJ	06	08	D	-	-	-	-	-	N	N
EACMDSPN	05	FF	D	-	-	-	-	-	N	N
EACMDSRX	04	FF	D	-	-	-	-	-	N	N
EAEXPMOD	07	02	D	-	-	-	-	-	N	N
EAFILENB	08	01	D	-	-	-	-	-	Y	N
EAFILERR	56	10	D	-	-	-	-	-	N	4
EAFILSEL	07	1C	D	-	-	-	-	-	Y	N
EAFILSLD	56	08	D	-	-	-	-	-	N	4
EAHEADR1	00	FF	D	-	-	-	-	-	N	N
EAHEADR2	01	FF	D	-	-	-	-	-	N	N
EAHVMOD_	09	80	D	-	-	-	-	-	Y	N
EAHVCNMD	08	08	D	-	-	-	-	-	Y	N
EAHVPLUG	08	40	D	-	-	-	-	-	N	N
EAHVSHEN	08	04	D	-	-	-	-	-	N	N
EAHVSHST	08	80	D	-	-	-	-	-	N	N
EAHVSWEN	08	02	D	-	-	-	-	-	Y	N
EALASTCM	02,03	FFFF	D	-	-	-	-	-	Y	N
EAMODEL_	09	0F	D	-	-	-	-	-	N	N
EAMODULE	07	20	D	-	-	-	-	-	Y	N
EAMUXID_	09	10	D	-	-	-	-	-	N	N
EAOPMODE	06	07	D	-	-	-	-	-	Y	N
EAPOT_SR	07	C0	D	-	-	-	-	-	N	N
EAS/WVER	58	FF	D	-	-	-	-	-	N	8
EASTEPL_	09	40	D	-	-	-	-	-	Y	N
EASTEPS_	09	20	D	-	-	-	-	-	Y	N
EASU_ACT	07	01	D	-	-	-	-	-	N	N
EATIMOT2	56	01	D	-	-	-	-	-	N	4
EATIMOT4	56	04	D	-	-	-	-	-	N	4
EATIMOUT	55	F8	D	-	-	-	-	-	N	N
EAT1MOUT	55	08	D	-	-	-	-	-	N	N
EAT2MOUT	55	10	D	-	-	-	-	-	N	N
EAT3MOUT	55	20	D	-	-	-	-	-	N	N
EAT4MOUT	55	40	D	-	-	-	-	-	N	N
EAT5MOUT	55	80	D	-	-	-	-	-	N	N
EAWISCO2	43	30	D	-	-	-	-	-	Y	0
EAWISCO3	43	C0	D	-	-	-	-	-	Y	0
EAWISSDW	43	02	D	-	-	-	-	-	Y	0
EAWISSOR	43	01	D	-	-	-	-	-	Y	0

2.2.5 Analogue parameter settings

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EACOEFKC	21	FF	A	N		22	-	0.01	Y	0
EACOEFKV	21	FF	A	N		24	-	0.03	Y	1
EACOEFTV	22	FF	A	N		21		-	Y	1
EACOEFTX	22	FF	A	N		21	-	-	Y	0
EAFILISU	16	FF	A	N	Ohm	17	-	-	Y	1
EAFILOSV	17	FF	A	N	Ohm	17	-	-	Y	1
EAFILOTS	17	FF	A	N	C	20	-	--	Y	1
EAFILTSU	16	FF	A	N	C	20	-	-	Y	1
EAHV_SV_	20	FF	A	N	kV	10	-	-	Y	1
EAHVTHRE	43	FF	A	N	kV	10	-	-	Y	1
EAIONCSV	19	FF	A	N	uA	12	-	-	Y	0
EAPEAOFF	19	FF	A	Y	V	15	-	-	Y	1
EAPOT_SV	20	FF	A	N	V	16	-	-	Y	0
EATOTCLL	17	FF	A	N	uA	11	-	-	Y	0
EATOTCSV	16	FF	A	N	uA	11	80.0	-	Y	0
EATOTCUL	18	FF	A	N	uA	11	80.0	-	Y	0

2.2.6 HV and beam current monitors

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EAHV_OUT	14	FF	A	N	V	8	-	-	N	1
EAHVMON_	10	FF	A	N	kV	10	8.5	-	N	0
EAIONC0_	24	FF	A	N	uA	12	-	-	N	N
EATIMOT3	57	FF	A	N	uA	12	-	-	N	4
EATOTC0_	23	FF	A	N	uA	11	80.0	-	N	N

2.2.7 Emitter filament monitors

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EAFILIMN	11	FF	A	N	mA	18	80.0	-	N	0
EAFILIMP	18	FF	A	N	Ohm	17	-	-	N	1
EAFILOUT	13	FF	A	N	V	9	-	-	N	1
EAFILVMN	12	FF	A	N	V	19	-	-	N	0
EAFILTEM	18	FF	A	N	C	20	-	-	N	1

2.2.8 IEL status and data

LABEL	LOC	MASK	TYPE	SIGN	UNIT	CAL	HIGH	LOW	LINK	MX
EADWPNUM	44	F0	D	-	-	-	-	-	N	N
EADWPSTA	51-54	FF	D	-	-	-	-	-	N	N
EAEFWINV	56	02	D	-	-	-	-	-	N	4
EAEFWOF1	46	F0	D	-	-	-	-	-	N	N
EAEFWOF2	57	F0	D	-	-	-	-	-	N	5
EAEFWPT1	45,46	0FFF	A	Y	V	14	69.6	-69.6	N	N
EAEFWPT2	56,57	0FFF	A	Y	V	14	69.6	-69.6	N	5
EAEFWRX1	44	01	D	-	-	-	-	-	N	N
EAEFWRX2	55	01	D	-	-	-	-	-	N	N
EAEFWTI1	48	FF	A	N	s	23		-	N	N
EAEFWTI2	59	FF	A	N	s	23	-	-	N	N
EAHIRSTA	44	08	D	-	-	-	-	-	N	N
EAPEAPOT	47	FF	A	N	V	15	-	-	N	N
EAPEAPT2	58	FF	A	N	V	15	-	-	N	9
EAPEARX1	44	04	D	-	-	-	-	-	N	N
EAPEARX2	55	04	D	-	-	-	-	-	N	N
EAPEATI1	49	FF	A	N	s	23	-	-	N	N
EAPEATI2	60	FF	A	N	s	23	-	-	N	N
EASUNRX1	44	02	D	-	-	-	-	-	N	N
EASUNRX2	55	02	D	-	-	-	-	-	N	N
EASUNTI1	50	FF	A	N	s	23	-	-	N	N
EASUNTI2	61	FF	A	N	s	23	-	-	N	N

2.2.9 Calibration tables

The transformation from raw values, r, into physical values, p, shall be done for analogue parameters via the linear relation:

$$p = c0 + c1 * r$$

for all curves except no. 21. The table below lists values of c0 and c1, and the values of p for raw data values of 0 and 255. These tables are valid for all ASPOC Flight Units.

No.	c0	c1	p(0)	p(255)	unit	USED FOR
1	1.0	0.0	-	-	-	not used
2	0.0	1.0	-	-	-	not used
3	0.0	0.00392157	-	-	-	not used
4	-273.2	1.942	-273.2	222.0	°C	temperature sensors
5	0.0	0.02525	0	6.439	V	+5V monitor
6	0.0	0.0813	0	20.73	V	+13.5V monitor
7	0.0	-0.02525	0	-6.439	V	-5V monitor
8	0.0	0.019608	0	5.0	V	HV control interface
9	0.0	0.019608	0	5.0	V	heater control interface
10	0.0	0.03921	0	10.0	kV	high voltage monitor
11	0.0	0.3921	0	100.0	µA	total HV current
12	0.0	0.1961	0	50.0	µA	beam current
13	0.0	1.0	-	-	-	not used
14	0.0	0.034	0	- p(2047)=69.60 p(2049)=-69.60 p(4095)=-0.03	V	spacecraft potential (EFW)
15	0.0	0.2	0	*)	V	spacecraft potential (PEACE) *)
16	0.0	0.2	0	51.0	V	spacecraft potential (set point)
17	0.0	1.1718	0	298.8	Ω	heater impedance
18	0.0	0.3922	0	100.0	mA	heater current
19	0.0	0.0588	0	15.0	V	heater voltage
20	-256.4	3.0027	-256.4	509.2	°C	heater temperature
21	nonlinear relation*)					integrating control coefficient
22	0.0	0.015686	0	4.0	-	control coefficient Kc
23	0.0	0.02048	0	5.22	s	event timers
24	0.0	0.03137	0	8.0	-	control coefficient Kv

*) see following page

Calibration table no. 15:

The parameters EAPEAPOT and EAPEAPT2 (the measured values of the potential) are UNSIGNED parameters:

raw (decimal)	engineering (Volt)
0	0
255	51.0

The parameter EAPEAOFF (the assumed offset) is a SIGNED parameter:

raw (decimal)	engineering (Volt)
0	0
1	0.2
127	25.4
129	-25.4
255	-0.2

Calibration table no. 21:

T(p) = 256/(256-T(r))

with:

T(p) ... integration time in units of sampling intervals
T(r) ... raw value of integration time

raw (hex)	raw (decimal)	engineering (relative units)
0	0	1
20	32	1.14
40	64	1.33
60	96	1.60
80	128	2.00
A0	160	2.67
C0	192	4.00
D0	208	5.33
E0	224	8.00
F0	240	16.0
F6	246	25.6
F8	248	32.0
FA	250	42.7
FC	252	64.0
FD	253	85.3
FE	254	128.0
FF	255	256.0

2.2.10 Alphabetic list of all parameters

LABEL	DESCRIPTION
EABK_ACT	"backup mode is active" flag
EABKMODE	backup mode
EACAP_A_	cover of module A is open
EACAP_B_	cover of module B is open
EACLNACT	cleaning active flag
EACLNDSB	automatic cleaning disabled flag
EACLNHWL	cleaning software limit disabled flag
EACMDREJ	"command rejected" flag
EACMDSPN	number of pending commands on stack
EACMDSRX	counter of received commands
EACOEFKC	control loop coefficient Kc
EACOEFKV	control loop coefficient Kv
EACOEFTV	control loop coefficient Tv
EACOEFTX	control loop coefficient Tx
EADWPNUM	number of DWP words received
EADWPST1	1. DWP status information
EADWPST2	2. DWP status information
EADWPST3	3. DWP status information
EADWPST4	4. DWP status information
EADWPST5	5. DWP status information
EADWPST6	6. DWP status information
EADWPST7	7. DWP status information
EADWPST8	8. DWP status information
EADWPSTA	DWP status
EAEFWINV	EFW inverted polarity flag
EAEFWOF1	no. of 1st valid and new potential
EAEFWOF2	no. of 2nd valid and new potential
EAEFWPT1	S/C potential EFW
EAEFWPT2	2nd S/C potential EFW
EAEFWRX1	S/C potential EFW received
EAEFWRX2	2nd S/C potential EFW received
EAEFWTI1	timing EFW
EAEFWTI2	2nd timing EFW
EAEXPMOD	experiment in active mode flag
EAFILENB	filament enabled
EAFILERR	filament error flag
EAFILIMN	filament current monitor
EAFILIMP	filament impedance on-board calculated
EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILOUT	filament control output
EAFILSEL	filament select
EAFILSLD	filament selected flag
EAFILTEM	filament temperature on-board calculated
EAFILTSU	filament temperature for startup
EAFILVMN	filament voltage monitor
EAHEADR1	frame header MSB (E2h)

EAHEADR2	frame header LSB (43h)
EAHIRSTA	high resolution monitor start
EAHRION0 through EAHRION9	high resolution ion current monitor
EAHVMOD_	module select monitor
EAHVMON_	high voltage monitor
EAHV_OUT	high voltage control output
EAHV_SV_	high voltage set value
EAHVCNMD	HV voltage control mode
EAHVPLUG	high voltage connector enabled
EAHVSHEN	Hshut line enabled
EAHVSHST	Hshut line status
EAHVSWEN	high voltage software enabled
EAHVTHRE	high voltage threshold
EAIONC0_ through EAIONC9_	ion current monitor
EAIONCSV	ion current set value
EALASTCM	last command
EAMODEL_	model ID
EAMODULE	module select
EAMUXID_	mux flag
EAOPMODE	operating mode
EAPEAOFF	offset for PEACE data
EAPEAPOT	S/C potential PEACE
EAPEAPT2	2nd S/C potential PEACE
EAPEARX1	S/C potential PEACE received flag
EAPEARX2	2nd S/C potential PEACE received flag
EAPEATI1	timing PEACE
EAPEATI2	2nd timing PEACE
EAPEPOTS	PEACE potential status
EAPEPT2S	2nd PEACE potential status
EAPOT_SR	S/C pot. source used
EAPOT_SV	S/C potential set value
EAS/WVER	software version
EASTEPL_	total current long steps (16 s)
EASTEPS_	total current large steps (4 µA)
EASU_ACT	startup active flag
EASUNRX1	sun pulse received flag
EASUNRX2	2nd sun pulse received flag
EASUNTI1	timing sun pulse
EASUNTI2	2nd timing sun pulse
EATIMOT2	feedback wait status
EATIMOT3	calculated ion current
EATIMOT4	cleaning timeout flag
EATIMOUT	timeout code
EAT1MOUT	timeout, no ignition
EAT2MOUT	timeout, no beam current
EAT3MOUT	timeout, EFW failure
EAT4MOUT	timeout, PEACE failure
EAT5MOUT	timeout, ion current set below limit
EATMPBOX	temperature motherboard

EATMPDPU	temperature DPU board
EATMPMD1	temperature top plate
EATMPMD2	temperature LMIS cover
EATOTC0_ through EATOTC9_	total current monitor
EATOTCLL	total current lower limit
EATOTCSV	total current set value
EATOTCUL	total current upper limit
EAV13_5_	+13.5 V monitor
EAVN5___	-5 V monitor
EAVP5___	+5 V monitor
EAWISCO2	WHISPER mode change condition 2
EAWISCO3	WHISPER mode change condition 3
EAWISSDW	WHISPER shutdown flag
EAWISSOR	WHISPER use backup mode flag
EAWISTAB	WHISPER decision table

2.2.11 Parameter short description

LABEL DESCRIPTION

EABK_ACT "backup mode is active" flag

RAW	DESCRIPTION
0	backup mode is not active
1	backup mode is active

EABKMODE backup mode

The backup mode is the internal contingency mode of the instrument for IEL failures. The code is identical to the operating mode (EAOPMODE).

EACAP_A_ cover of module A is open

RAW	DESCRIPTION
0	cover is closed
1	cover is open

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

EACAP_B_ cover of module B is open

RAW	DESCRIPTION
0	cover is closed
1	cover is open

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

EACLNACT cleaning active flag

flag indicating that the cleaning cycle for an emitter is in progress

RAW	DESCRIPTION
0	cleaning is not active
1	cleaning is active

EACLNDSB automatic cleaning disabled flag

flag indicating whether the automatic cleaning cycle for an emitter is enabled

RAW	DESCRIPTION
0	automatic cleaning is enabled
1	automatic cleaning is disabled

EACLNHWL cleaning software limit disabled flag

flag indicating the limitation of high voltage during a cleaning cycle.

RAW	DESCRIPTION
0	high voltage is limited by software to 9 kV
1	high voltage is limited by hardware

EACMDREJ "command rejected" flag

A command may be rejected by the instrument if the instrument is not in the right mode to respond to the command. In this case the command is not executed and the rejected-flag is set. Only defined telecommands may be rejected. Undefined telecommand are ignored.

RAW	DESCRIPTION
0	last received command is not rejected
1	last received command is rejected

EACMDSPN number of pending commands on stack

Telecommands are put into a stack (size 255) after reception, and are executed from this stack. This parameter counts the remaining (= not yet executed) commands in the stack.

EACMDSRX counter of received commands

8-bit counter of the telecommands received since power-on.

EACOEFKC control loop coefficient Kc

The characteristics of the beam current loop is determined by two coefficients of a proportional-integral-type controller. Kc gives the proportional component.

EACOEFKV control loop coefficient Kv

The characteristics of the spacecraft potential control loop is determined by two coefficients of a proportional-integral-type controller. Kv gives the proportional component.

EACOEFTV control loop coefficient Tv

Tv determines the integral component of the spacecraft potential control loop.

EACOEFTX control loop coefficient Tx

Tx determines the integral component of the beam current control loop.

EADWPNUM number of DWP words received

8-bit counter of all data transmissions from DWP since the last reset pulse. The contents of EADWPST1 - EADWPST8 is valid only up to the value of EADWPNUM.

EADWPST1 1. DWP status information

4-bit status flags of data transmission #1 since the last reset pulse from DWP.

EADWPST2 2. DWP status information

4-bit status flags of data transmission #2 since the last reset pulse from DWP.

EADWPST3 3. DWP status information

4-bit status flags of data transmission #3 since the last reset pulse from DWP.

EADWPST4 4. DWP status information

4-bit status flags of data transmission #4 since the last reset pulse from DWP.

EADWPST5 5. DWP status information

4-bit status flags of data transmission #5 since the last reset pulse from DWP.

EADWPST6 6. DWP status information

4-bit status flags of data transmission #6 since the last reset pulse from DWP.

EADWPST7 7. DWP status information

4-bit status flags of data transmission #7 since the last reset pulse from DWP.

EADWPST8 8. DWP status information

4-bit status flags of data transmission #8 since the last reset pulse from DWP.

EADWPSTA DWP status

Comprises the 8 DWP status information parameters above (EADWPST1-EADWPST8).

EAEFWINV EFW inverted polarity flag

The sign of incoming spacecraft potential data from EFW is inverted if this flag is set.

RAW	DESCRIPTION
0	polarity of incoming EFW data is unchanged
1	polarity of incoming EFW data is inverted

EAEFWOF1 no. of 1st valid and new potential

Points to the data transmission from DWP, when the first update of the potential during the present frame interval occurred. This parameter is valid only if EAEFWRX1=1.

RAW	DESCRIPTION
0	The spacecraft potential from EFW was not updated during the present frame interval.
x	An update of the spacecraft potential from EFW occurred at the x-th data transmission from DWP during the present frame interval.

EAEFWOF2 no. of 2nd valid and new potential

Points to the data transmission from DWP, when the second update of the potential during the present frame interval occurred. Note: Since the potential is updated not more often than once per spin, not more than 2 updates can occur during one reset interval. This parameter is valid only if EAEFWRX2=1.

RAW	DESCRIPTION
0	The spacecraft potential from EFW has been updated 0 or 1 times during the present frame interval.
x	A second update of the spacecraft potential from EFW occurred at the x-th data transmission from DWP during the present frame interval.

EAEFWPT1 S/C potential EFW

Spacecraft potential from EFW: first updated value in the present frame interval (see EAEFWOF1 for a definition). This parameter is valid only if EAEFWRX1=1.

EAEFWPT2 2nd S/C potential EFW

Spacecraft potential from EFW: second updated value in the present frame interval. This parameter is valid only if EAEFWRX2=1.

EAEFWRX1 S/C potential EFW received

Indicates that the spacecraft potential from DWP has been updated at least once during the present frame interval.

RAW	DESCRIPTION
0	no update
1	The spacecraft potential from EFW has been updated during the present frame interval, and its value has been written into parameter EAEFWPT1.

EAEFWRX2 2nd S/C potential EFW received

Indicates that the spacecraft potential from DWP has been updated at least twice during the present frame interval.

RAW	DESCRIPTION
0	no update
1	The spacecraft potential from EFW has been updated twice during the present frame interval, and the second value has been written into parameter EAEFWPT2.

EAEFWTI1 timing EFW

Time since the last reset pulse, when the spacecraft potential defined as EAEFWPT1 has been received. This parameter is valid only if EAEFWRX1=1.

EAEFWTI2 2nd timing EFW

Time since the last reset pulse, when the spacecraft potential defined as EAEFWPT2 has been received. This parameter is valid only if EAEFWRX2=1.

EAEXPMOD experiment in active mode flag

Active modes are all modes except standby mode.
This parameter is fully defined by the experiment mode (EAOPMODE).

RAW	DESCRIPTION
0	experiment is not in an active mode: EAOPMODE = standby mode (0) or technical mode (6)
1	experiment is in an active mode: EAOPMODE <> standby mode and technical mode

EAFILENB filament enabled

RAW	DESCRIPTION
0	filaments are disabled
1	filaments are enabled

EAFILERR filament error

flag indicating that the impedance of the active filament is outside the nominal range (70 to 255 Ohms or -75 to +420 C)

RAW	DESCRIPTION
0	no error
1	error

EAFILIMN filament current monitor

EAFILIMP filament impedance on-board calculated

Filament impedance, calculated on board from the filament voltage and current monitors. The value is inaccurate for very low voltages. This parameter occupies the same position in the HK telemetry as EAFILTEM, but the associated calibration curve yields impedance rather than temperature.

EAFILISU filament impedance for startup

Set value for the filament impedance, to be reached during the start-up procedure of an emitter, as a condition for high voltage turn-on. This parameter occupies the same position in the HK telemetry as EAFILTSU, but the associated calibration curve yields impedance rather than temperature.

EAFILOSV filament operating impedance set point

Set value for the filament impedance to be maintained during normal operation. This parameter occupies the same position in the HK telemetry as EAFILOTS, but the associated calibration curve yields impedance rather than temperature.

EAFILOTS filament operating temperature set point

Set value for the filament temperature to be maintained during normal operation. This parameter occupies the same position in the HK telemetry as EAFILOSV, but the associated calibration curve yields temperature rather than impedance.

EAFILOUT filament control output

Monitor for the analogue internal interface between DPU and filament power supply, which determines the electrical output power of the supply.

EAFILSEL filament select

Number of the filament (emitter) which has been selected. The values range from 0 to 3 for the four filaments per module.

Not all four emitters are operational in each module. A non-operational emitter may be heated without risk for the instrument, but it would not ignite when high voltage is applied.
The following table shows valid combined selections of the parameters EAMODULE (module select) and EAFILSEL (filament select).

S/C (Dor)	ASPOC Unit	valids (hexadecimal) EAMODULE	EAFILSEL
6	FM-007	0	1,2,3
		1	1,2,3
	(some remaining chance for emitter 0 in EAMODULE=1)		
7	FM-008	0	0,1,3
		1	0,1,2,3
	(only 50% efficiency of emitter 1 in EAMODULE=0)		
8	FM-009	0	0,1,2,3
		1	0,1,2,3
5	FM-010	0	0,1,2,3
		1	0,2,3
	(EAMODULE=0 is a Cluster-I spare)		
	FM-005	0	1,2,3
		1	1,2,3
	(EAMODULE=0 is a Cluster-I spare)		

EAFILSLD filament selected flag

flag indicating that one of the filaments has been selected. Only if this parameter is set, the parameter EAFILSEL is valid.

RAW	DESCRIPTION
0	no filament selected
1	filament selected

EAFILTEM filament temperature on-board calculated

Filament temperature, calculated on board from the filament voltage and current monitors. The value is inaccurate for very low voltages. This parameter occupies the same position in the HK telemetry as EAFILIMP, but the associated calibration curve yields temperature rather than impedance.

EAFILTSU filament temperature for startup

Set value for the filament temperature, to be reached during the start-up procedure of an emitter, as a condition for high voltage turn-on. This parameter occupies the same position in the HK telemetry as EAFILISU, but the associated calibration curve yields temperature rather than impedance.

EAFILVMN filament voltage monitor

EAHEADR1 frame header MSB

First, high-order byte of a constant frame header (value 0xE2)

EAHEADR2 frame header LSB

Second, low-order byte of a constant frame header (value 0x43)

EAHIRSTA high resolution monitor start

Indicates that a sample of high-resolution beam current data starts at the beginning of the current frame, which contains the first data of this sample.

RAW	DESCRIPTION
0	high resolution data do not start in this frame
1	high resolution data start in this frame

EAHRION0 through EAHRION9 high resolution ion current monitor

10 values of high resolution ion current sampled with ca. 40 ms, starting at the beginning of the frame with EAHIRSTA=1.

EAHVMOD_ module select monitor

Indicates which emitter module has been selected. This value is returned from the high voltage unit (see also EAMODULE).

RAW	DESCRIPTION
0	the first module ("A") is selected
1	the second module ("B") is selected

EAHVMON_ high voltage monitor

Output voltage of the high voltage power supply.

EAHVTHRE high voltage threshold

Threshold value for the high voltage to trigger an emitter cleaning cycle.

EAHV_OUT high voltage control output

Monitor for the analogue internal interface between DPU and high voltage power supply, which determines the output (current or voltage, depending on mode) of the supply.

EAHV_SV_ high voltage set value

Set value for the output voltage of the high voltage power supply. Used only if the supply is in voltage mode (see EAHVCNMD). Note that any commanded value of this parameter is overwritten by the automatic levels during an emitter start-up procedure starting at "5 kV" and increasing.

EAHVCNMD HV voltage control mode

In current mode (the normal mode) the high voltage unit controls the output current corresponding to the parameter EAHV_OUT. In voltage mode it generates a constant voltage.

RAW	DESCRIPTION
0	current mode
1	voltage mode

EAHVPLUG high voltage connector enabled

Status of the high voltage disarming connector.

RAW	DESCRIPTION
0	disabled, connector is mounted
1	armed, connector is off

EAHVSHEN Hshut line enabled

High voltage enable status, as commanded by the DPU to the supply.

RAW	DESCRIPTION
0	high voltage is disabled
1	high voltage is enabled

EAHVSHST — Hshut line status

Status of the internal high voltage enable interface line between DPU and supply, as monitored by the DPU.

RAW	DESCRIPTION
0	on, line is enabled
1	off, line is disabled

EAHVSWEN — high voltage software enabled

High voltage enable status, as determined by on-board software.

RAW	DESCRIPTION
0	high voltage is disabled
1	high voltage is enabled

EAIONC0_ through EAIONC9_ — ion current monitor

10 values of the ion current within the present frame interval in increments of ca. 0.5 s.

EAIONCSV — ion current set value

Set value for the ion beam current. Used in constant beam current mode.

EALASTCM — last command

Last command which has been executed from the command stack.

EAMODEL_ — model ID

Instrument model.

RAW	DESCRIPTION
0	N/A
1	N/A
2	EM-001
3	FM-007
4	N/A
5	N/A
6	FM-005
7	N/A
8	FM-008
9	FM-009
10	FM-010

EAMODULE module select

Selection of the emitter module. This value is sent from the DPU to the high voltage unit (see also EAHVMOD_).

RAW	DESCRIPTION
0	the first module ("A") is selected
1	the second module ("B") is selected

EAMUXID_ mux flag

Multiplex flag to distinguish between the two HK frame formats which are sent in alternation.

EAOPMODE operating mode

Operating mode of the experiment. After IEL or emitter failures the commanded mode may be overridden by the backup mode (EABKMODE) or standby.
This parameter remains unchanged in the "feedback wait status (EATIMOT2=1, "FWX").

RAW	DESCRIPTION
0	standby
1	constant total current
2	constant beam current
3	feedback from EFW
4	hot standby
5	test and commissioning
6	technical
7	feedback from PEACE

EAPEAOFF offset for PEACE data

Offset added to spacecraft potential data received from PEACE before entering the control loop. This value is set by telecommand.

EAPEAPOT S/C potential PEACE

Spacecraft potential from PEACE: first value received in the present frame interval. This parameter is valid only if EAPEARX1=1. Valid raw data range between 1 and 127.

EAPEAPT2 2nd S/C potential PEACE

Spacecraft potential from PEACE: second value received in the present frame interval. This parameter is valid only if EAPEARX2=1. Valid raw data range between 1 and 127.

EAPEARX1 S/C potential PEACE received

Indicates that the spacecraft potential from PEACE has been received at least once during the present frame interval.

RAW	DESCRIPTION
0	not received
1	The spacecraft potential from PEACE has been received during the present frame interval, and its value has been written into parameter EAPEAPOT.

EAPEARX2 2nd S/C potential PEACE received

Indicates that the spacecraft potential from PEACE has been received twice during the present frame interval.

RAW	DESCRIPTION
0	not received
1	The spacecraft potential from PEACE has been received twice during the present frame interval, and the second value has been written into parameter EAPEAPT2.

EAPEATI1 timing PEACE

Time since the last reset pulse, when the spacecraft potential defined as EAPEAPOT has been received. This parameter is valid only if EAPEARX1=1.

EAPEATI2 2nd timing PEACE

Time since the last reset pulse, when the spacecraft potential defined as EAPEAPT2 has been received. This parameter is valid only if EAPEARX2=1.

EAPEPOTS PEACE spacecraft potential status

Status of the first spacecraft potential value received from PEACE in the present frame interval. This parameter occupies the same position in the HK telemetry as EAPEAPOT, and is valid only if EAPEARX1=1.

EAPEPT2S PEACE potential "error" status

Status of the 2nd spacecraft potential value received from PEACE in the current frame interval. This parameter occupies the same position in the HK telemetry as EAPEAPT2, and is valid only if EAPEARX2=1.

EAPOT_SR S/C pot. source used

Indicates the data source (EFW or PEACE) for the spacecraft potential which is used for the beam current control during feedback mode.
This parameter is fully defined by the experiment mode (EAOPMODE).

RAW	DESCRIPTION
0	EAOPMODE = 0, 1, 2, 4, 5, or 6
1	EAOPMODE = 3 (feedback EFW)
2	EAOPMODE = 7 (feedback PEACE)
3	error

EAPOT_SV S/C potential set value

Set value for the spacecraft potential. Used in feedback modes from EFW and PEACE.

EAS/WVER software version

Indicates the version of the experiment software in on-board PROM.

EASTEPL_ total current long steps

Indicates the duration of a single beam current step in test and commissioning mode, and the duration of the emitter cleaning cycle.

RAW	DESCRIPTION
0	8 second steps, or 20 s cleaning
1	16 second steps, or 60 s cleaning

EASTEPS_ total current large steps

Indicates the high voltage output current increment (decrement) between current steps in test and commissioning mode, and the total current applied during emitter cleaning.

RAW	DESCRIPTION
0	2 µA steps or 50 µA cleaning current
1	4 µA steps or >70 µA cleaning current

EASU_ACT startup active flag

RAW	DESCRIPTION
0	no start-up in progress
1	start-up procedure for an emitter is in progress; the flag is already set at the selection of a module or a filament (command ZEAMODxS or ZEAMODxS)

EASUNRX1 sun pulse received flag

Indicates that the sun reference pulse (SRP) has been received at least once during the present frame interval.

RAW	DESCRIPTION
0	no SRP received
1	SRP received

EASUNRX2 2nd sun pulse received flag

Indicates that the sun reference pulse (SRP) has been received twice during the present frame interval.

RAW	DESCRIPTION
0	no second SRP received
1	second SRP received

EASUNTI1 timing sun pulse

Time since the last reset pulse, when the first SRP within the present frame interval has been received. This parameter is valid only if EASUNRX1=1.

EASUNTI2 2nd timing sun pulse

Time since the last reset pulse, when the second SRP within the present frame interval has been received. This parameter is valid only if EASUNRX2=1.

EATIMOT2 feedback wait status

Indicates that a timeout condition has caused the experiment to switch into feedback wait status .

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EATIMOT3 calculated ion current

Set value of the ion current, calculated by on-board software and sent to the high voltage supply during feedback mode.

EATIMOT4 cleaning timeout flag

Indicates that the instrument has entered standby mode after the high voltage has exceeded the threshold value for cleaning.

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EATIMOUT timeout code no. 1

Parameter containing the timeout flags 1-5 (see below).

MASK	DESCRIPTION
01	EAT1MOUT
02	EAT2MOUT
04	EAT3MOUT
08	EAT4MOUT
10	EAT5MOUT

EAT1MOUT timeout, no ignition

Indicates that an emitter has failed to ignite within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EAT2MOUT timeout, no beam current

Indicates that the beam current has dropped to zero and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EAT3MOUT timeout, EFW failure

Indicates that the data transmission from EFW has been stopped and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EAT4MOUT timeout, PEACE failure

Indicates that the data transmission from PEACE has been stopped and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EAT5MOUT timeout, ion current set below limit

Indicates that the beam current calculated on board during feedback mode has dropped below 50% of the lower HV output current limit, and has failed to recover within a given timeout period.
This parameter is set at the end of the timeout period.
It is reset when the condition is no longer fulfilled, or with any new operation mode command.

RAW	DESCRIPTION
0	no timeout
1	timeout condition fulfilled

EATMPBOX temperature motherboard

Reading of the temperature sensor located at the motherboard.

EATMPDPU temperature DPU board

Reading of the temperature sensor located at one of the DPU boards.

EATMPMD1 temperature top plate

Reading of the temperature sensor located at the top plate of the electronics box.

EATMPMD2 temperature LMIS cover

Reading of the temperature sensor located near the covers of the emitter modules.

EATOTC0_ through EATOTC9_ total current monitor

10 values of the total output current of the HV supply within the present frame interval in increments of ca. 0.5 s.

EATOTCLL total current lower limit

Lower limit of the total output current of the HV supply. Used in feedback modes and in test and commissioning mode to limit the total current.
This parameter also serves as a condition to detect an emitter failure (EATOTC0_ < EATOTCLL over 255 seconds). The respective timeout flag is EAT2MOUT.
50% of this value is also used as a lower limit of the calculated ion current in feedback mode, below which a flag is set, which calls for a "calculated ion current out of range" (INV) timeout after 40 seconds (timeout flag EAT5MOUT).

EATOTCSV total current set value

Set value of the total output current of the HV supply in constant total current mode. Also used as a start value in the test and commissioning mode T&C. Note that in this mode the contents of this variable is constantly overwritten by the different current steps, and therefore the parameter has to be set again after mode T&C if needed by another mode.

EATOTCUL total current upper limit

Upper limit of the total output current of the HV supply. Used in feedback modes and in test and commissioning mode to limit the total current.

EAV13_5_ +13.5 V monitor

Reading of the internal voltage monitor for +13.5 V.

EAVN5___ -5 V monitor

Reading of the internal voltage monitor for -5 V.

EAVP5___ +5 V monitor

Reading of the internal voltage monitor for +5 V.

EAWISCO2 WHISPER mode change condition 2

Bit pattern number 1 of 2 (in an or-relation) of the WHISPER status information, causing the experiment to react according to the settings in EAWISSDW and EAWISSOR (see below) if the parameter matches the incoming WHISPER status data (bits 13 and 12 of the word received from DWP).

EAWISCO3 WHISPER mode change condition 3

Bit pattern number 2 of 2 (in an or-relation) of the WHISPER status information, causing the experiment to react according to the settings in EAWISSDW and EAWISSOR (see below) if the parameter matches the incoming WHISPER status data (bits 13 and 12 of the word received from DWP).

EAWISSDW WHISPER shutdown flag

Indicates if the experiment shall switch into feedback wait status (ion beam off) if one of the patterns EAWISCO2-3 is matched by the incoming WHISPER status data.

RAW	DESCRIPTION
0	no action
1	switch into feedback wait status

EAWISSOR WHISPER use backup mode flag

Indicates if the experiment shall switch into the mode which has been commanded as a backup mode if one of the patterns EAWISCO2-3 is matched by the incoming WHISPER status data.

RAW	DESCRIPTION
0	no action
1	switch into backup mode

EAWISTAB WHISPER decision table

Parameter containing the WHISPER parameters (see above), and emitter cleaning flags.

MASK	DESCRIPTION
01	EAWISSOR
02	EAWISSDW
04	EACLNDSB
08	EACLNHWL
30	EAWISCO2
C0	EAWISCO3

2.3 Initial Settings

Analogue parameters are NOT changed by instrument mode changes. Some status flags change with instrument mode changes.

The following table contains initial settings stored in program memory and present after instrument turn-on, which sets the instrument into standby mode.

2.3.1 Status/logic

LABEL	Initial Value
EABK_ACT	0
EABKMODE	0
EACLNACT	0
EACLNDSB	0
EACLNHWL	0
EACMDREJ	0
EACMDSPN	0
EACMDSRX	0
EAEXPMOD	0
EAFILENB	0
EAFILERR	0
EAFILSEL	0
EAFILSLD	0
EAHEADR1	0xE2
EAHEADR2	0x43
EAHVMOD_	0
EAHVCNMD	1
EAHVPLUG	depends on HV disable connector status
EAHVSHEN	0
EAHVSHST	1
EAHVSWEN	0
EALASTCM	0
EAMODEL_	0
EAMODULE	0
EAOPMODE	0
EAPOT_SR	0
EAS/WVER	0
EASTEPL_	0
EASTEPS_	0
EASU_ACT	0
EATIMOT2	0
EATIMOT3	0
EATIMOT4	0
EATIMOUT	0
EAWISCO2	0
EAWISCO3	0
EAWISSDW	0
EAWISSOR	0

2.3.2 Analogue parameter settings

LABEL	Raw	Engineering Initial Value
EACOEFKC	0x1A	(0.41)
EACOEFKV	0x14	(0.63)
EACOEFTV	0x3B	(1.3)
EACOEFTX	0x80	(2.0)
EAFILIMP	0x00	(0 Ohm)
EAFILISU	0xb9	(299 °C)
EAFILOSV	0xb7	(293 °C)
EAFILOTS	0xb7	(293 °C)
EAFILTEM	0x00	(0 °C)
EAFILTSU	0xb9	(299 °C)
EAHVTHRE	0xbf	(7.5 kV)
EAHV_SV_	0x00	(0 kV)
EAIONCSV	0x0c	(2.4 µA)
EAPEAOFF	0x00	(0 V)
EAPOT_SV	0x00	(0 V)
EATOTCLL	0x05	(2.0 µA)
EATOTCSV	0x19	(10 µA)
EATOTCUL	0x80	(50 µA)

2.4 Important parameters, listed by instrument mode

2.4.1 Introduction

Each instrument mode, in particular the active modes with ion emission, requires a different set of parameters to be defined. Their value affects the operation of the instrument in this mode. As an example, the constant total current mode ("ITOT") requires the set value of the ion current (EATOTCSV), whereas the feedback mode from EFW ("FEFW") requires, among others, the target value of the spacecraft potential (EAPOT_SV).

Constraints for a mode are indicated by a second set of parameters. The required raw values of parameters for a mode are given in a second table.

2.4.2 Feedback mode with EFW

ACRONYM: FEFW
EAOPMODE: 3

PARAMETER TO BE DEFINED

EABKMODE	backup mode
EACOEFKC	control loop coefficient Kc
EACOEFKV	control loop coefficient Kv
EACOEFTV	control loop coefficient Tv
EACOEFTX	control loop coefficient Tx
EAEFWINV	EFW inverted polarity flag
EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILSEL	filament select
EAFILTSU	filament temperature for startup
EAIONCSV	ion current set value
EAMODULE	module select
EAPEAOFF	offset for PEACE data
EAPOT_SV	S/C potential set value
EATOTCLL	total current lower limit
EATOTCSV	total current set value
EATOTCUL	total current upper limit
EAWISTAB	WHISPER decision table

PARAMETER	RAW VAL.	DESCRIPTION
EAFILENB	1	filament enabled
EAHVPLUG	1	high voltage connector enabled
EAHVSHEN	1	Hshut line enabled
EAHVSWEN	1	high voltage software enabled
case EAHVMOD_ = 0:		
EACAP_A_	1	cover of module A is open
case EAHVMOD_ = 1:		
EACAP_B_	1	cover of module A is open

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

2.4.3 Feedback mode with PEACE

ACRONYM: FPEA
EAOPMODE: 7

PARAMETER TO BE DEFINED

EABKMODE	backup mode
EACOEFKC	control loop coefficient Kc
EACOEFKV	control loop coefficient Kv
EACOEFTV	control loop coefficient Tv
EACOEFTX	control loop coefficient Tx
EAEFWINV	EFW inverted polarity flag
EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILSEL	filament select
EAFILTSU	filament temperature for startup
EAIONCSV	ion current set value
EAMODULE	module select
EAPEAOFF	offset for PEACE data
EAPOT_SV	S/C potential set value
EATOTCLL	total current lower limit
EATOTCSV	total current set value
EATOTCUL	total current upper limit
EAWISTAB	WHISPER decision table

PARAMETER	RAW VAL.	DESCRIPTION
EAFILENB	1	filament enabled
EAHVPLUG	1	high voltage connector enabled
EAHVSHEN	1	Hshut line enabled
EAHVSWEN	1	high voltage software enabled
case EAHVMOD_ = 0:		
EACAP_A_	1	cover of module A is open
case EAHVMOD_ = 1:		
EACAP_B_	1	cover of module A is open

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

2.4.4 Constant beam current mode

ACRONYM:	IION
EAOPMODE:	2

PARAMETER TO BE DEFINED

EACOEFKC	control loop coefficient Kc
EACOEFTX	control loop coefficient Tx
EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILSEL	filament select
EAFILTSU	filament temperature for startup
EAIONCSV	ion current set value
EAMODULE	module select
EATOTCSV	total current set value

PARAMETER	RAW VAL.	DESCRIPTION
EAFILENB	1	filament enabled
EAHVPLUG	1	high voltage connector enabled
EAHVSHEN	1	Hshut line enabled
EAHVSWEN	1	high voltage software enabled
case EAHVMOD_ = 0:		
EACAP_A_	1	cover of module A is open
case EAHVMOD_ = 1:		
EACAP_B_	1	cover of module A is open

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

2.4.5 Constant total current mode

ACRONYM:	ITOT
EAOPMODE:	1

PARAMETER TO BE DEFINED

EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILSEL	filament select
EAFILTSU	filament temperature for startup
EAMODULE	module select
EATOTCSV	total current set value

PARAMETER	RAW VAL.	DESCRIPTION
EAFILENB	1	filament enabled
EAHVPLUG	1	high voltage connector enabled
EAHVSHEN	1	Hshut line enabled
EAHVSWEN	1	high voltage software enabled
case EAHVMOD_ = 0:		
EACAP_A_	1	cover of module A is open
case EAHVMOD_ = 1:		
EACAP_B_	1	cover of module A is open
		Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

2.4.6 Test and commissioning mode

ACRONYM: T&C
EAOPMODE: 5

PARAMETER TO BE DEFINED

EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILSEL	filament select
EAFILTSU	filament temperature for startup
EAMODULE	module select
EASTEPL_	total current long steps (16 s)
EASTEPS_	total current large steps (4 µA)
EATOTCLL	total current lower limit
EATOTCSV	total current set value
EATOTCUL	total current upper limit

PARAMETER	RAW VAL.	DESCRIPTION
EAFILENB	1	filament enabled
EAHVPLUG	1	high voltage connector enabled
EAHVSHEN	1	Hshut line enabled
EAHVSWEN	1	high voltage software enabled
case EAHVMOD_ = 0:		
EACAP_A_	1	cover of module A is open
case EAHVMOD_ = 1:		
EACAP_B_	1	cover of module A is open

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

2.4.7 Technical mode

ACRONYM:	TECH
EAOPMODE:	6

PARAMETER TO BE DEFINED

Depending on telecommands sent during technical mode. Virtually any parameter can be relevant.

2.4.8 Hot standby mode

ACRONYM:	HOT
EAOPMODE:	4

PARAMETER TO BE DEFINED

EAFILISU	filament impedance for startup
EAFILOSV	filament operating impedance set point
EAFILOTS	filament operating temperature set point
EAFILTSU	filament temperature for startup

2.4.9 Standby mode

ACRONYM:	STDB
EAOPMODE:	0

PARAMETER TO BE DEFINED

none

3. Control

3.1 Control Philosophy

3.1.1 Introduction

For an introduction the reader is referred to section 1.3.6., mode and parameter changes. It may be added that the seeming complexity of commanded and - above all - internal mode switching should not distract the attention from the underlying, rather simple approach to the control.

3.1.2 Parameters

Parameters may be changed at any time by single telecommands, the changes go into effect immediately, provided the present operating mode makes use of this parameter.

The selection of the active emitter and emitter module is an exception to this rule (see below). This selection is possible only before an active mode is entered (i.e. during standby mode).

There is no keep-alive memory. After turn-on all parameters, which are relevant for a given mode and which deviate from the default settings in PROM, must be set by telecommand. A typical number is 5 parameters.

3.1.3 Modes

Mode changes and switching between different emitters (out of the 8 emitters available) are subjected to some restrictions dictated by the emitter hardware and high voltage safety considerations.

A typical procedure for a mode change would:

- at first make sure that all relevant parameters have been set,
- then select a particular emitter,
- then enable the emitter filaments and high voltage (if applicable),
- and finally send the mode command.

Internal mode switching may occur if anomalies with the ion emitters or the feedback loop with EFW or PEACE (if active) are detected on board. In many cases the instrument would switch into standby mode and wait for further telecommands.

3.1.4 Macrocommands

The instrument ASPOC/Cluster-II is not really suited for summarising groups of commands into macrocommands. The only command groups which are sent rather often is related to the selection of 1 out of 8 emitters, followed by some mode change command. One could therefore define 8 macros (one per emitter) containing 3 commands each which are necessary to select a new emitter (see Appendix A.2.).

3.1.5 Redundancy concept

Redundancy switching in ASPOC is triggered by the sampling line of the OBDH for both the telecommands and the data acquisition in parallel.

If the MAIN TM sampling line is active, ASPOC sends data to the MAIN TM and listens to telecommands on the MAIN channel.

If the REDUNDANT TM sampling line is active, ASPOC sends data to the REDUNDANT TM and listens to telecommands on the REDUNDANT channel.

3.1.6 Timing of telecommands

In order to allow verification of all commands in the "last command" parameter (EALASTCM) in HK telemetry, only one command per reset pulse is actually executed from the internal command stack sized 255 commands. This has a consequence on the verification of the commands in the telemetry, which will experience delays when several commands are sent in one burst (see also section 3.2.1, memory load commands). As the maximum number of individual telecommands within a command sequence is about 7, a verification window of 1 minute would be sufficient.

3.2 External Telecommands

Number of allocated channels:
1 housekeeping (main and redundant)

Experiment RTU commanding address(es): not applicable (no address lines to the experiment)

Direct commands: NONE

On/off commands: NONE

3.2.1 Memory load commands

Memory load commands received by the experiment are stored in a stack of size 255. In order to allow verification of all commands in the "last command" parameter (EALASTCM) in HK telemetry, only one command per reset pulse is actually executed from the stack. The execution of an individual command starts at the reset pulse and is in general completed within one second or less.

The following tables are to be read as follows: The column "EXEC. IN MODES" lists experiment modes in which the respective command is executed:

STDB	command valid in standby mode		
ACT	command valid in any of the active modes:		
		ITOT	constant total high voltage current
		IION	constant ion beam current
		FEFW	feedback from S/C pot. measured by EFW
		PEA	feedback from S/C pot. measured by PEACE
		HOT	hot standby
		T&C	test and commissioning
TECH	command valid in technical mode		

The commands are ignored in other modes.

The column "CAL" (for parameter commands) indicates the row number in the calibration table (2.2.9.) which belongs to the parameter set by the command.

The allowed range for parameter commands is the same as for the telemetry. The relation between TC and TM is given in section 3.3.5.

There are no operational constraints on telecommands with the following exceptions:

- Technical mode (ZEATECHS) shall be commanded only during interactive operations (commissioning) and in close cooperation with the experimenter.
- Some parameter ranges of "parameter commands" (3.2.1.5.) and some combinations of parameters have "soft" constraints (for example, the upper limit of the filament operating temperature is a trade-off between power consumption, lifetime, and stability of the beam current).

Checksums are not used.

A detailed description of the commands is given in section 3.7.

3.2.1.1 General Commands

LABEL	CODE	FUNCTION	EXEC. IN MODES		
ZEAEXPMS	0x1x00	set experiment mode	STDB	ACT	TECH
ZEASTDBS	0x1000	standby mode	STDB	ACT	TECH
ZEAITOTS	0x1100	const total I mode (stdalone 1)	STDB	ACT	TECH
ZEAIIONS	0x1200	const beam I mode (stdalone 2)	STDB	ACT	TECH
ZEAFEFWS	0x1300	feedback mode from EFW	STDB	ACT	TECH
ZEAHOT_S	0x1400	hot standby mode		ACT	TECH
ZEAT&C_S	0x1500	test and commissioning mode	STDB	ACT	TECH
ZEATECHS	0x1600	technical mode	STDB	ACT	TECH
ZEAFPEAS	0x1700	feedback mode from PEACE	STDB	ACT	TECH
ZEABAKMS	0x2x00	backup mode select	STDB	ACT	TECH
ZEABAK1S	0x2000	backup mode 1 select (standby)	STDB	ACT	TECH
ZEABAK2S	0x2100	backup mode 2 select (total cur.)	STDB	ACT	TECH
ZEABAK3S	0x2200	backup mode 3 select (beam cur.)	STDB	ACT	TECH
ZEABAK5S	0x2300	backup mode 5 select (feedback EFW)	STDB	ACT	TECH
ZEABAK4S	0x2400	backup mode 4 select (hot stdby)	STDB	ACT	TECH
ZEABAK6S	0x2700	backup mode 6 select (feedback PEACE)	STDB	ACT	TECH
ZEAFILMS	0x3x00	filament select	STDB		
ZEAFIL1S	0x3000	filament 1 select	STDB		
ZEAFIL2S	0x3100	filament 2 select	STDB		
ZEAFIL3S	0x3200	filament 3 select	STDB		
ZEAFIL4S	0x3300	filament 4 select	STDB		
ZEAMODUS	0x4x00	module select	STDB		
ZEAMODAS	0x4000	filaments module 1 select	STDB		
ZEAMODBS	0x4100	filaments module 2 select	STDB		
ZEASTELS	0x4x00	step length select	STDB	ACT	TECH
ZEASTESS	0x4x00	step size select	STDB	ACT	TECH
ZEASTSSS	0x4800	small step size select	STDB	ACT	TECH
ZEASTSLS	0x4900	large step size select	STDB	ACT	TECH
ZEASTLSS	0x4A00	small step length select	STDB	ACT	TECH
ZEASTLLS	0x4B00	large step length select	STDB	ACT	TECH
ZEAEFWPS	0x5000	EFW default polarity	STDB	ACT	TECH
ZEAEFWNS	0x5100	EFW inverse polarity	STDB	ACT	TECH

3.2.1.2 Direct switch commands

LABEL	CODE	FUNCTION	EXEC. IN MODES		
ZEAFR1OS	0xC101	filament 1 on			TECH
ZEAFR1XS	0xC102	filament 1 off			TECH
ZEAFR2OS	0xC103	filament 2 on			TECH
ZEAFR2XS	0xC104	filament 2 off			TECH
ZEAFR3OS	0xC105	filament 3 on			TECH
ZEAFR3XS	0xC106	filament 3 off			TECH
ZEAFR4OS	0xC107	filament 4 on			TECH
ZEAFR4XS	0xC108	filament 4 off			TECH
ZEAM1ONS	0xC10B	filaments module 1 on			TECH
ZEAM2ONS	0xC10C	filaments module 2 on			TECH
ZEAH1ONS	0xC10D	HV 1 select			TECH
ZEAH2ONS	0xC10E	HV 2 select			TECH

3.2.1.3 High voltage control

LABEL	CODE	FUNCTION	EXEC. IN MODES		
ZEAHLINE	0x7000	HV off			TECH
ZEAHLIND	0x7100	HV on / CRITICAL*)			TECH
ZEAHV__D	0x8000	disable HV	STDB		TECH
ZEAHV__E	0x8100	enable HV / CRITICAL*)	STDB		TECH
ZEAHVUMS	0x9000	set voltage control			TECH
ZEAHVIMS	0xA000	set current control			TECH

3.2.1.4 Filament control

LABEL	CODE	FUNCTION	EXEC. IN MODES		
ZEAFIL_D	0x6000	disable filaments	STDB	ACT	TECH
ZEAFIL_E	0x6100	enable filaments	STDB	ACT	TECH
ZEAFILID	0xB000	filament converter off			TECH
ZEAFILIE	0xB100	filament converter on			TECH

3.2.1.5 Parameter commands

The values "xx" are identical to the raw value of the parameter set by the parameter command. The same coding and range applies to parameters and parameter commands. THe relation between TC and TM is given in Section 3.3.5.

LABEL	CODE	FUNCTION	CAL	EXEC. IN MODES		
ZEAFIDAS	0xC2xx	filam. value set/tech mode	9			TECH
ZEAHVDAS	0xC3xx	HV set value/tech mode	8			TECH
ZEAFISUS	0xC4xx	filam. impedance: startup	17	STDB	ACT	TECH
ZEAFISUS	0xC4xx	filam. temperature: startup	20	STDB	ACT	TECH
ZEAFISVS	0xC5xx	filam. impedance: set value	17	STDB	ACT	TECH
ZEAFISVS	0xC5xx	filam. temp.: set value	20	STDB	ACT	TECH
ZEAPOFFS	0xC6xx	offset for PEACE data	15	STDB	ACT	TECH
ZEAITSVS	0xC7xx	total current set value	11	STDB	ACT	TECH
ZEAITSUS	0xC8xx	total current upper limit	11	STDB	ACT	TECH
ZEAITSLS	0xC9xx	total current lower limit	11	STDB	ACT	TECH
ZEASPSVS	0xCAxx	S/C potential set value	16	STDB	ACT	TECH
ZEAWHISS	0xCBxx	WHISPER code table, cleaning flags	-	STDB	ACT	TECH
ZEACLTXS	0xCCxx	ctrl loop coeff. Tx	21	STDB	ACT	TECH
ZEACLKCS	0xCDxx	control loop coeff. Kc	22	STDB	ACT	TECH
ZEAIISVS	0xCExx	beam current set value	12	STDB	ACT	TECH
ZEAHVTHR	0xCFxx	set high voltage threshold	10	STDB	ACT	TECH
ZEACLTVS	0xD0xx	control loop coeff. Tv	12	STDB	ACT	TECH
ZEACLKVS	0xD1xx	control loop coeff. Kv	24	STDB	ACT	TECH

*) Commands marked "CRITICAL" are critical during ground tests only, because they are related to high voltage turn-on.

3.2.1.6 Alphabetic list of all commands

LABEL	CODE	FUNCTION	EXEC. IN MODES		
ZEABAKMS	0x2x00	backup mode select	STDB	ACT	TECH
ZEABAK1S	0x2000	backup mode 1 select (standby)	STDB	ACT	TECH
ZEABAK2S	0x2100	backup mode 2 select (total cur.)	STDB	ACT	TECH
ZEABAK3S	0x2200	backup mode 3 select (beam cur.)	STDB	ACT	TECH
ZEABAK4S	0x2400	backup mode 4 select (hot stdby)	STDB	ACT	TECH
ZEABAK5S	0x2300	backup mode 5 select (feedback EFW)	STDB	ACT	TECH
ZEABAK6S	0x2700	backup mode 6 select (feedback PEACE)	STDB	ACT	TECH
ZEACLKCS	0xCDxx	control loop coeff. Kc	STDB	ACT	TECH
ZEACLKVS	0xD1xx	control loop coeff. Kv	STDB	ACT	TECH
ZEACLTVS	0xD0xx	control loop coeff. Tv	STDB	ACT	TECH
ZEACLTXS	0xCCxx	ctrl loop coeff. Tx	STDB	ACT	TECH
ZEAEFWNS	0x5100	EFW inverse polarity	STDB	ACT	TECH
ZEAEFWPS	0x5000	EFW default polarity	STDB	ACT	TECH
ZEAEXPMS	0x1x00	set experiment mode	STDB	ACT	TECH
ZEAFEFWS	0x1300	feedback mode from EFW	STDB	ACT	TECH
ZEAFIDAS	0xC2xx	filam. value set/tech mode			TECH
ZEAFIL_D	0x6000	disable filaments	STDB	ACT	TECH
ZEAFIL_E	0x6100	enable filaments	STDB	ACT	TECH
ZEAFIL1S	0x3000	filament 1 select	STDB		
ZEAFIL2S	0x3100	filament 2 select	STDB		
ZEAFIL3S	0x3200	filament 3 select	STDB		
ZEAFIL4S	0x3300	filament 4 select	STDB		
ZEAFILID	0xB000	filament converter off			TECH
ZEAFILIE	0xB100	filament converter on			TECH
ZEAFILMS	0x3x00	filament select	STDB		
ZEAFISUS	0xC4xx	filam. temperature: startup	STDB	ACT	TECH
ZEAFISVS	0xC5xx	filam. temp.: set value	STDB	ACT	TECH
ZEAFPEAS	0x1700	feedback mode from PEACE	STDB	ACT	TECH
ZEAFR1OS	0xC101	filament 1 on			TECH
ZEAFR1XS	0xC102	filament 1 off			TECH
ZEAFR2OS	0xC103	filament 2 on			TECH
ZEAFR2XS	0xC104	filament 2 off			TECH
ZEAFR3OS	0xC105	filament 3 on			TECH
ZEAFR3XS	0xC106	filament 3 off			TECH
ZEAFR4OS	0xC107	filament 4 on			TECH
ZEAFR4XS	0xC108	filament 4 off			TECH
ZEAH1ONS	0xC10D	HV 1 select			TECH
ZEAH2ONS	0xC10E	HV 2 select			TECH
ZEAHLINE	0x7000	HV off			TECH
ZEAHLIND	0x7100	HV on / CRITICAL*)			TECH
ZEAHOT_S	0x1400	hot standby mode		ACT	TECH
ZEAHV__D	0x8000	disable HV	STDB		TECH
ZEAHV__E	0x8100	enable HV / CRITICAL*)	STDB		TECH
ZEAHVDAS	0xC3xx	HV set value/tech mode			TECH
ZEAHVIMS	0xA000	set current control			TECH
ZEAHVTHR	0xCFxx	set high voltage threshold	STDB	ACT	TECH

ZEAHVUMS	0x9000	set voltage control			TECH	

LABEL	CODE	FUNCTION	EXEC. IN MODES			
ZEAIIONS	0x1200	const beam I mode (stdalone 2)	STDB	ACT	TECH	
ZEAIISVS	0xCExx	beam current set value	STDB	ACT	TECH	
ZEAITOTS	0x1100	const total I mode (stdalone 1)	STDB	ACT	TECH	
ZEAITSLS	0xC9xx	total current lower limit	STDB	ACT	TECH	
ZEAITSUS	0xC8xx	total current upper limit	STDB	ACT	TECH	
ZEAITSVS	0xC7xx	total current set value	STDB	ACT	TECH	
ZEAM1ONS	0xC10B	filaments module 1 on			TECH	
ZEAM2ONS	0xC10C	filaments module 2 on			TECH	
ZEAMODAS	0x4000	filaments module 1 select	STDB			
ZEAMODBS	0x4100	filaments module 2 select	STDB			
ZEAMODUS	0x4x00	module select	STDB			
ZEAPOFFS	0xC6xx	offset for PEACE data	STDB	ACT	TECH	
ZEASPSVS	0xCAxx	S/C potential set value	STDB	ACT	TECH	
ZEASTDBS	0x1000	standby mode	STDB	ACT	TECH	
ZEASTELS	0x4x00	step length select		STDB	ACT	TECH
ZEASTESS	0x4x00	step size select		STDB	ACT	TECH
ZEASTLLS	0x4B00	large step length select	STDB	ACT	TECH	
ZEASTLSS	0x4A00	small step length select	STDB	ACT	TECH	
ZEASTSLS	0x4900	large step size select	STDB	ACT	TECH	
ZEASTSSS	0x4800	small step size select	STDB	ACT	TECH	
ZEAT&C_S	0x1500	test and commissioning mode	STDB	ACT	TECH	
ZEATECHS	0x1600	technical mode	STDB	ACT	TECH	
ZEAWHISS	0xCBxx	WHISPER code table, cleaning flags	STDB	ACT	TECH	

*) Commands marked "CRITICAL" are critical during ground tests only, because they are related to high voltage turn-on.

3.3 Reflection of TCs on TM

3.3.1 General Commands

Command	Code	Changes Parameter	into
ZEAEXPMS	0x1x00	EAOPMODE	x
ZEASTDBS	0x1000	EAOPMODE	0
ZEAITOTS	0x1100	EAOPMODE	1
ZEAIIONS	0x1200	EAOPMODE	2
ZEAFEFWS	0x1300	EAOPMODE	3
ZEAHOT_S	0x1400	EAOPMODE	4
ZEAT&C_S	0x1500	EAOPMODE	5
ZEATECHS	0x1600	EAOPMODE	6
ZEAFPEAS	0x1700	EAOPMODE	7
ZEABAKMS	0x2x00	EABKMODE	x
ZEABAK1S	0x2000	EABKMODE	0
ZEABAK2S	0x2100	EABKMODE	1
ZEABAK3S	0x2200	EABKMODE	2
ZEABAK5S	0x2300	EABKMODE	3
ZEABAK4S	0x2400	EABKMODE	4
ZEABAK6S	0x2700	EABKMODE	7
ZEAFILMS	0x3x00	EAFILSEL	x
		EAFILSLD	1
ZEAFIL1S	0x3000	EAFILSEL	0
		EAFILSLD	1
ZEAFIL2S	0x3100	EAFILSEL	1
		EAFILSLD	1
ZEAFIL3S	0x3200	EAFILSEL	2
		EAFILSLD	1
ZEAFIL4S	0x3300	EAFILSEL	3
		EAFILSLD	1
ZEAMODUS	0x4x00	EAMODULE	x (see TC definition for exact mask)
ZEAMODAS	0x4000	EAMODULE	0
ZEAMODBS	0x4100	EAMODULE	1
ZEASTELS	0x4x00	EASTEPL_	x (see TC definition for exact mask)
ZEASTESS	0x4x00	EASTEPS_	x (see TC definition for exact mask)
ZEASTSSS	0x4800	EASTEPS_	0
ZEASTSLS	0x4900	EASTEPS_	1
ZEASTLSS	0x4A00	EASTEPL_	0
ZEASTLLS	0x4B00	EASTEPL_	1
ZEAEFWPS	0x5000	EAEFWINV	0
ZEAEFWNS	0x5100	EAEFWINV	1

3.3.2 Direct switch commands (for technical mode only)

Command	Code	Changes Parameter	into
ZEAFR1OS	0xC101	-	
ZEAFR1XS	0xC102	-	
ZEAFR2OS	0xC103	-	
ZEAFR2XS	0xC104	-	
ZEAFR3OS	0xC105	-	
ZEAFR3XS	0xC106	-	
ZEAFR4OS	0xC107	-	
ZEAFR4XS	0xC108	-	
ZEAM1ONS	0xC10B	-	
ZEAM2ONS	0xC10C	-	
ZEAH1ONS	0xC10D	-	
ZEAH2ONS	0xC10E	-	

3.3.3 High voltage control

Command	Code	Changes Parameter	into
ZEAHLINE	0x7000	EAHVSHST	1
ZEAHLIND	0x7100	EAHVSHST	0
ZEAHV__D	0x8000	EAHVSWEN	0
ZEAHV__E	0x8100	EAHVSWEN	1
ZEAHVUMS	0x9000	EAHVCNMD	1
ZEAHVIMS	0xA000	EAHVCNMD	0

3.3.4 Filament control

Command	Code	Changes Parameter	into
ZEAFIL_D	0x6000	EAFILENB	0
ZEAFIL_E	0x6100	EAFILENB	1
ZEAFILID	0xB000	-	
ZEAFILIE	0xB100	-	

3.3.5 Parameter commands

Command	Code	Changes Parameter	into
ZEAFIDAS	0xC2xx	EAFILOUT	"xx" (hex)
ZEAHVDAS	0xC3xx	EAHV_OUT	"xx" (hex)
ZEAFISUS	0xC4xx	EAFILISU	"xx" (hex)
ZEAFISUS	0xC4xx	EAFILTSU	"xx" (hex)
ZEAFISVS	0xC5xx	EAFILOSV	"xx" (hex)
ZEAFISVS	0xC5xx	EAFILOTS	"xx" (hex)
ZEAPOFFS	0xC6xx	EAPEAOFF	"xx" (hex)
ZEAITSVS	0xC7xx	EATOTCSV	"xx" (hex)
ZEAITSUS	0xC8xx	EATOTCUL	"xx" (hex)
ZEAITSLS	0xC9xx	EATOTCLL	"xx" (hex)
ZEASPSVS	0xCAxx	EAPOT_SV	"xx" (hex)
ZEAWHISS	0xCBxx	EAWISTAB	"xx" (hex)
ZEACLTXS	0xCCxx	EACOEFTX	"xx" (hex)
ZEACLKCS	0xCDxx	EACOEFKC	"xx" (hex)
ZEAIISVS	0xCExx	EAIONCSV	"xx" (hex)
ZEAHVTHR	0xCFxx	EAHVTHRE	"xx" (hex)
ZEACLTVS	0xD0xx	EACOEFTV	"xx" (hex)
ZEACLKVS	0xD1xx	EACOEFKV	"xx" (hex)

3.4 On-board Calibration Tables Modification

On-board calibration tables cannot be modified.

3.5 On-board Software Modification

On-board software cannot be modified.

3.6 Internal Control and Commands

Refer to section 1.3.6.2 and 1.3.6.3 for internal mode changes. They occur with
- start-up of emitters,
- failure of emitters,
- failure of IEL link, including the case of forced ion beam turn-off in some environmental conditions.

The internal mode in the right column causes all TM signatures listed in the left column.

TM Signature	Internal Mode
EASU_ACT = 1	ongoing start-up of the selected emitter The bit is set when a module or a filament has been selected. The bit is reset to 0 when the start-up is ended by ignition of the emitter and the commanded operation mode is executed fully.
EATIMOUT & 0x01 = 0x01 EAOPMODE = 0	standby mode, caused by emitter failure during start-up (condition "IGN")
EATIMOUT & 0x02 = 0x02 EAOPMODE = 0	standby mode, caused by low emitter current (condition "I=0")
EATIMOUT & 0x04 = 0x04 EABK_ACT = 1	backup mode, caused by absence of EFW data (condition "ENV")
EATIMOUT & 0x04 = 0x04 EAWISSDW = 1	feedback wait status, caused by EFW data disabled by WHISPER (condition "ENV")
EATIMOUT & 0x08 = 0x08 EABK_ACT = 1	backup mode, caused by absence of PEACE data (condition "PNV")
EATIMOUT & 0x08 = 0x08 EAWISSDW = 1	feedback wait status, caused by PEACE data disabled by WHISPER (condition "PNV")
EATIMOUT & 0x10 = 0x10	feedback wait status, caused by calculated ion current out of range (condition "INV")
EAEFWPT1 & 0x800=0x800	feedback wait status, caused by negative S/C potential (condition "V<0")
EATIMOT2 & 0x01 = 0x01 EAOPMODE = 0	indicates that the instrument is in feedback wait status (condition "FWX")

3.7 Constraints and Applicability of Telecommands

Similar to the situation with operational procedures also single telecommands have certain properties (purpose, applicability, constraints, etc.) which are listed in this section.

TELECOMMAND:	**ZEABAKMS**
CODE:	0x2000 (predefined value) 0xF8FF (predefined mask) 0x0700 (parameter mask)
TITLE:	backup mode select
PURPOSE:	to select any of the 6 possible modes as backup mode; may be used to replace the individual commands to select backup modes ZEABAK1S through ZEABAK6S
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	Only 6 different values of the parameter are allowed: 0 hex backup mode 1 select (standby) 1 hex backup mode 2 select (const. total current) 2 hex backup mode 3 select (const. beam current) 3 hex backup mode 5 select (feedback from EFW) 4 hex backup mode 4 select (hot standby) 7 hex backup mode 6 select (feedback from PEACE) Parameter = 3 hex (full code = 0x2300): The inter-experiment link to EFW/DWP should be fully operational from the start of the feedback mode (to be commanded separately). Violation of this constraint causes the experiment to enter standby mode when it should enter feedback mode from EFW. Parameter = 7 hex (full code = 0x2700): The inter-experiment link to PEACE should be fully operational from the start of the feedback mode (to be commanded separately). Violation of this constraint causes the experiment to enter standby mode when it should enter feedback mode from PEACE.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = parameter (raw value)
RELATED CMDS:	ZEABAK1S, ZEABAK2S, ZEABAK3S, ZEABAK4S, ZEABAK5S, ZEABAK6S

TELECOMMAND:	**ZEABAK1S**
CODE:	0x2000
TITLE:	backup mode 1 select (standby)
PURPOSE:	to select standby mode as backup mode
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = 0
RELATED CMDS:	ZEABAKMS, ZEABAK2S, ZEABAK3S, ZEABAK4S, ZEABAK5S, ZEABAK6S

TELECOMMAND:	**ZEABAK2S**
CODE:	0x2100
TITLE:	backup mode 2 select (constant total current)
PURPOSE:	to select constant total current mode as backup mode
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = 1
RELATED CMDS:	ZEABAKMS, ZEABAK1S, ZEABAK3S, ZEABAK4S, ZEABAK5S, ZEABAK6S

TELECOMMAND: ZEABAK3S

CODE:	0x2200
TITLE:	backup mode 3 select (constant beam current)
PURPOSE:	to select constant beam current mode as backup mode
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = 2
RELATED CMDS:	ZEABAKMS, ZEABAK1S, ZEABAK2S, ZEABAK4S, ZEABAK5S, ZEABAK6S

TELECOMMAND: ZEABAK4S

CODE:	0x2400
TITLE:	backup mode 4 select (hot standby)
PURPOSE:	to select hot standby mode as backup mode
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = 4
RELATED CMDS:	ZEABAKMS, ZEABAK1S, ZEABAK2S, ZEABAK3S, ZEABAK5S, ZEABAK6S

TELECOMMAND:	**ZEABAK5S**
CODE:	0x2300
TITLE:	backup mode 5 select (feedback from EFW)
PURPOSE:	to select feedback mode from EFW as backup mode
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	The inter-experiment link to EFW/DWP should be fully operational from the start of the feedback mode (to be commanded separately). Violation of this constraint causes the experiment to enter standby mode when it should enter feedback mode from EFW.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = 3
RELATED CMDS:	ZEABAKMS, ZEABAK1S, ZEABAK2S, ZEABAK3S, ZEABAK4S, ZEABAK6S

TELECOMMAND: ZEABAK6S

CODE:	0x2700
TITLE:	backup mode 6 select (feedback from PEACE)
PURPOSE:	to select feedback mode from PEACE as backup mode
APPLICABILITY:	for future use during feedback modes using the IEL links; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	The inter-experiment link to PEACE should be fully operational from the start of the feedback mode (to be commanded separately). Violation of this constraint causes the experiment to enter standby mode when it should enter feedback mode from PEACE.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EABKMODE = 7
RELATED CMDS:	ZEABAKMS, ZEABAK1S, ZEABAK2S, ZEABAK3S, ZEABAK4S, ZEABAK5S

TELECOMMAND: ZEACLKCS

CODE:	0xCDxx
TITLE:	set control loop coefficient Kc
PURPOSE:	to set control loop coefficient Kc, which determines the proportional term of the beam current control loop
APPLICABILITY:	for future use during feedback modes or constant beam current mode; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in a control loop instability of the beam current.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EACOEFKC = xx (raw)
RELATED CMDS:	ZEACLTXS

TELECOMMAND:	**ZEACLKVS**
CODE:	0xD1xx
TITLE:	set control loop coefficient Kv
PURPOSE:	to set control loop coefficient Kv, which determines the proportional term of the spacecraft potential control loop
APPLICABILITY:	for future use during feedback modes; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in a control loop instability of the spacecraft potential.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EACOEFKV = xx (raw)
RELATED CMDS:	ZEACLTVS

TELECOMMAND:	**ZEACLTVS**
CODE:	0xD0xx
TITLE:	set control loop coefficient Tv
PURPOSE:	to set control loop coefficient Tv, which determines the integrating term of the spacecraft potential control loop
APPLICABILITY:	for future use during feedback modes; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in a control loop instability of the spacecraft potential.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EACOEFTV = xx (raw)
RELATED CMDS:	ZEACLKVS

TELECOMMAND:	**ZEACLTXS**
CODE:	0xCCxx
TITLE:	set control loop coefficient Tx
PURPOSE:	to set control loop coefficient Tx, which determines the integrating term of the beam current control loop
APPLICABILITY:	for future use during feedback modes or constant beam current mode; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in a control loop instability of the beam current.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EACOEFTX = xx (raw)
RELATED CMDS:	ZEACLKCS

TELECOMMAND:	**ZEAEFWNS**
CODE:	0x5100
TITLE:	set EFW inverse polarity
PURPOSE:	to invert the polarity of incoming spacecraft potential data from EFW
APPLICABILITY:	to correct a wrong sign of incoming data from EFW; for future use during EFW feedback mode; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	To be issued only if incoming EFW data have inverted polarity. Violation of this constraint may result in a control loop instability of the spacecraft potential.
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAEFWINV = 1
RELATED CMDS:	ZEAEFWPS

TELECOMMAND:	**ZEAEFWPS**
CODE:	0x5000
TITLE:	set EFW default polarity
PURPOSE:	to set the default polarity of incoming spacecraft potential data from EFW
APPLICABILITY:	to return to unmodified processing of incoming data from EFW; for future use during EFW feedback mode; has no effect in other modes
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints, provided normal operation of the IEL to EFW
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAEFWINV = 0
RELATED CMDS:	ZEAEFWPS

TELECOMMAND:	**ZEAEXPMS**
CODE:	0x1000 (predefined value) 0xF8FF (predefined mask) 0x0700 (parameter mask)
TITLE:	set experiment mode
PURPOSE:	to set any of the experiment modes FEFW, HOT_, IION, ITOT, FPEA, STDB, T&C_, TECH
APPLICABILITY:	this is the operating mode selection for the experiment in the form of a single command where the experiment mode is passed as a parameter; it is equivalent to the commands for individual instrument modes ZEAFEFWS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS.
RESPONS.:	experimenter
CONSTRAINTS:	The following values of the parameter are valid: 0 (hex) STDB (standby) 1 (hex) ITOT (constant total current) 2 (hex) IION (constant beam current) 3 (hex) FEFW (feedback from EFW) 4 (hex) HOT_ (hot standby) 5 (hex) T&C_ (test and commissioning) 6 (hex) TECH (technical) 7 (hex) FPEA (feedback from PEACE) Further constraints are listed under the respective mode commands ZEAFEFWS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS.
RESOURCES:	see equivalent mode commands
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	see equivalent mode commands
FINAL STATUS:	see equivalent mode commands
VERIFICATION:	EAOPMODE = parameter (raw value)
RELATED CMDS:	ZEAFEFWS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS

TELECOMMAND:	**ZEAFEFWS**
CODE:	0x1300
TITLE:	set feedback mode from EFW
PURPOSE:	to set feedback mode from EFW (acronym "FEFW")
APPLICABILITY:	one of the main operating modes of the experiment; this is an active mode with ion emission
RESPONS.:	experimenter
CONSTRAINTS:	- see section 2.4, "important parameters", for a list of parameters affecting the performance of the instrument in this mode; - enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command - enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command - a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode - other relevant parameters may be changed also after this command - spacecraft potential data from EFW should be available (otherwise the experiment switches into backup mode) - cover of selected module must be open - initial mode shall not be technical mode
RESOURCES:	required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on: - plasma environment (which via the control loop determines the emitted ion current) - upper limit of total current (EATOTCUL) which limits the ion current available to on-board control - initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	initial mode shall not be technical mode
FINAL STATUS:	feedback mode from EFW
VERIFICATION:	EAOPMODE = 3
RELATED CMDS:	ZEAEXPMS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS

TELECOMMAND: ZEAFIDAS

CODE:	0xC2xx
TITLE:	set filament power in technical mode
PURPOSE:	to set filament power in technical mode
APPLICABILITY:	to be used in technical mode for explicit settings of the filament power; normally filament power is controlled by on-board software
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator - only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in an instability of the filament power supply.
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAFILOUT = xx (raw)
RELATED CMDS:	none

TELECOMMAND:	**ZEAFIL_D**
CODE:	0x6000
TITLE:	disable filaments
PURPOSE:	to disable the filament power converter
APPLICABILITY:	to undo a previous enable filament command while the experiment is still in standby mode; the power-on status is disabled. Entering standby mode does NOT disable the filaments
RESPONS.:	experimenter
CONSTRAINTS:	- command is rejected if the experiment is already in an active mode and the filaments are powered; to turn off filaments use the standby mode command, followed by a filament disable command
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	standby mode
VERIFICATION:	EAFILENB = 0
RELATED CMDS:	ZEAFIL_E

TELECOMMAND:	**ZEAFIL_E**
CODE:	0x6100
TITLE:	enable filaments
PURPOSE:	to enable the filament power converter
APPLICABILITY:	to enable the filament power converter in preparation of a future mode change into an active mode; this command is required before any active mode command
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby mode
FINAL STATUS:	no change to initial status
VERIFICATION:	EAFILENB = 1
RELATED CMDS:	ZEAFIL_D

TELECOMMAND:	**ZEAFIL1S**
CODE:	0x3000
TITLE:	select filament 1
PURPOSE:	to select filament number 1 of any emitter module
APPLICABILITY:	to select filament number 1 of any emitter module for future activation in an active mode; one of the filaments must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment must be in standby mode; this TC must not be used on: S/C FM6 (ASPOC FM-007)
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAFILSEL = 0, EAFILSLD = 1
RELATED CMDS:	ZEAFILMS, ZEAFIL2S, ZEAFIL3S, ZEAFIL4S

TELECOMMAND:	**ZEAFIL2S**
CODE:	0x3100
TITLE:	select filament 2
PURPOSE:	to select filament number 2 of any emitter module
APPLICABILITY:	to select filament number 2 of any emitter module for future activation in an active mode; one of the filaments must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment must be in standby mode; this TC must not be used on: S/C FM5 (ASPOC FM-010) if EAMODULE=1 (hex)
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAFILSEL = 1, EAFILSLD = 1
RELATED CMDS:	ZEAFILMS, ZEAFIL1S, ZEAFIL3S, ZEAFIL4S

TELECOMMAND: ZEAFIL3S

CODE:	0x3200
TITLE:	select filament 3
PURPOSE:	to select filament number 3 of any emitter module
APPLICABILITY:	to select filament number 3 of any emitter module for future activation in an active mode; one of the filaments must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment must be in standby mode; this TC must not be used on: S/C FM7 (ASPOC FM-008) if EAMODULE=0 (hex)
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAFILSEL = 2, EAFILSLD = 1
RELATED CMDS:	ZEAFILMS, ZEAFIL1S, ZEAFIL2S, ZEAFIL4S

TELECOMMAND: ZEAFIL4S

CODE:	0x3300
TITLE:	select filament 4
PURPOSE:	to select filament number 4 of any emitter module
APPLICABILITY:	to select filament number 4 of any emitter module for future activation in an active mode; one of the filaments must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment must be in standby mode;
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAFILSEL = 3, EAFILSLD = 1
RELATED CMDS:	ZEAFILMS, ZEAFIL1S, ZEAFIL2S, ZEAFIL3S

TELECOMMAND:	**ZEAFILID**
CODE:	0xB000
TITLE:	turn filament converter off
PURPOSE:	to turn off the filament power converter in technical mode
APPLICABILITY:	to be used in technical mode to turn off filament power; normally filament power is controlled by on-board software
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAFILIMN = 0, EAFILVMN = 0
RELATED CMDS:	ZEAFILIE

TELECOMMAND:	**ZEAFILIE**
CODE:	0xB100
TITLE:	turn filament converter on
PURPOSE:	to turn on the filament power converter in technical mode
APPLICABILITY:	to be used in technical mode to turn on filament power; normally filament power is controlled by on-board software
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAFILIMN > 0, EAFILVMN > 0
RELATED CMDS:	ZEAFILID

TELECOMMAND:	**ZEAFILMS**
CODE:	0x3000 (predefined value) 0xFCFF (predefined mask) 0x0300 (parameter mask)
TITLE:	select filament
PURPOSE:	to select a filament of an emitter module
APPLICABILITY:	to select a filament of any emitter module for future activation in an active mode; one of the filaments must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment must be in standby mode Only 4 different values of the parameter are possible in general: 0 (hex) select filament 1 1 (hex) select filament 2 2 (hex) select filament 3 3 (hex) select filament 4 This TC must not be used on: S/C FM6 (ASPOC FM-007) with parameter=0 if EAMODULE=0 S/C FM6 (ASPOC FM-007) with parameter=0 if EAMODULE=1 S/C FM7 (ASPOC FM-008) with parameter=2 if EAMODULE=0 S/C FM8 (ASPOC FM-009): no constraints S/C FM5 (ASPOC FM-010) with parameter=0 if EAMODULE=0 S/C FM5 (ASPOC FM-010) with parameter=0 if EAMODULE=1
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAFILSEL = parameter (raw value), EAFILSLD = 1
RELATED CMDS:	ZEAFIL1S, ZEAFIL2S, ZEAFIL3S, ZEAFIL4S

TELECOMMAND:	**ZEAFISUS**
CODE:	0xC4xx
TITLE:	set filament temperature for start-up
PURPOSE:	to set lower limit of filament temperature which must be reached at the end of the automatic start-up procedure
APPLICABILITY:	for future use during the start-up procedure embedded into active modes; if commanded during start-up, the change goes into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in reduced lifetime or failure to start ion emission.
RESOURCES:	affects filament power during start-up procedures, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAFILTSU = xx (raw), EAFILTSU = xx (raw)
RELATED CMDS:	ZEAFISVS

TELECOMMAND:	**ZEAFISVS**
CODE:	0xC5xx
TITLE:	set filament temperature
PURPOSE:	to set filament temperature for normal operation
APPLICABILITY:	normally for future use during an active mode; if commanded during an active mode, the change goes into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in reduced lifetime or failure of ion emission.
RESOURCES:	affects filament power during normal operation, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAFILOSV = xx (raw), EAFILOTS = xx (raw)
RELATED CMDS:	ZEAFISUS

TELECOMMAND: ZEAFPEAS

CODE:	0x1700
TITLE:	set feedback mode from PEACE
PURPOSE:	to set feedback mode from PEACE (acronym "FPEA")
APPLICABILITY:	one of the operating modes of the experiment; this is an active mode with ion emission
RESPONS.:	experimenter
CONSTRAINTS:	- see section 2.4, "important parameters", for a list of parameters affecting the performance of the instrument in this mode; - enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command - enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command - a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode - other relevant parameters may be changed also after this command - spacecraft potential data from PEACE should be available (otherwise the experiment switches into backup mode) - cover of selected module must be open - initial mode shall not be technical mode
RESOURCES:	required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on: - plasma environment (which via the control loop determines the emitted ion current) - upper limit of total current (EATOTCUL) which limits the ion current available to on-board control - initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	initial mode shall not be technical mode
FINAL STATUS:	feedback mode from PEACE
VERIFICATION:	EAOPMODE = 7
RELATED CMDS:	ZEAEXPMS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFEFWS, ZEASTDBS, ZEAT&C_S, ZEATECHS

TELECOMMAND: ZEAFR1OS

CODE:	0xC101
TITLE:	turn on filament 1
PURPOSE:	to turn on filament number 1 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 1 to "on" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator, in particular the associated turn-off command is required before any other "turn on filament" command can be sent
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR1XS

TELECOMMAND: ZEAFR1XS

CODE:	0xC102
TITLE:	turn off filament 1
PURPOSE:	to turn off filament number 1 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 1 to "off" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR1OS

TELECOMMAND: ZEAFR2OS

CODE:	0xC103
TITLE:	turn on filament 2
PURPOSE:	to turn on filament number 2 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 2 to "on" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator, in particular the associated turn-off command is required before any other "turn on filament" command can be sent
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR2XS

TELECOMMAND: ZEAFR2XS

CODE:	0xC104
TITLE:	turn off filament 2
PURPOSE:	to turn off filament number 2 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 2 to "off" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR2OS

TELECOMMAND: ZEAFR3OS

CODE:	0xC105
TITLE:	turn on filament 3
PURPOSE:	to turn on filament number 3 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 3 to "on" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator, in particular the associated turn-off command is required before any other "turn on filament" command can be sent
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR3XS

TELECOMMAND: ZEAFR3XS

CODE:	0xC106
TITLE:	turn off filament 3
PURPOSE:	to turn off filament number 3 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 3 to "off" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR3OS

TELECOMMAND:	**ZEAFR4OS**
CODE:	0xC107
TITLE:	turn on filament 4
PURPOSE:	to turn on filament number 4 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 4 to "on" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator, in particular the associated turn-off command is required before any other "turn on filament" command can be sent
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR4XS

TELECOMMAND:	**ZEAFR4XS**
CODE:	0xC108
TITLE:	turn off filament 4
PURPOSE:	to turn off filament number 4 in technical mode
APPLICABILITY:	may be used in technical mode to switch the relay for filament 4 to "off" status
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	affects filament power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAFR4OS

TELECOMMAND: ZEAH1ONS

CODE:	0xC10D
TITLE:	switch high voltage to module 1
PURPOSE:	to switch the high voltage converter to module 1 in technical mode
APPLICABILITY:	to be used in technical mode only; causes the high voltage converter to select emitter module 1
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAH2ONS

TELECOMMAND: ZEAH2ONS

CODE:	0xC10E
TITLE:	switch high voltage to module 2
PURPOSE:	to switch the high voltage converter to module 2 in technical mode
APPLICABILITY:	to be used in technical mode only; causes the high voltage converter to select emitter module 2
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAH1ONS

TELECOMMAND:	**ZEAHLINE**
CODE:	0x7000
TITLE:	switch off high voltage
PURPOSE:	to switch off the high voltage converter in technical mode
APPLICABILITY:	to be used in technical mode only
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	releases any high voltage power which may have been consumed before, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHVMON_ = 0
RELATED CMDS:	ZEAHLIND

TELECOMMAND:	**ZEAHLIND**
CODE:	0x7100
TITLE:	switch on high voltage
PURPOSE:	to switch on the high voltage converter in technical mode
APPLICABILITY:	to be used in technical mode only
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator - this is a critical command during ground tests
RESOURCES:	turns on high voltage power, which amounts to up to ca. 30% of total nominal power depending on actual current and voltage selections
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHVMON_ > 0
RELATED CMDS:	ZEAHLINE

TELECOMMAND:	**ZEAHOT_S**
CODE:	0x1400
TITLE:	set hot standby mode
PURPOSE:	to set hot standby mode (acronym "HOT")
APPLICABILITY:	this is a mode where one emitter filament is powered, but without high voltage and ion emission; for predictable medium-term intervals without ion emission (e.g. short eclipses)
RESPONS.:	experimenter
CONSTRAINTS:	- see section 2.4, "important parameters", for a list of parameters affecting the performance of the instrument in this mode; - initial mode must be an active mode with ion emission There is an anomalous behaviour of the instrument if this command is executed while high voltage is not enabled, see "final status". Because of the complexity involved it is recommended NOT TO USE THIS COMMAND in time-tagged mode without near real-time ground control.
RESOURCES:	required power is reduced from the initial status by the amount of high voltage power consumed previously. This may have been up to ca. 30% of total nominal power depending on current and voltage selections. Remaining power consumption is less than ca. 70% of total nominal power; see also "hot standby mode power" in section 4.2; the exact value depends on thermal parameters.
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	initial mode must be an ion emission mode (ITOT, IION, T&C, FEFW, FPEA)
FINAL STATUS:	hot standby mode There is an anomalous behaviour of the instrument: If the next mode command is one that would put the instrument into an active ion emission mode (ITOT, IION, T&C, FEFW, FPEA) then this following mode command will cause high voltage to be turned on IRRESPECTIVE of the status of the high voltage enable parameter EAHVSWEN. High voltage will stay ON until the command ZEAHLINE (HV OFF) is sent or until the instrument is powered off.
VERIFICATION:	EAOPMODE = 4
RELATED CMDS:	ZEAEXPMS, ZEAIIONS, ZEAITOTS, ZEAFEFWS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS

TELECOMMAND:	**ZEAHV__D**
CODE:	0x8000
TITLE:	disable high voltage
PURPOSE:	to disable the high voltage power converter
APPLICABILITY:	to undo a previous enable HV command while the experiment is still in standby mode; the power-on status is disabled. Entering standby mode does NOT disable high voltage
RESPONS.:	experimenter
CONSTRAINTS:	- command is ignored if the experiment is already in an active mode and high voltage has already been switched on; to turn off high voltage use the standby mode command, followed by the high voltage disable command
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	standby mode
VERIFICATION:	EAHVSWEN = 0
RELATED CMDS:	ZEAHV__E

TELECOMMAND:	**ZEAHV__E**
CODE:	0x8100
TITLE:	enable high voltage
PURPOSE:	to enable the high voltage power converter
APPLICABILITY:	to enable the HV power converter in preparation of a future mode change into an active mode; this command is required before any active mode command
RESPONS.:	experimenter
CONSTRAINTS:	this is a critical command during ground tests
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby mode
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHVSWEN = 1
RELATED CMDS:	ZEAHV__D

TELECOMMAND:	**ZEAHVDAS**
CODE:	0xC3xx
TITLE:	set high voltage in technical mode
PURPOSE:	to set HV current or voltage in technical mode
APPLICABILITY:	to be used in technical mode for explicit settings of the interface from the DPU to the high voltage converter. If operating in voltage controlled mode (EAHVCNMD = 1), the value is used for the high voltage setting, in current controlled mode (EAHVCNMD=0) for HV current setting.
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator - only a limited range of the parameter "xx" is allowed, which must be determined during commissioning. Deviations may result in an instability of the ion current or emission of a high current.
RESOURCES:	affects high voltage power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHV_OUT = xx (raw), EAHV_SV_ = set value high voltage in kV according to the calibration curve
RELATED CMDS:	none

TELECOMMAND: ZEAHVIMS

CODE:	0xA000
TITLE:	set current control mode
PURPOSE:	to set current control mode for the high voltage supply
APPLICABILITY:	to be used in technical mode to set current control mode for the high voltage supply. This is the default mode. This mode change, if commanded during ion emission, will change the emitted ion current depending on the characteristics of the emitter.
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	may affect high voltage power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHVCNMD = 0
RELATED CMDS:	ZEAHVUMS

TELECOMMAND:	**ZEAHVTHR**
CODE:	0xCFxx
TITLE:	set high voltage threshold
PURPOSE:	to define a HV threshold value, which serves as upper limit to the high voltage reached during start-up, and as a threshold for the initiation of an automatic cleaning sequence for the emitter. This sequence consists of the application of a high current for 20 - 60 seconds. If the commanded parameter is 0xFF, the threshold checking is disabled.
APPLICABILITY:	before start-up, to define the upper limit of the startup voltage, b) during normal operation to define the threshold for the initiation of the emitter cleaning procedure.
RESPONS.:	experimenter
CONSTRAINTS:	value should be set carefully in order to avoid too frequent triggering of cleaning (if too low) or irrecoverable contamination of the emitter (if too high).
RESOURCES:	no immediate change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	any
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHVTHRE_ = xx (raw) This parameter is located in Byte 43 of the housekeeping data frame, if the parameter EAMUXID_=1.
RELATED CMDS:	ZEAWHISS, ZEASTELS, ZEASTESS

TELECOMMAND:	**ZEAHVUMS**
CODE:	0x9000
TITLE:	set voltage control mode
PURPOSE:	to set voltage control mode for the high voltage supply
APPLICABILITY:	to be used in technical mode to set voltage control mode for the high voltage supply. Useful to apply a defined voltage to an emitter before ignition. If sent during ion emission, the command will change the emitted ion current depending on the characteristics of the emitter.
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator, in particular the set value for high voltage (EAHV_OUT) must lie in a narrow range, which can be determined during commissioning. Deviations may result in an instability of the ion current or emission of a high current.
RESOURCES:	may affect high voltage power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	EAHVCNMD = 1
RELATED CMDS:	ZEAHVIMS

TELECOMMAND:	**ZEAIIONS**
CODE:	0x1200
TITLE:	set constant beam current mode
PURPOSE:	to set constant beam current mode (acronym "IION")
APPLICABILITY:	one of the main operating modes of the experiment; this is an active mode with ion emission
RESPONS.:	experimenter
CONSTRAINTS:	- see section 2.4, "important parameters", for a list of parameters affecting the performance of the instrument in this mode; - enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command - enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command - a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode - other relevant parameters may be changed also after this command - cover of selected module must be open - initial mode shall not be technical mode
RESOURCES:	required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on: - set value of ion beam current (EAIONCSV) - high voltage efficiency - initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	initial mode shall not be technical mode
FINAL STATUS:	constant beam current mode
VERIFICATION:	EAOPMODE = 2
RELATED CMDS:	ZEAEXPMS, ZEAHOT_S, ZEAITOTS, ZEAFEFWS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS

TELECOMMAND:	**ZEAIISVS**
CODE:	0xCExx
TITLE:	set beam current
PURPOSE:	to set ion beam current
APPLICABILITY:	to be used to define the beam current emitted during constant beam current mode; the command may be sent before or during this mode
RESPONS.:	experimenter
CONSTRAINTS:	- no particular constraints - Only a limited range of the parameter "xx" is useful in a particular plasma environment, which must be determined by experience in orbit. Deviations result in a non-optimum scientific performance of the experiment.
RESOURCES:	- in standby mode: no change - in any active mode: the command may affect high voltage power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAIONCSV = xx (raw)
RELATED CMDS:	none

TELECOMMAND:	**ZEAITOTS**
CODE:	0x1100
TITLE:	set constant total current mode
PURPOSE:	to set constant total current mode (acronym "ITOT")
APPLICABILITY:	one of the operating modes of the experiment; this is an active mode with ion emission; this mode controls the output current of the high voltage converter and does not correct for variations of the efficiency of the emitter; useful as a backup mode in case of difficulties with the beam current measurement.
RESPONS.:	experimenter
CONSTRAINTS:	- see section 2.4, "important parameters", for a list of parameters affecting the performance of the instrument in this mode; - enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command - enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command - a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode - other relevant parameters may be changed also after this command - cover of selected module must be open - initial mode shall not be technical mode
RESOURCES:	required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on: - set value of the total current (EATOTCSV) - high voltage efficiency - initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	initial mode shall not be technical mode
FINAL STATUS:	constant total current mode
VERIFICATION:	EAOPMODE = 1
RELATED CMDS:	ZEAEXPMS, ZEAHOT_S, ZEAIIONS, ZEAFEFWS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S, ZEATECHS

TELECOMMAND: ZEAITSLS

CODE: 0xC9xx

TITLE: set total current lower limit

PURPOSE: to set the lower limit of the total output current of the high voltage supply

APPLICABILITY: this value serves three purposes:
- to define a lower limit of the total current range stepped through in test and commissioning mode
- to define a lower limit of the total current used to detect a failure of the emitter and to call the necessary procedures. The associated timeout flag is EAT2MOUT.
- to define 50% of this value as a lower limit of the current applied by the on-board control algorithm during one of the feedback modes, trying to maintain a constant spacecraft potential. The associated timeout flag is EAT5MOUT.

RESPONS.: experimenter

CONSTRAINTS:
- no particular constraints
- only a limited range of the parameter "xx" is useful both scientifically and technically:
- technically, values below 2 µA may result in an unstable ion emission
- the value must not be higher than the upper total current limit (EATOTCUL)
- otherwise the value is determined by scientific considerations

RESOURCES:
- in standby mode: no change
- in any active mode: the command may affect high voltage power, which amounts to up to ca. 30% of total nominal power

SPACECRAFT: no particular requirements

GROUND SEG.: no particular requirements

INITIAL STATUS: no particular requirements

FINAL STATUS: no change to initial status

VERIFICATION: EATOTCLL = xx (raw)

RELATED CMDS: ZEAITSUS, ZEAITSVS

TELECOMMAND: ZEAITSUS

CODE:	0xC8xx
TITLE:	set total current upper limit
PURPOSE:	to set the upper limit of the total output current of the high voltage supply
APPLICABILITY:	this value serves two purposes: - to define an upper limit of the current range stepped through in test and commissioning mode - to define an upper limit of the current applied by the on-board control algorithm during one of the feedback modes, trying to maintain a constant spacecraft potential
RESPONS.:	experimenter
CONSTRAINTS:	- only a limited range of the parameter "xx" is useful both scientifically and technically: - technically, high values may result in reduced lifetime of the emitter - the value must not be lower than the lower total current limit (EATOTCLL) - otherwise the value is determined by scientific considerations
RESOURCES:	- in standby mode: no change - in any active mode: the command may affect high voltage power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EATOTCUL = xx (raw)
RELATED CMDS:	ZEAITSLS, ZEAITSVS

TELECOMMAND:	**ZEAITSVS**
CODE:	0xC7xx
TITLE:	set total current
PURPOSE:	to set the total output current of the high voltage supply
APPLICABILITY:	to be used to define the total current output of the high voltage supply during constant total current mode; the command may be sent before or during this mode. Note that the parameter EATOTCSV will be overwritten in test and commissioning mode (T&C) by the actual values of the current steps.
RESPONS.:	experimenter
CONSTRAINTS:	Only a limited range of the parameter "xx" is useful in a particular plasma environment, which must be determined by experience in orbit. Deviations result in a non-optimum scientific performance of the experiment.
RESOURCES:	- in standby mode: no change - in any active mode: the command may affect high voltage power, which amounts to up to ca. 30% of total nominal power
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EATOTCSV = xx (raw)
RELATED CMDS:	ZEAITSLS, ZEAITSUS

TELECOMMAND:	**ZEAM1ONS**
CODE:	0xC10B
TITLE:	select filaments of module 1
PURPOSE:	to switch the filament power converter to module 1 in technical mode
APPLICABILITY:	to be used in technical mode only; causes the filament converter to select emitter module 1
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAM2ONS

TELECOMMAND:	**ZEAM2ONS**
CODE:	0xC10C
TITLE:	select filaments of module 2
PURPOSE:	to switch the filament power converter to module 2 in technical mode
APPLICABILITY:	to be used in technical mode only; causes the filament converter to select emitter module 2
RESPONS.:	experimenter
CONSTRAINTS:	- only during technical mode - requires special attention by the operator
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	technical mode required
FINAL STATUS:	no change to initial status
VERIFICATION:	no direct verification
RELATED CMDS:	ZEAM1ONS

TELECOMMAND: ZEAMODAS

CODE:	0x4000
TITLE:	select module 1
PURPOSE:	to select module number 1 (A) for filament and high voltage
APPLICABILITY:	to select module number 1 (A) for future activation in an active mode; one of the modules must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment in standby mode
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAMODULE = 0
RELATED CMDS:	ZEAMODBS, ZEAMODUS

TELECOMMAND: ZEAMODBS

CODE:	0x4100
TITLE:	select module 2
PURPOSE:	to select module number 2 (B) for filament and high voltage
APPLICABILITY:	to select module number 2 (B) for future activation in an active mode; one of the modules must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment in standby mode
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAMODULE = 1
RELATED CMDS:	ZEAMODAS, ZEAMODUS

TELECOMMAND:	**ZEAMODUS**
CODE:	0x4000 (predefined value) 0xFEFF (predefined mask) 0x0100 (parameter mask)
TITLE:	select module
PURPOSE:	to select module A or B for filament and high voltage
APPLICABILITY:	to select module A or B for future activation in an active mode; one of the modules must have been selected since the last switching into standby mode, before an active mode can be commanded
RESPONS.:	experimenter
CONSTRAINTS:	experiment in standby mode Only 2 different values of the parameter are possible: 0 (hex) select module 1 (A) 1 (hex) select module 2 (B)
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	standby
FINAL STATUS:	standby
VERIFICATION:	EAMODULE = parameter (raw value)
RELATED CMDS:	ZEAMODAS, ZEAMODBS

TELECOMMAND:	**ZEAPOFFS**
CODE:	0xC6xx
TITLE:	set offset for PEACE data
PURPOSE:	to set an offset value for spacecraft potential data from PEACE
APPLICABILITY:	to maintain continuity of the spacecraft potential in feedback mode if the data source is changed (EFW to PEACE or back). The command sets an offset value which is added to incoming PEACE data before the spacecraft potential control algorithm is applied.
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAPEAOFF = xx (raw)
RELATED CMDS:	none

TELECOMMAND:	**ZEASPSVS**
CODE:	0xCAxx
TITLE:	set spacecraft potential
PURPOSE:	to define the target value of the spacecraft potential for control in feedback mode
APPLICABILITY:	to be used to define the spacecraft potential during constant feedback mode from EFW or PEACE; the command may be sent before or during these modes
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAPOT_SV = xx (raw)
RELATED CMDS:	ZEAIISVS, ZEAITSVS

TELECOMMAND:	**ZEASTDBS**
CODE:	0x1000
TITLE:	set standby mode
PURPOSE:	to set standby mode (acronym "STDB")
APPLICABILITY:	this is the passive mode without power at the filaments and high voltage; this is the default mode after power-on
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	required power is reduced from the initial status by the amount of high voltage and filament power consumed previously. This may have been up to ca. 60% of total nominal power depending on current and voltage selections. Remaining power consumption is about 40% of total nominal power; see also "standby mode power" in section 4.2.
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	standby mode This command does NOT reset the following parameters to disabled status: EAFILENB (filament enable) EAHVSWEN (high voltage software enable) EAHVSHEN (hshut line enable) The above parameters can only be reset by explicit disable commands or by unpowering the instrument. One of the following parameters has to be set again before any active command can be commanded: EAFILSEL by command ZEAFILxS (x=1 ... 4 or M) EAMODULE by command ZEAMODxS (x=A or B or U)
VERIFICATION:	EAOPMODE = 0
RELATED CMDS:	ZEAEXPMS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFEFWS, ZEAFPEAS, ZEAT&C_S, ZEATECHS

TELECOMMAND:	**ZEASTELS**
CODE:	0x4A00 (predefined value) 0xFEFF (predefined mask) 0x0100 (parameter mask)
TITLE:	step length select
PURPOSE:	to set the step length (duration) of current steps in test and commissioning mode, and the duration of the emitter cleaning cycle
APPLICABILITY:	defines the step length during test and commissioning mode, and at the same time the duration of the cleaning cycles; changes go into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	Only 2 different values of the parameter are possible: for test and commissioning mode: 0 (hex) short step length (8 seconds) 1 (hex) long step length (16 seconds) for cleaning cycle: 0 (hex) short duration (20 seconds) 1 (hex) long duration (60 seconds)
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EASTEPL_ = parameter (raw value)
RELATED CMDS:	ZEASTLLS, ZEASTLSS, ZEASTSLS, ZEASTSSS

TELECOMMAND:	**ZEASTESS**
CODE:	0x4800 (predefined value) 0xFEFF (predefined mask) 0x0100 (parameter mask)
TITLE:	step size select
PURPOSE:	to set the step size (current) for current steps in test and commissioning mode, and the total current applied during an emitter cleaning cycle
APPLICABILITY:	defines the step size during test and commissioning mode, and at the same time the total current during the cleaning cycles; changes go into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	Only 2 different values of the parameter are possible: for test and commissioning mode: 0 (hex) small step size (2 µA total current) 1 (hex) large step size (4 µA total current) for cleaning cycle: 0 (hex) low current (50 µA total current) 1 (hex) high current (maximum capability of the supply, >70 µA total current)
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EASTEPS_ = parameter (raw value)
RELATED CMDS:	ZEASTLLS, ZEASTLSS, ZEASTSLS, ZEASTSSS

TELECOMMAND:	**ZEASTLLS**
CODE:	0x4B00
TITLE:	select large step length
PURPOSE:	to set the large step length (duration) for current steps in test and commissioning mode (16 seconds), and the long duration of the emitter cleaning cycle (60 seconds)
APPLICABILITY:	defines the step length during test and commissioning mode, and at the same time the duration of the cleaning cycles; changes go into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EASTEPL_ = 1
RELATED CMDS:	ZEASTELS, ZEASTESS, ZEASTLSS, ZEASTSLS, ZEASTSSS

TELECOMMAND:	**ZEASTLSS**
CODE:	0x4A00
TITLE:	select small step length
PURPOSE:	to set the small step length (duration) for current steps in test and commissioning mode (8 seconds), and the short duration of the emitter cleaning cycle (20 seconds)
APPLICABILITY:	defines the step length during test and commissioning mode, and at the same time the duration of the cleaning cycles; changes go into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EASTEPL_ = 0
RELATED CMDS:	ZEASTELS, ZEASTESS, ZEASTLLS, ZEASTSLS, ZEASTSSS

TELECOMMAND:	**ZEASTSLS**
CODE:	0x4900
TITLE:	select large step size
PURPOSE:	to set the large step size (magnitude of current increment/decrement) for current steps in test and commissioning mode (4 µA total current), and the high total current applied during an emitter cleaning cycle (>70 µA total current)
APPLICABILITY:	defines the step size during test and commissioning mode, and at the same time the total current during the cleaning cycles; changes go into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EASTEPS_ = 1
RELATED CMDS:	ZEASTELS, ZEASTESS, ZEASTLLS, ZEASTLSS, ZEASTSSS

TELECOMMAND:	**ZEASTSSS**
CODE:	0x4800
TITLE:	select small step size
PURPOSE:	to set the small step size (magnitude of current increment/decrement) for current steps in test and commissioning mode (2 µA total current), and the low total current applied during an emitter cleaning cycle (50 µA total current)
APPLICABILITY:	defines the step size during test and commissioning mode, and at the same time the total current during the cleaning cycles; changes go into effect immediately
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EASTEPS_ = 0
RELATED CMDS:	ZEASTELS, ZEASTESS, ZEASTLLS, ZEASTLSS, ZEASTSLS

TELECOMMAND: ZEAT&C_S

CODE: 0x1500

TITLE: set test and commissioning mode

PURPOSE: to set test and commissioning mode (acronym "T&C")

APPLICABILITY: one of the operating modes of the experiment; this is an active mode with ion emission; this mode sets the output current of the high voltage converter according to a step function; useful for calibration and commissioning procedures.

RESPONS.: experimenter

CONSTRAINTS:
- see section 2.4, "important parameters", for a list of parameters affecting the performance of the instrument in this mode;
- enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command
- enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command
- a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode
- other relevant parameters may be changed also after this command
- cover of selected module must be open
- initial mode shall not be technical mode

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on:
- set value of the upper limit of total current (EATOTCUL)
- high voltage efficiency
- initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter

SPACECRAFT: no particular requirements

GROUND SEG.: no particular requirements

INITIAL STATUS: Initial mode shall not be technical mode.
Total current starts from previously set value (EATOTCSV), increasing or decreasing in the direction at the end of a previous operation in this mode. The default direction after power-on is increasing.

FINAL STATUS: test and commissioning mode
The total current set value parameter (EATOTCSV) is overwritten during this mode. After the end of the operation in this mode this parameter contains the last current value of the step function.

VERIFICATION: EAOPMODE = 5

RELATED CMDS: ZEAEXPMS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFEFWS, ZEAFPEAS, ZEASTDBS, ZEATECHS

TELECOMMAND:	**ZEATECHS**
CODE:	0x1600
TITLE:	set technical mode
PURPOSE:	to set technical mode (acronym "TECH")
APPLICABILITY:	for low level check-out of the experiment; should not be used in normal operation
RESPONS.:	experimenter
CONSTRAINTS:	requires special attention by the operator
RESOURCES:	required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on various parameters.
SPACECRAFT:	no particular requirements
GROUND SEG.:	real-time HK required
INITIAL STATUS:	no particular requirements
FINAL STATUS:	technical mode
VERIFICATION:	EAOPMODE = 6
RELATED CMDS:	ZEAEXPMS, ZEAHOT_S, ZEAIIONS, ZEAITOTS, ZEAFEFWS, ZEAFPEAS, ZEASTDBS, ZEAT&C_S

TELECOMMAND:	**ZEAWHISS**
CODE:	0xCBxx
TITLE:	set WHISPER code table
PURPOSE:	to define the reaction of the experiment on WHISPER status information available through the inter-experiment link in feedback mode; two bits of the parameter define the reaction of the instrument when the high voltage threshold for cleaning is exceeded.
APPLICABILITY:	to be used in case of interference by WHISPER during active spacecraft potential control in feedback mode from EFW or PEACE; also to define the reaction of the instrument when the high voltage threshold for cleaning is exceeded; the 8 bits "xx" contain the parameters EAWISTAB which itself contains the parameters EAWISSOR, EAWISSDW, EACLNDSB, EACLNHWL, EAWISCO2, EAWISCO3.
RESPONS.:	experimenter
CONSTRAINTS:	no particular constraints
RESOURCES:	no change
SPACECRAFT:	no particular requirements
GROUND SEG.:	no particular requirements
INITIAL STATUS:	no particular requirements
FINAL STATUS:	no change to initial status
VERIFICATION:	EAWISTAB = xx (raw)
RELATED CMDS:	none

4. Environment

4.1 Thermal

4.1.1 Conditions

No particular requirements for any operating mode: the temperatures shall lie within nominal range for platform mounted units.

4.1.2 Monitoring

There are four temperature sensors in the experiment:

PARAMETER	LOCATION OF SENSOR
EATMPBOX	at the motherboard.
EATMPDPU	at one of the DPU boards
EATMPMD1	at the top plate of the electronics box
EATMPMD2	near the covers of the emitter modules

The data are contained in HK telemetry in every other frame.

The parameter location and range are given in section 2.2.3.

The calibration and units are given in section 2.2.9 as row no. 4.

Reaction on deviations

CONDITION:	Small deviations (< 10°) from the nominal range for platform mounted units
ACTION:	No action required
CONDITION:	Large deviations (> 10°)
ACTION:	ESOC to turn power off (procedure QEAPOWOF) and wait for an analysis of the situation by the experimenter.

4.1.3 Control

There is no thermal control hardware in the experiment.

4.1.4 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 4.1:

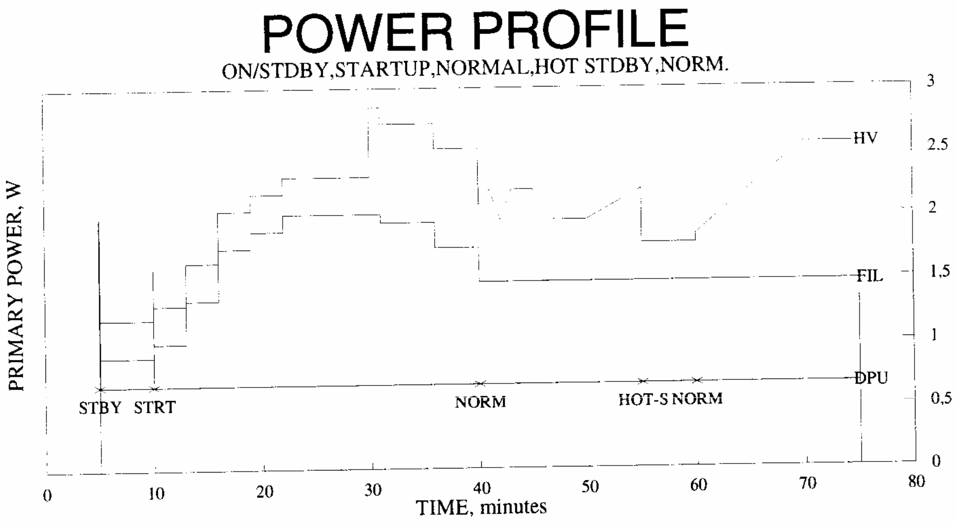
QEAPOWOF	turn power off

4.2 Power

4.2.1 Profiles

The lower line (DPU) gives primary power consumed by the DPU. The range between the lines "DPU" and "FIL" gives primary power consumed by the filament converter, the range between "FIL" and "HV" gives high voltage power. The upper line (HV) gives total primary power.

Examples for all modes are shown. Modes begin at the respective label below the "DPU" line. The label "NORM" stands for the regular active modes FEFW, FPEA, IION, or ITOT. The detailed structure in all modes except standby (STDB) is an example only. In reality power depends on the plasma environment, thermal conditions and ion current parameters.



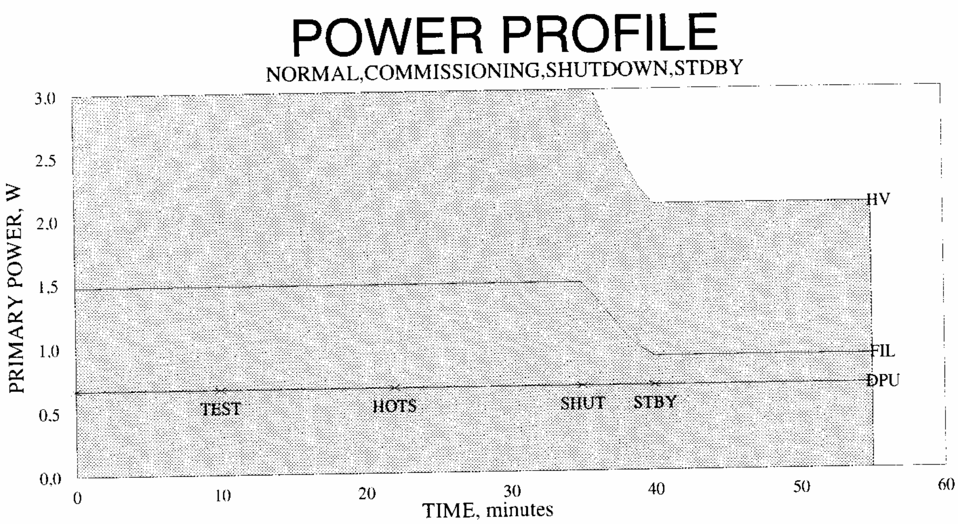


Fig. 8 Power profiles

4.2.2 High Voltages

The ion emitters operate with high voltage, using a high voltage supply which is internal to ASPOC. In normal operation the high voltage supply is current controlled, and the voltage adjusts itself in the range 4 to 8 kV, depending on the current and characteristics of the individual ion emitter.

All active experiment modes with ion emission include activation of high voltage (modes ITOT, IION, FEFW, FPEA, T&C, TECH).

Safety precautions are taken. Activation of high voltage requires two independent telecommands. There is no high voltage at exposed surfaces.

4.2.3 Conditions

There is no constant relationship between instrument operating mode and power consumption:

- Standby mode has constant power consumption following 1.5 seconds after instrument turn-on. During the first 1.5 seconds there is an increased power consumption caused by uploading of program code from PROM into RAM ("DPU start-up phase").

- Start-up of emitters has a structured power profile with somewhat elevated consumption during the heating of the filament followed by maximum during ion beam ignition. The power value during ignition cannot be predicted exactly as it depends on the physical characteristics of an individual emitter. Only the upper limit, which is determined by the capabilities of the high voltage supply, can be given.

- During all active modes (with ion beam emission) the power consumption has a constant part for the DPU and heating of the emitter plus a variable part for the ion beam at high voltage.

Mode	Phase	Power (mW) Min.	Typ.	Max.
Standby (STDB)	DPU Start-up	2020	2020	2020
Standby (STDB)	Standby	1120	1120	1120
Hot standby (HOT)	-	1630	1630	1630
Startup *)	Filament start-up	1780	1780	1780
	Beam ignition	2190	2190	2190
All active modes *)	-	1630	1710	2460

*) Start-up occurs during the initial phase of all active modes:
ITOT, IION, FEFW, FPEA, T&C, TECH

4.2.4 Monitoring

4.2.4.1 Secondary supply voltages

There are three secondary supply voltage monitors:

PARAMETER	VOLTAGE
EAVP5___	+ 5 V
EAVN5___	- 5 V
EAV13_5_	+ 13.5 V

The data are contained in HK telemetry in every other frame.

The parameter location and range are given in section 2.2.2.

The calibration and units are given in section 2.2.9 as rows no. 5, 6, and 7.

Reaction on deviations

CONDITION: Small deviations (< 5%) from the nominal range
ACTION: PI to look for anomalies in the performance of the instrument. No further action is required if no anomalies are observed.

CONDITION: Large deviations (> 5%), but without anomalies on the OBDH interfaces
ACTION: ESOC to command standby mode (procedure QEASTDBS) or perform a power-off power-on cycle with the same effect, skip any other commands and wait for an analysis of the situation by the experimenter.

CONDITION: Large deviations (> 5%) with anomalies on the OBDH interfaces
ACTION: ESOC to turn power off (procedure QEAPOWOF) and wait for an analysis of the situation by the experimenter.

4.2.4.2 Secondary high voltage

PARAMETER	DESCRIPTION
EAHVMON_	high voltage monitor
EAOPMODE	operation mode
EAIONC0_	ion current monitor
EAT1MOUT	timeout, no ignition
EAT2MOUT	timeout, no beam current
EATOTC0_	total current monitor

The high voltage data EAHVMON_ are contained in HK telemetry in every other frame.

The parameter location and range are given in section 2.2.6.

The calibration and units are given in section 2.2.9 as row no. 10.

If one of the timeout flags is set (EAT1MOUT, EAT2MOUT), this may indicate a problem with high voltage.

Reaction on deviations

CONDITION:	High voltage parameter EAHVMON_ is > 7.5 kV continuously over more than 15 minutes, and no cleaning procedure with the same emitter (same parameters EAFILSEL and EAMODULE) has been performed since the beginning of the orbit.
ACTION:	ESOC to initiate the cleaning procedure for emitters (QEACLEAN) as soon as all constraints for this procedure are fulfilled.
ACTION:	The experimenter has to analyse the situation and eventually avoid operation of this emitter in future.
CONDITION:	High voltage parameter EAHVMON_ is > 7.5 kV continuously over more than 15 minutes, and a cleaning procedure with the same emitter (same parameters EAFILSEL and EAMODULE) has been performed before in the orbit.
ACTION:	ESOC to inhibit further operation with the same emitter until the experimenter has analysed the situation: Do not send any of the mode commands ZEAEXPMS, ZEAITOTS, ZEAIIONS, ZEAFEFWS, ZEAFPEAS, ZEAT&C_S while both parameters EAFILSEL and EAMODULE point to the problematic emitter.
ACTION:	The experimenter has to analyse the situation and eventually avoid operation of this emitter in future.
CONDITION:	The instrument has detected some failure on board and switched into standby mode (EAOPMODE=0), although the last commanded mode was another mode. However, none of the timeout flags (EAT1MOUT, EAT2MOUT, EAT3MOUT, EAT4MOUT, EAT5MOUT, EATIMOT2, EATIMOT4) is set.
ACTION:	This condition may indicate an emitter or high voltage failure, but also other causes are possible (e.g. IEL problems). The procedure QEAEFAID shall be invoked, which requires ESOC to stop further master schedule commanding, the experimenter to analyse housekeeping data before the event and eventually select other emitters for future operations, and the PI/JSOC/ESOC to modify the command schedule.
CONDITION:	The leakage current of an emitter (= the difference between total current and ion beam current = EATOTC0_-EAIONC0) has increased significantly and permanently during at least 10 minutes compared to the values of the commissioning phase, and no cleaning procedure with the same emitter (same parameters EAFILSEL and EAMODULE) has been performed since the beginning of the orbit. Note that the permitted range of EATOTC0_-EAIONC0_ is a function of EATOTC0_.
ACTION:	ESOC to initiate the cleaning procedure for emitters (QEACLEAN) as soon as all constraints for this procedure are fulfilled.
ACTION:	The experimenter has to analyse the situation and eventually avoid operation of this emitter in future (same as with total emitter failures).

CONDITION:	The leakage current of an emitter (= the difference between total current and ion beam current = EATOTC0_ - EAIONC0) has increased significantly and permanently during at least 10 minutes compared to the values of the commissioning phase, and a cleaning procedure with the same emitter (same parameters EAFILSEL and EAMODULE) has been performed before in the orbit. Note that the permitted range of EATOTC0_-EAIONC0_ is a function of EATOTC0_.
ACTION:	Same as with total emitter failures: ESOC to inhibit further operation with the same emitter until the experimenter has analysed the situation: Do not send any of the mode commands ZEAEXPMS, ZEAITOTS, ZEAIIONS, ZEAFEFWS, ZEAFPEAS, ZEAT&C_S while both parameters EAFILSEL and EAMODULE point to the problematic emitter.
CONDITION:	One of the timeout flags (EAT1MOUT, EAT2MOUT) is set, and the experiment mode is standby (STDB) (parameter EAOPMODE=0), although another mode has been commanded. This indicates a problem with high voltage.
ACTION:	Same as with total emitter failures: ESOC to inhibit further operation with the same emitter until the experimenter has analysed the situation: Do not send any of the mode commands ZEAEXPMS, ZEAITOTS, ZEAIIONS, ZEAFEFWS, ZEAFPEAS, ZEAT&C_S while both parameters EAFILSEL and EAMODULE point to the problematic emitter.
ACTION:	The experimenter has to analyse the situation and eventually avoid operation of this emitter in future (same as with total emitter failures).

4.2.5 Control

The power consumption of the experiment is controlled indirectly by:

- experiment mode selection
- maximum total current selection (EATOTCUL)
- beam current or spacecraft potential target value selection (with scientific rationale, EAIONCSV or EAPOT_SV)
- emitter filament thermal conditions (filament temperature, ambient temperature, losses)

4.2.6 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 4.2:

QEACLEAN	emitter cleaning
QEAEFAID	possible emitter failure detected on board
QEAPOWOF	turn power off
QEASTDBS	set standby mode

4.3 Communications

4.3.1 Bit rates associated to each TA and each instrument mode

The bit rate of ASPOC is constant:

- 72 bytes per HK frame (about 108 bits per second)

4.3.2 Conditions

N/A

4.3.3 Monitoring

N/A

4.3.4 Control

N/A

4.3.5 Procedures

none

4.4 Timing

4.4.1 Conditions

4.4.1.1 Introduction

The experiment ASPOC is not a very time critical instrument. The required timing accuracy is well below the Cluster-II requirements.

4.4.1.2 Command timing

Memory load commands received by the experiment are stored in a stack of size 255. In order to allow verification of all commands in the "last command" parameter (EALASTCM) in HK telemetry, only one command per reset pulse is actually executed from the stack. The execution of an individual command starts at the reset pulse and is completed within one second or less.

4.4.1.3 Internal mode timing

If an active mode is commanded and the selected emitter is still cold, the experiment begins with a heating procedure (start-up) for the emitter. This takes up to about 33 minutes, depending on thermal conditions and on the ignition voltage of the selected ion emitter. During start-up the parameter EASU_ACT=1.

The start-up phase consists of a heat-up phase and an ignition phase. During the heat-up phase the filament of an emitter is heated until the start-up temperature is reached. The heat-up time is a function of ambient temperature and the thermal properties of the individual emitter. Tests in the vacuum chamber have resulted in times between 9 min and 14 min. Thereafter the high voltage is turned on at 5 kV and is slowly increased to the maximum value (set by the high voltage threshold, default setting = 7.5 kV, preferred setting during start-up = 8.5 kV) at a rate of 1 digit per reset interval = 450 V/min.

The duration of the start-up is the sum of heat-up time and ignition time. It will stay between the extreme limits of about 9 and 33 min. The observed values during testing were between 12 and 20 minutes.

This delay has to be taken into account when coordinating ASPOC with other experiments.

It is possible and sensible to command an active mode (with ion emission) by the duration of the start-up earlier than the rest of the scientific paylod.

4.4.1.4 Precautions for test and commissioning mode

In planning operations with test and commissioning mode (T&C) one has to consider the reaction delays for commands inside the experiment, if the current as a function of time has to be predicted exactly.

4.4.1.5 IEL timing

For the timing on the inter-experiment link for the spacecraft potential see the related sections.

4.4.2 Monitoring

no requirements

4.4.3 Control

no requirements

4.4.4 Procedures

none

4.5 Interface to Other Experiments (IEL)

4.5.1 Conditions

- The interface to EFW (via DWP) must be operational and EFW must send valid spacecraft potential data for mode FEFW (feedback from EFW)

- The interface to PEACE must be operational and PEACE must send valid spacecraft potential data for mode FPEA (feedback from PEACE)

- During both modes the commissioning phase must have shown that the experiment WHISPER in its active modes does not interfere with the spacecraft potential control.

- Deviations or loss of data are handled by ASPOC internally by switching into a "backup" mode. More details about internal mode switching can be found in section 1.3.6.

4.5.2 Monitoring

There following parameters are most relevant for monitoring the IEL:

PARAMETER	DESCRIPTION
EABK_ACT	backup active flag
EABKMODE	backup mode
EAOPMODE	operation mode
EAEFWRX1	S/C potential EFW received
EAEFWRX2	2nd S/C potential EFW received
EAPEARX1	S/C potential PEACE received
EAPEARX2	2nd S/C potential PEACE received
EATIMOT2	feedback wait status
EAT3MOUT	timeout, EFW failure
EAT4MOUT	timeout, PEACE failure
EAT5MOUT	timeout, ion current set below limit

The data are contained in HK telemetry in every other frame.

The parameter location and range are given in section 2.2.3.

The calibration and units are given in section 2.2.9 as row no. 4.

Reaction on deviations

CONDITION: The instrument has detected some failure on board and switched into standby mode (EAOPMODE=0), although the last commanded mode was another mode. However, none of the timeout flags (EAT1MOUT, EAT2MOUT, EAT3MOUT, EAT4MOUT, EAT5MOUT, EATIMOT2) is set.

ACTION: This condition may indicate an IEL failure, but also other causes are possible (e.g. emitter problems).
The procedure QEAEFAID shall be invoked, which requires ESOC to stop further master schedule commanding, the experimenter to analyse housekeeping data before the event and eventually select other emitters for future operations, and the PI/JSOC/ESOC to modify the command schedule.

CONDITION: One of the timeout flags (EAT3MOUT, EAT4MOUT, EAT5MOUT, EATIMOT2) is set, and the experiment mode is in mode standby (STDB) (parameter EAOPMODE=0), although another mode has been commanded. This indicates a problem with the IEL link, although other causes are possible. The experiment cannot recover itself from this mode without additional commands.

ACTION: ESOC would have to repeat the most recent five enable, emitter selection and mode commands in order to bring the experiment back into the mode before the timeout occurred:
ZEAFILxS with x = 1 ... 4 or M
ZEAMODxS with x = A or B or U
ZEAFIL_E
ZEAHV__E
ZEA<mode>S with <mode> = most recent mode
This may be too difficult to handle in practice, so it is recommended to set no action and wait for the next regular mode command in the time-tagged command sequence.

ACTION: In any case the experimenter has to analyse the situaion and eventually review the command planning.

CONDITION: One of the timeout flags (EAT3MOUT, EAT4MOUT, EAT5MOUT, EATIMOT2) is set, and the experiment mode is in mode standby (STDB) (parameter EAOPMODE=0) or the backup mode is active (EABK_ACT=1), although another mode has been commanded. This indicates a problem with the IEL link, although other causes are possible. The experiment can recover itself from this mode autonomously.

ACTION: No immediate action required. The experimenter has to analyse the situation and eventually review the command planning.

4.5.3 Control

See actions under monitoring strategy.

4.5.4 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 4.5:

QEAEFAID possible emitter failure detected on board

5. Commissioning

5.1 Initialization of the Instrument

5.1.1 Timeline

TIME	STEP	DESCRIPTION	PROCEDURE
final orbit reached	1	Fire pyro's to open covers. Later maneouvres pose no risk for the emitters. All steps of the commissioning can be executed at any spacecraft spin rate.	QEAFPYRO
-	2	Initial turn-on without high voltage:	
		- turn on power	QEAPOWON
		- status check:	QEAINITL
		- 4 temperatures	
		- 3 voltages	
		- reception of SRP	
		- 2 cap status	
		- disarming plug status	
		- basic test:	
		- verify TC	
		- test filament DAC	
		- test module switching	
		Duration: 15-30 min. Possible contingencies: G1, G2	
	3	If cover has remained closed after pyro firing (G1): verify remaining pressure inside. Duration: ca. 30 min. Other instruments: not needed	QEAPRVER
step 1 + 1 week minimum, >2 weeks recommended (outgassing)	4	Initial high voltage turn-on, consisting of:	QEAINITH
		HV test on module 1	QEAHVTST
		start-up emitter 1 on module 1	QEASTART
		start-up emitter 2 on module 1	QEASTART
		start-up emitter 3 on module 1	QEASTART
		start-up emitter 4 on module 1	QEASTART
		HV test on module 2	QEAHVTST
		start-up emitter 1 on module 2	QEASTART
		start-up emitter 2 on module 2	QEASTART

		start-up emitter 3 on module 2	QEASTART
		start-up emitter 4 on module 2	QEASTART
		Toral duration: ca. 1 hour per emitter = 8 hours per instrument Possible contingencies: E1-E8, F1-F4 Other experiments: not needed This step can take place at any time.	

The sequence of steps after step 4 is an example only. Constraints for the sequence and others are given in Section 5.1.2.

The instrument status before the beginning of each step shall be standby mode (STDB).

TIME	STEP	DESCRIPTION	PROCEDURE
	5	test full current sweep Duration: ca. 40 minutes Possible contingencies: E1-E8, F1-F4 Other experiments: not needed EFW in voltage mode is desirable partial deployment of EFW is permitted Apart from the preference stated above, this step can take place at any time.	QEADCHAR
	6	test feedback with EFW with emitter 1 on module 1 (for example) Duration: ca. 1 hour Possible contingencies: I1-I4 Other experiments: EFW needed partial deployment of EFW is permitted WHISPER needed (status of WHISPER to be known) PEACE desired This step can take place as soon as EFW can deliver good potential.	QEAFTEFW
	7	test feedback with PEACE with emitter 2 on module 1 (for example) Duration: ca. 1 hour Possible contingencies: I1-I4 Other experiments: PEACE needed WHISPER needed (status of WHISPER to be known)	QEAFTPEA

		EFW needed partial deployment of EFW is permitted This step can take place as soon as PEACE can deliver reasonably good potential.	

The following steps 8-10 shall be scheduled for the interference and intercalibration test phase.

All tests should be made both in low and high plasma density regions.

If the timing of the campaign with respect to the orbit plane leads to long periods in the solar wind, the tests can still be performed, but their scientific value is lower because:

1. the difference between high and low density plasma cannot be measured

2. the effect of the ASPOC ion beam and other active experiments (EDI current, EFW bias current) on the spacecraft potential will be small.

TIME	STEP	DESCRIPTION	PROCEDURE
	8	Interference tests for interference coming from ASPOC Duration: ca. 1 hour This interference test may be combined to a general interference campaign for all active experiments. ASPOC is aware of a request by WHISPER / WEC for turning the ion beam on and off every few minutes. ASPOC supports this proposal in the context of interference tests. However, the procedure shall take into account the fact that the exact time of ignition after the start-up cannot be predicted (1-2 minutes uncertainty). Subsequent turn-on times (when the emitters are already hot) can be scheduled exactly.	
	9	Susceptibility tests: effect of WHISPER on EFW potential Duration: ca. 1 hour Possible contingencies: I1-I4	 This is an EFW-WHISPER procedure
		effect of WHISPER on feedback Duration: ca. 1 hour Possible contingencies: I1-I4	QEAWHIFB
		effect of EDI on EFW potential	This is an EDI-EFW procedure

Duration: ca. 1 hour
Possible contingencies: I1-I4

10 Intercalibration tests between ASPOC, CIS, EDI, EFW, PEACE
Duration: ca. 2 hours

The initial "cycling tests" of the ion emitters, which is an operation of ASPOC during the commissioning phase as described in 5.4, may be scheduled in between the steps 4-10 or afterwards. For further details, constraints etc. see description of the procedure QEAEMOPT.

A possible overall scenario is as follows:

Orbit	Activity
1	test with 8 x 1 hour operation
2	test with 8 x 1 hour operation
2	verification with 8 x 5 minutes
3	data dump and analysis
4	test with 8 x 2 hours operation
4	verification with 8 x 5 minutes
5	data dump and analysis
6	test with 8 x 3 hours operation
6	verification with 8 x 5 minutes
7	data dump and analysis
8	test with 4 x 4 hours operation
8	verification with 4 x 5 minutes
9	data dump and analysis
10	test with 2 x 6 hours operation
11	test with 2 x 6 hours operation
11	verification with 4 x 5 minutes
12	data dump and analysis
13	test with 2 x 8 hours operation
14	test with 2 x 8 hours operation
14	verification with 4 x 5 minutes
15	data dump and analysis

TIME	STEP	DESCRIPTION	PROCEDURE
	11	test 1 hour operation of emitters (first run for reference) Duration: 8 x 80 minutes (25 minutes start-up (typical) and 60 minutes operation for each emitter) Possible contingencies: in particular E1-E3 Other experiments: not needed	QEAEMOPT,t=75, sel=(A1,A2,A3,A4,B1,B2,B3,B4)
	12	test 1 hour operation of emitters	QEAEMOPT,t=75,

	(second run for comparison) Duration: 8 x 80 minutes Same conditions as in step 11	sel=(A1,A2,A3,A4,B1,B2,B3,B4)
13	test 5 minutes operation of emitters (for verification of ignition voltage) Duration: 8 x 5 minutes Same conditions as in step 11	QEAEMOPT,t=20, sel=(A1,A2,A3,A4,B1,B2,B3,B4)
14	data analysis (analyse performance during previous steps) decide on continuation of emitter cycling test Duration: ca. 6 hours (during office hours) following data retrieval	
15	test 2 hours operation of emitters Duration: 8 x 140 minutes (25 minutes start-up (typical) and 120 minutes operation for each emitter) Otherwise same conditions as in step 11	QEAEMOPT,t=135, sel=(A1,A2,A3,A4,B1,B2,B3,B4)
16	test 5 minutes operation of emitters Duration: 8 x 5 minutes	QEAEMOPT,t=20, sel=(A1,A2,A3,A4,B1,B2,B3,B4)
17	data analysis	
18	test 3 hours operation of emitters Duration: 8 x 200 minutes (25 minutes start-up (typical) and 180 minutes operation for each emitter) Otherwise same conditions as in step 11	QEAEMOPT,t=195, sel=(A1,A2,A3,A4,B1,B2,B3,B4)
19	test 5 minutes operation of emitters Duration: 8 x 5 minutes	QEAEMOPT,t=20, sel=(A1,A2,A3,A4,B1,B2,B3,B4)
20	data analysis	
21	test 4 hours operation of emitters (one module only) Duration: 4 x 260 minutes (25 minutes start-up (typical) and 240 minutes operation for each emitter) Otherwise same conditions as in step 11	QEAEMOPT,t=255, sel=(A1,A2,A3,A4)
22	test 5 minutes operation of emitters Duration: 4 x 5 minutes	QEAEMOPT,t=20, sel=(A1,A2,A3,A4)

23	data analysis	
24	test 6 hours operation of emitters (one module only) Duration: 4 x 380 minutes (25 minutes start-up (typical) and 360 minutes operation for each emitter) Otherwise same conditions as in step 11	QEAEMOPT,t=375, sel=(B1,B2,B3,B4)
25	test 5 minutes operation of emitters Duration: 4 x 5 minutes	QEAEMOPT,t=20, sel=(B1,B2,B3,B4)
26	data analysis	
27	test 8 hours operation of emitters (one module only) Duration: 4 x 500 minutes (25 minutes start-up (typical) and 480 minutes operation for each emitter) Otherwise same conditions as in step 11	QEAEMOPT,t=495, sel=(A1,A2,A3,A4)
28	test 5 minutes operation of emitters Duration: 4 x 5 minutes	QEAEMOPT,t=20, sel=(A1,A2,A3,A4)
29	data analysis (analyse performance during previous step) decide on maximum operation time for one emitter during nominal operations	

5.1.2 Operational constraints

General constraints for initialisation:

- Individual steps of the timeline to be performed with only one instrument at a time. For example, the testing of all 8 emitters of one instrument shall be completed before the next instrument is tested.

- Otherwise two instruments can be handled quasi-simultaneously.

- Real-time housekeeping telemetry shall be available.

Constraints for initial high voltage turn-on:

- Cover must have been opened a sufficient time before turn-on to allow outgassing of the emitter module (at least 1 day).

- Commissioning of the emitters is possible basically in any plasma region (solar wind or lobe). Desirable are low plasma density (inside magnetosphere) and stable conditions during the test.

- The instruments EFW, PEACE, CIS should be operational as far as possible in order to speed up interference and intercalibration experience.

- Only one spacecraft at a time

Constraints for the test of feedback with EFW:

Feedback tests with EFW may be performed immediately after the commissioning of the emitters. For this purpose additional requirements apply:

- first test at low plasma density preferred (inside the magnetosphere)

- slowly varying predicted plasma conditions (strong and rapid fluctuations of the spacecraft potential should be avoided during the first test of the control loop)

- EFW fully operational, calibrated

- EFW has to operate in a mode which provides spacecraft potential data to ASPOC via the IEL

- Interference of other instruments on the spacecraft potential measurement by EFW shall be avoided. This can be achieved by switching off possibly disturbing instruments (WHISPER in active mode, EDI), or by confirming the absence of such interference by susceptibility measurements of effects by EDI and WHISPER on EFW.

- booms must be fully deployed, spin conditions stable

- Only one spacecraft tested at a time: operation requires full attention of experienced personnel

- Feedback mode tests should be made at least in 2 regions along the orbit with largely different plasma conditions (high and low density).

Constraints for the test of feedback with PEACE:

- The emitters must have been commissioned.

- first test at low plasma density preferred (inside the magnetosphere)

- slowly varying predicted plasma conditions (strong and rapid fluctuations of the spacecraft potential should be avoided during the first test of the control loop)

- PEACE fully operational and calibrated

- A comparison of spacecraft potential data by EFW and PEACE over a significant amount of time (several tens of hours covering different regions in the magnetosphere and the solar wind) must have provided confidence in the algorithm used by PEACE to calculate the potential.

- PEACE should operate in a mode with the best resolution in the low energy range

- Interference of other instruments on the spacecraft potential measurement by PEACE shall be avoided. This can be achieved by switching off possibly disturbing instruments (WHISPER in active mode, EDI), or by confirming the absence of such interference by susceptibility measurements of effects by EDI and WHISPER on PEACE.

- The test should be made after the feedback test with EFW because of the additional complexity.

- Only one spacecraft tested at a time: operation requires full attention of experienced personnel

- Feedback mode tests should be made at least in 2 regions along the orbit with largely different plasma conditions (high and low density).

Constraints for the test of WHISPER effects on the feedback with EFW:

- Successful completion of the feedback test with EFW

- Experience with the effect of active WHISPER operation on the spacecraft potential measurements by EFW over a significant amount of time (several tens of hours covering different regions in the magnetosphere and the solar wind).

- EFW fully operational, calibrated

- EFW has to operate in a mode which provides spacecraft potential data to ASPOC via the IEL

- WHISPER has to operate in active and passive modes.

- booms must be fully deployed, spin conditions stable

- Only one spacecraft tested at a time: operation requires full attention of experienced personnel

Constraints for the interference campaign (interferences by ASPOC):

- Instruments interested in tests of possible interference shall be operational (CIS, EDI, EFW, PEACE, STAFF, WBD, WHISPER, ...)

- Successful commissioning of ASPOC

- Plasma conditions should allow at least one test with the full beam current range: low or medium ambient plasma density (within magnetosphere). A second or more tests in other regions are desirable.

- More (up to 4) spacecraft may be tested at a time: depending on requirements by susceptible instruments

Constraints for the intercalibration campaign:

- Basically the same as for the interference campaign. The main difference will be in the timeline of the ion beam current.

- More (up to 4) spacecraft may be tested at a time: depending on requirements by participating instruments

- Intercalibration tests related to spacecraft potential should be made at least in 2 regions along the orbit with largely different plasma conditions (high and low density).

5.1.3 Other constraints

None

5.1.4 Resources

On the spacecraft: Nominal power and bitrate.

At ESOC:

# EGSE at ESOC	1
# ESOC workstations	1
people near EGSE	1-3
surface for equipment	2 tables
move EGSE	no
remote access to EGSE	yes
commission 2 instruments in parallel	--
commission 2 instruments quasi-parallel	yes

5.1.5 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 5.1:

QEAEMOPT	optimisation of emitter operations
QEAFPYRO	fire both pyros
QEAFTEFW	feedback test with EFW
QEAFTPEA	feedback test with PEACE
QEAHVTST	HV test during initialisation
QEAINITL	initial experiment turn-on
QEAINITH	initial high voltage turn-on
QEAPOWON	turn power on
QEAPRVER	verify pressure in module
QEASTART	start-up test of one emitter
QEAWHIFB	test effect of WHISPER on feedback loop

5.2 Mechanisms

5.2.a Under Spacecraft control

5.2.1 Pyrotechnics

The covers of both emitter modules of ASPOC have to be opened before any high voltage operation by spacecraft-powered pyro's.

detail timing constraints, temperature constraints

Timing constraints:

- Final orbit reached
- At least 1 week before high voltage operations with ASPOC.

Temperature constraints:

Within nominal temperature range for platform mounted units: 0 ... 40°

Procedure:

QEAFPYRO fire both pyros

See Annex A.3 for a full description.

5.2.b Under Experiment control

none

5.2.2 Active covers

none

5.2.3 Booms

none

5.2.c Environmental control

none

5.3 High Voltages on

See initialisation procedure for high voltage in section 5.1 (QEAINITH).

5.4 Transition from Commissioning to Nominal Operations

After the initial commissioning (at least the steps 1-4 in the timeline) of ASPOC this instrument shall be turned on for several hours each time on a regular basis in order to assess several operating parameters of the ion emitters. The second part of the ASPOC commissioning (steps 5ff) with feedback mode tests, interference, susceptibility and intercalibration tests may overlap with this regular turn-on of ASPOC, which is described below.

The purpose of this scenario is the assessment of the maximum continuous operation time of all emitters within one emitter module, which does not yet lead to any cross-contamination of the emitter needles. This effect would be observable as an increase of the ignition voltage when one of the emitters is operated a second time.

Real-time ground control is not necessary.

Operation may be in parallel on all spacecraft. Per orbit a full cycle with all emitters of one or both modules (up to 8 emitters) shall be performed.

Some of these operating periods may be coordinated with the commissioning of EFW and WEC (see also Section 6.2.6, emitter cycling).

EFW shall indicate periods within or after the WEC commissioning when EFW is operating and providing spacecraft potential data from one of the probes, and without other commissioning activity. The booms may be partly or fully deployed. During this period ASPOC shall be commanded into "feedback mode" to test the on-board spacecraft potential control.

6. Nominal Operations

6.1 Operational Modes

References to previous sections

For an overview on operational modes see section 1.3.4.1.

For some technical details about modes see section 1.3.4.2.

For mode changes see section 1.3.6, and in particular the mode matrix in section 1.3.6.2, table 3.

For important parameters, listed by instrument mode see section 2.4.

For the general commanding philosophy in normal operations see also section 3.1.

6.1.1 Mode FEFW

NAME: feedback mode from EFW

FUNCTION: Updates ion beam current whenever valid spacecraft potential data from EFW are received in order to control the potential to the value of EAPOT_SV.

WHEN TO USE: One of the possible preferred modes for routine operation, if EFW provides valid spacecraft potential data on board.

WHERE TO USE: Outside eclipses, otherwise no particular constraints

COMMANDING: Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS
  filament selection, with x = 1...4 or M
ZEAMODxS
  module selection, with x = A or B or U
ZEAFIL_E
  filament enable
ZEAHV__E
  high voltage enable

The above commands shall be sent even if the emitter and the module are already selected, in order to have a defined sequence in case an autonomous shutdown took place.

The mode command itself is:

ZEAFEFWS or ZEAEXPMS,0x300

DEFAULT PARAMETER SETTINGS:

PARAMETER	RAW CONTENTS	
EABKMODE	0	backup mode
EACOEFKC	0x30	control loop coefficient Kc
EACOEFKV	0x32	control loop coefficient Kv
EACOEFTV	0x00	control loop coefficient Tv
EACOEFTX	0x20	control loop coefficient Tx
EAEFWINV	0	EFW inverted polarity flag
EAFILOTS	0xB7	filament operating temperature set point
EAFILTSU	0xB9	filament temperature for startup
EAIONCSV	0x0C	ion current set value
EAPOT_SV	0x19	S/C potential set value
EATOTCLL	0x05	total current lower limit
EATOTCSV	0x19	total current set value
EATOTCUL	0x80	total current upper limit
EAWISTAB	0	WHISPER decision table

ENVIRONMENTAL CONSTRAINTS:
no eclipse

EXPERIMENTAL CONSTRAINTS:

- enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command
- enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command
- a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode
- other relevant parameters may be changed also after this command
- spacecraft potential data from EFW should be available (otherwise the experiment switches into backup mode)
- cover of selected module must be open
- initial mode shall not be technical mode

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on:
- plasma environment (which via the control loop determines the emitted ion current)
- upper limit of total current (EATOTCUL) which limits the ion current available to on-board control
- initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter

VERIFICATION: EAOPMODE = 3

6.1.2 Mode FPEA

NAME: feedback mode from PEACE

FUNCTION: Updates ion beam current whenever valid spacecraft potential data from PEACE are received in order to control the potential to the value of EAPOT_SV.

WHEN TO USE: One of the possible modes for routine operation, if PEACE provides valid spacecraft potential data on board. Priority should be given to the mode FEFW.

WHERE TO USE: Outside eclipses, otherwise no particular constraints

COMMANDING: Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS
    filament selection, with x = 1...4 or M
ZEAMODxS
    module selection, with x = A or B or U
ZEAFIL_E
    filament enable
ZEAHV__E
    high voltage enable

The mode command itself is:

ZEAFPEAS or ZEAEXPMS,0x700

DEFAULT PARAMETER SETTINGS:

PARAMETER	RAW CONTENTS	
EABKMODE	0	backup mode
EACOEFKC	0x30	control loop coefficient Kc
EACOEFKV	0x32	control loop coefficient Kv
EACOEFTV	0x00	control loop coefficient Tv
EACOEFTX	0x20	control loop coefficient Tx
EAEFWINV	0	EFW inverted polarity flag
EAFILOTS	0xB7	filament operating temperature set point
EAFILTSU	0xB9	filament temperature for startup
EAIONCSV	0x0C	ion current set value
EAPEAOFF	0	offset for PEACE data
EAPOT_SV	0x19	S/C potential set value
EATOTCLL	0x05	total current lower limit
EATOTCSV	0x19	total current set value
EATOTCUL	0x80	total current upper limit
EAWISTAB	0	WHISPER decision table

ENVIRONMENTAL CONSTRAINTS:
no eclipses

EXPERIMENTAL CONSTRAINTS:
- enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command

- enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command
- a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode
- other relevant parameters may be changed also after this command
- spacecraft potential data from PEACE should be available (otherwise the experiment switches into backup mode)
- cover of selected module must be open
- initial mode shall not be technical mode

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on:
- plasma environment (which via the control loop determines the emitted ion current)
- upper limit of total current (EATOTCUL) which limits the ion current available to on-board control
- initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter

VERIFICATION: EAOPMODE = 7

6.1.3 Mode HOT

NAME: hot standby mode

FUNCTION: Keeps the emitter filament at operating temperature while high voltage is turned off

WHEN TO USE: For anticipated periods of about 10-40 minutes when no ion emission is required, in order to reduce the number of commands and to reduce the thermal stress of the emitter by avoiding one stop-start cycle.

WHERE TO USE: no particular constraints

COMMANDING: Since the mode previous to hot standby must be an active mode, no emitter select or enable commands have to be sent. The only command required is the mode command itself:

ZEAHOT_S or ZEAEXPMS,0x400

DEFAULT PARAMETER SETTINGS:

PARAMETER	RAW CONTENTS	
EAFILOTS	0xB7	filament operating temperature set point
EAFILTSU	0xB9	filament temperature for startup

ENVIRONMENTAL CONSTRAINTS:
no particular constraints

EXPERIMENTAL CONSTRAINTS:
- initial mode must be an active mode with ion emission (ITOT, IION, T&C, FEFW, FPEA)

RESOURCES: required power is reduced from the initial status by the amount of high voltage power consumed previously. This may have been up to ca. 30% of total nominal power depending on current and voltage selections. Remaining power consumption is less than ca. 70% of total nominal power; see also "hot standby mode power" in section 4.2; the exact value depends on thermal parameters.

VERIFICATION: EAOPMODE = 4

6.1.4 Mode IION

NAME: constant beam current mode

FUNCTION: Updates total current of the high voltage power supply to maintain a constant ion beam current (EAIONCSV)

WHEN TO USE: One of the possible preferred modes for routine operation. May also serve for the procedures to measure the current/voltage characteristics, if the current sweep is produced by individual time-tagged parameter settings.

WHERE TO USE: no particular constraints

COMMANDING: Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS
  filament selection, with x = 1...4 or M
ZEAMODxS
  module selection, with x = A or B or U
ZEAFIL_E
  filament enable
ZEAHV__E
  high voltage enable

The mode command itself is:

ZEAIIONS or ZEAEXPMS,0x200

DEFAULT PARAMETER SETTINGS:

PARAMETER	RAW CONTENTS	
EACOEFKC	0x30	control loop coefficient Kc
EACOEFTX	0x20	control loop coefficient Tx
EAFILOTS	0xB7	filament operating temperature set point
EAFILTSU	0xB9	filament temperature for startup
EAIONCSV	0x0C	ion current set value
EATOTCLL	0x05	total current lower limit
EATOTCUL	0x80	total current upper limit

ENVIRONMENTAL CONSTRAINTS:
no particular constraints

EXPERIMENTAL CONSTRAINTS:

- enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command
- enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command
- a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode
- other relevant parameters may be changed also after this command
- cover of selected module must be open
- initial mode shall not be technical mode

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on:

- set value of ion beam current (EAIONCSV)
- high voltage efficiency
- initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter

VERIFICATION: EAOPMODE = 2

6.1.5 Mode ITOT

NAME: constant total current mode

FUNCTION: reads every second the parameter EATOTCSV and outputs this current value to the high voltage power supply

WHEN TO USE: One of the possible preferred modes for routine operation. May also serve for the procedures to measure the current/voltage characteristics, if the current sweep is produced by individual time-tagged parameter settings.

WHERE TO USE: no particular constraints

COMMANDING: Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS
filament selection, with x = 1...4 or M
ZEAMODxS
module selection, with x = A or B or U
ZEAFIL_E
filament enable
ZEAHV__E
high voltage enable

The mode command itself is:

ZEAITOTS or ZEAEXPMS,0x100

DEFAULT PARAMETER SETTINGS:

PARAMETER	RAW CONTENTS	
EACOEFKC	0x30	control loop coefficient Kc
EACOEFTX	0x20	control loop coefficient Tx
EAFILOTS	0xB7	filament operating temperature set point
EAFILTSU	0xB9	filament temperature for startup
EATOTCSV	0x19	total current set value
EATOTCLL	0x05	total current lower limit
EATOTCUL	0x80	total current upper limit

ENVIRONMENTAL CONSTRAINTS:
no particular constraints

EXPERIMENTAL CONSTRAINTS:
- enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command
- enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command
- a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode
- other relevant parameters may be changed also after this command
- cover of selected module must be open
- initial mode shall not be technical mode

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on:

- set value of the total current (EATOTCSV)
- high voltage efficiency
- initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter

VERIFICATION: EAOPMODE = 1

6.1.6 Mode STDB

NAME: standby mode

FUNCTION: Turns off high voltage, turns off filament power, and resets the enable flags for filaments and high voltage:

EAFILENB
filament enable
EAHVSWEN
high voltage software enable
EAHVSHEN
hshut line enable

Also resets the validity of any previous filament and module selection (so the selection has to be repeated if necessary), but the parameter values of the selection (EAFILSEL and E EAMODULE) remain unchanged. One of the following parameters has to be set again before any active command can be commanded:

EAFILSEL by command ZEAFILxS (x=1 ... 4 or M)

EAMODULE by command ZEAMODxS (x=A or B or U)

WHEN TO USE: Whenever the experiment should turn passive.

WHERE TO USE: no particular constraints

COMMANDING: The only command required is the mode command itself:

ZEASTDBS or ZEAEXPMS,0x000

DEFAULT PARAMETER SETTINGS:
none

ENVIRONMENTAL CONSTRAINTS:
no particular constraints

EXPERIMENTAL CONSTRAINTS:
no particular constraints

RESOURCES: required power is reduced from the initial status by the amount of high voltage and filament power consumed previously. This may have been up to ca. 60% of total nominal power depending on current and voltage selections. Remaining power consumption is about 40% of total nominal power; see also "standby mode power" in section 4.2.

VERIFICATION: EAOPMODE = 0

6.1.7 Mode T&C

NAME: test and commissioning mode

FUNCTION: operates the ion emitter in a step function for the total current
The initial current value is the value of the parameter EATOTCSV (the total current set value).
The direction (sign) of the steps, when the command is sent, continues from the status when the mode has been left previously. The initial status after power-on is positive (increasing current).
The current range is limited by the total current limits EATOTCLL and EATOTCUL. Starting from the initial value the current is increased or decreased, but the direction is reversed before one of the limits would be exceeded.

WHEN TO USE: May serve for the procedures to measure the current/voltage characteristics, if the built-in parameters of the current sweep are suitable.

WHERE TO USE: no particular constraints

COMMANDING: Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS
    filament selection, with x = 1...4 or M
ZEAMODxS
    module selection, with x = A or B or U
ZEAFIL_E
    filament enable
ZEAHV__E
    high voltage enable

The mode command itself is:

ZEAT&C_S or ZEAEXPMS,0x500

DEFAULT PARAMETER SETTINGS:

PARAMETER	RAW CONTENTS	
EAFILOTS	0xB7	filament operating temperature set point
EAFILTSU	0xB9	filament temperature for startup
EASTEPL_	0	8 s steps
EASTEPS_	0	2 µA steps
EATOTCSV	0x19	total current set value
EATOTCLL	0x05	total current lower limit
EATOTCUL	0x80	total current upper limit

ENVIRONMENTAL CONSTRAINTS:
no particular constraints

EXPERIMENTAL CONSTRAINTS:
- enable command for filaments (ZEAFIL_E) must have been issued since power-on or a preceding disable command
- enable command for high voltage (ZEAHV__E) must have been issued since power-on or a preceding disable command

- a select command for an emitter module (ZEAMODxS) or an emitter number (ZEAFILxS) must have been issued since the last switching into standby mode
- other relevant parameters may be changed also after this command
- cover of selected module must be open
- initial mode shall not be technical mode

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on:

- set value of the total current (EATOTCSV)
- high voltage efficiency
- initial status of experiment: if the emitter is already being operating when the command is issued, then no additional heater power is required to start up the emitter

6.1.8 Mode TECH

NAME: technical mode

FUNCTION: allows low level check-out operations

WHEN TO USE: May serve for the procedures to measure the current/voltage characteristics, if the built-in parameters of the current sweep are suitable.

WHERE TO USE: no particular constraints

COMMANDING: Since the mode implies emitter filament operation and high voltage, the following commands have to be sent before to enable and select the emitter:

ZEAFILxS
filament selection, with x = 1...4 or M
ZEAMODxS
module selection, with x = A or B or U
ZEAFIL_E
filament enable
ZEAHV__E
high voltage enable

The mode command itself is:

ZEATECHS or ZEAEXPMS,0x600

DEFAULT PARAMETER SETTINGS:
Depending on telecommands sent during technical mode. Virtually any parameter can be relevant.

ENVIRONMENTAL CONSTRAINTS:
no particular constraints

EXPERIMENTAL CONSTRAINTS:
requires special attention by the operator
requires real-time housekeeping TM
The operator has to constantly log the status of the instrument. He must take care to reset all relays etc. which have been set.

RESOURCES: required power may amount up to maximum nominal power; see also "active mode power" in section 4.2; the exact value depends on various parameters.

VERIFICATION: EAOPMODE = 6

6.2 Operational Procedures

6.2.1 Philosophy

The instrument modes (ITOT, IION, FEFW, FPEA, T&C, TEST, HOT, STDB) are related to the technical capabilities of the instrument.

ASPOC is active only during scientific measurements of other instruments

ASPOC data need to be recorded only during:
- active modes of ASPOC (including an eventual ca. 25 minute start-up period for the emitters before general data taking periods,
- standby mode of ASPOC during general data taking periods (scientific measurements of other instruments)
- periods when EFW or PEACE provide spacecraft potential data via the IEL.

ASPOC housekeeping data need not be recorded during other periods.

ASPOC should be switched off during radiation belt (perigee) crossings. It shall go into standby mode during all other times except the active mode periods mentioned above.

6.2.2 Preferred mode

The preferred mode for nominal operations will be determined after first experience in orbit. It may be one of the following:

ITOT	constant total current mode
IION	constant beam current mode
FEFW	feedback mode from EFW
FPEA	feedback mode from PEACE

The selection will also depend on possible constraints for the feedback modes (e.g. interference by other instruments, see below).

The procedure QEAMODES is a generic procedure to bring the instrument into one of the operating modes and to turn off at the end of the operation time.

6.2.3 Interference by other instruments

Interference by other instruments falls into the following two categories:

1) Modification of the current equilibrium between the spacecraft and the ambient plasma by instruments which create currents into the plasma:

   EDI: current of the electron beam

   EFW: bias currents to the four probes

WHISPER: AC current pulses to the antenna in active modes

These additional currents in turn change the spacecraft potential.

If ASPOC is in one of its feedback modes for spacecraft potential, its control loop will change the ion beam current to maintain a constant potential within the constraints of this control: the time constant of the order of a few spin periods, and the upper technical limit of the ion beam current. In particular, ASPOC is not capable to compensate any short-term (millisecond range) potential variations caused by active WHISPER modes.

If ASPOC is in constant current mode, the result of this interference will be a modified spacecraft potential. The amount of the change is probably negligible for interfering currents below 1 µA in total.

2) Interference by some instrument on the measurement of the spacecraft potential by EFW or PEACE, while ASPOC is in feedback mode to control this potential:

This interference affects at first instance EFW or PEACE, but any disturbance of the measurement propagates through to ASPOC via the control loop. The result is a static or dynamic variation of the ion beam current and in turn of the real spacecraft potential.

As a theoretical example, the electron beam of EDI might hit a probe of EFW and cause a bad measurement of the spacecraft potential.

Another theoretical example: Assuming that WHISPER in an active mode does not modify the average spacecraft potential, it may nevertheless change the electron distribution function of PEACE such that the spacecraft potential derived from this distribution becomes wrong.

6.2.4 Routine measurement of the current/voltage characteristics

Every few (typically 6) hours, but at least once at the beginning of the first data acquisition period in each orbit, the normal mode should be interrupted for a beam current sweep lasting about 2 minutes, for a routine measurement of the current/voltage characteristics, if there is no interference with the main scientific objectives of that particular data taking period. The mode used for this purpose may be one of the following:

T&C	test and commissioning mode
ITOT	constant total current mode
IION	constant beam current mode

The procedure QEARCHAR is a generic procedure for this purpose.

6.2.5 Detailed investigations of the current/voltage characteristics and other beam effects

During every 3rd orbit the normal mode should be interrupted for detailed investigations of the current/voltage characteristics and other beam effects which last about 5 minutes. These procedures shall be agreed with all other experimenters in order to avoid disturbances of other measurements. The mode used for this purpose may be one of the following:

T&C test and commissioning mode
ITOT constant total current mode
IION constant beam current mode

The procedure QEADCHAR is a generic procedure for this purpose.

6.2.6 Cycling between emitters

The selected emitter shall be changed every hour at the beginning of the mission, in particular during the commissioning phase. It is known from tests in the vacuum chamber that frequent changes of emitters minimise the risk of cross-contamination between emitters. One of the observed effects is an increase of the start-up voltage.

Starting from one hour per emitter, all eight emitters will be cycled with slowly increasing time intervals until a significant increase of the start-up voltage or other signatures of cross-contamination are observed. The time interval for subsequent nominal operations will be determined from this experience. Values up to 6 hours are expected.

It is, however, possible that particularly the shorter data taking periods involving burst mode can be covered by one emitter without change.

The maximum continuous operating time of any single emitter will be determined during commissioning. In the transition period between initial turn-on of the instrument and the beginning of nominal operations ASPOC shall be turned on for several hours each time on a regular basis in order to assess the operating parameters (in particular the ignition voltage) of the ion emitters.

The following issues must be considered for the emitter cycling:

The new emitter must be selected by telecommand in the form of parameters to a command sequence. A single henceforth parameter setting is, however, not feasible. What is needed, is a "henceforth cycling sequence".

The cycling sequence is spacecraft dependent and changes several times during the mission.

The cycling is in principle independent of magnetospheric regions.

After execution of the cycling commands the new emitter will need 15 to 33 minutes until it can continue with the ion emission. This may affect the science data taking of other instruments, and these times shall not be placed into regions with the highest scientific interest of a particular data acquisition period.

The upper limit of operation time for a single emitter, as determined in the commissioning phase, may be exceeded by a small amount if thereby continuous operation during an acquisition period can be provided.

The procedure QEAEMCYC performs this emitter change.

6.2.7 Early turn-on

ASPOC may be turned on ca. 25 minutes before the science data taking period in order to allow emitter start-up to occur before the scientifically interesting region.

6.2.8 Relation between spacecraft

The same mode shall be used on all four spacecraft, also during the measurement of the current voltage characteristics in the current stepping mode.

6.2.9 Ground support by the experimenter team

On the ground the ASPOC team must keep track of several parameters of each individual emitter:

- accumulated operation time
- elapsed time since last operation
- operation time of neighbouring emitters since the last operation of the emitter
- current-voltage characteristics
- temperature requirements for start-up and nominal operation
- associated influence on the power profile

6.2.10 General constraints

A constraint for all modes is the successful commissioning.

It is NOT required that EFW be operational. Geotail experience has shown that the potential is sufficiently stable, when a constant current is emitted.

For feedback modes (FEFW, FPEA) there is the constraint that no interference has been detected during commissioning.

6.2.11 Number of telecommands for routine operations

The number of TC's are approximate.

Case without on-board macrocommands:

5 TC's	Setting of instrument parameters after turn-on
7 TC's	Switching into active mode
n*3 TC's	Change of emitter, which should occur at the beginning of every new data taking period along one orbit, and also within data taking periods which are longer than a maximum duration which will be determined during the commissioning phase.
1 TC	Parameter change during an orbit (e.g. spacecraft potential; 1 is an average value)
10 TC	Determination of spacecraft current-voltage characteristics
1 TC	Standby mode (end of active operations)

Case with on-board macrocommands:

7 TC's	Setting of instrument parameters after turn-on
1 Macro + 1 TC	Switching into active mode
n*(macro + TC)	Change of emitter, which should occur at the beginning of every new data taking period along one orbit, and also within data taking periods which are longer than a maximum duration which will be determined during the commissioning phase.
1 TC	Parameter change during an orbit (e.g. spacecraft potential; 1 is an average value)
1 Macro + 5 TC	Determination of spacecraft current-voltage characteristics
1 TC	Standby mode (end of active operations)

6.2.12 Monitoring during normal operations

The monitoring philosophy is briefly described in Section 2.1: Normal monitoring is through housekeeping TM via ESOC, JSOC. or the PI.

6.2.12.1 Parameters to be checked by on-board monitoring

Many of the ASPOC HK parameters are subcommutated which makes their automatic on-board monitoring difficult, and this is not foreseen in general. One possible exception are partial crashes of the experiment DPU (e.g. by a single event upset), which are not always caught by its watch-dog. On-board monitoring could help to detect as many of these failures as possible. There are two possible approaches, and both should be implemented:

1) Monitor the parameter EATOTC0_

The scale range of the parameter EATOTC0_ is 0-100 µA, but more than 90 µA cannot be produced by the experiment. Therefore on-board monitoring action shall be triggered by:

EATOTC0_ > 90 µA during 8 or more consecutive formats

(90 µA = 229 raw).

2) Monitor the parameter EAMUXID_

Malfunction of the DPU could have the effect that the parameter EAMUXID_ does not change its value in every frame. On-board monitoring software can detect this case in the following way:

Define 2 conditions for the parameter EAMUXID_.
a) EAMUXID_ must be 0 over 8 consecutive frames (8*5.15 s)
b) EAMUXID_ must be 1 over 8 consecutive frames (8*5.15 s)

The value of 8 was chosen to cover safely the time between power-on (duration ca. 5 seconds) and the first pair of HK frame outputs.

EAMUXID_ is byte 09, mask 0x10.

The action to be taken for both parameters EATOTC0_ and EAMUXID_ is to power off the instrument.

Without ground control the instrument shall be turned on again at the next time-tagged turn-on.

With ground control the instrument may be turned on again after about 60 seconds and further telecommands permitted under the condition that the default power-on state of the experiment is compatible with the time-tagged command sequences. This depends on the parameters of the initialisation command sequence (at the beginning of the orbit) which shall not deviate "too much" from the power-on defaults. The resulting state of the instrument will be standby mode until time-tagged experiment mode commands are received.

6.2.12.2 Parameters to be checked by ESOC

ESOC shall issue a warning to the PI if one of the parameters listed below goes out of limit (as given in Section 2.2), or one of the flags listed below is set. The parameter limits are mode-independent.

PARAMETER	DESCRIPTION
EAHVMON_	high voltage monitor
EATMPBOX	temperature at the motherboard.
EATMPDPU	temperature at one of the DPU boards
EATMPMD1	temperature at the top plate of the electronics box
EATMPMD2	temperature near the covers of the emitter modules
EAVP5___	secondary voltage + 5 V
EAVN5___	secondary voltage - 5 V
EAV13_5_	secondary voltage + 13.5 V

FLAG	DESCRIPTION
EABK_ACT	backup active flag
EACMDREJ	"command rejected" flag
EATIMOT2	feedback wait status
EAT1MOUT	timeout, no ignition
EAT2MOUT	timeout, no beam current
EAT3MOUT	timeout, EFW failure
EAT4MOUT	timeout, PEACE failure
EAT5MOUT	timeout, ion current set below limit

ESOC shall also monitor the same four parameters which are also checked by JSOC for scientific performance monitoring (section 6.2.12.4) and issue a warning to the PI if one of the parameters listed below goes out of limit.

- | EAFILTEM - EAFILOTS | > 20 deg C, while ASPOC is in an active mode (not standby, EAOPMODE<>0) and after start-up is completed (EASU_ACT=0).

- EAHVMON_: ESOC shall issue a warning to the PI if:

  a) the parameter is between 7.0 and 7.5 kV and shows an increasing trend with time (variations on the time scale shorter than 2-3 minutes may be ignored)

  b) the parameter exceeds the value of 7.5 kV for longer than 5 minutes outside the start-up phase.

- EATOTC0_: ESOC shall issue a warning to the PI if the parameter is oscillating with large amplitude in one of the feedback modes (FEFW or FPEA, EAOPMODE=3 or EAOPMODE=7, respectively).

- Loss current I_LOSS = 100 * (EATOTC0_ - EAIONC0_) / EATOTC0_:

  ESOC shall issue a warning to the PI if I_LOSS (the loss current normalised to the total current in percent) exceeds the values tabulated in 6.2.12.4.

6.2.12.3 Parameters to be checked by the PI

The experimenter shall not only analyse the parameters which have been checked before by ESOC, but also some additional ones. The AIT database for the following parameters does not contain hard limits. The evaluation of these parameters requires careful study of the operation history and full knowledge of the instrument.

Parameters to be checked in all modes:

PARAMETER	DESCRIPTION
EAFILIMN	filament current monitor
EAFILTEM	filament temperature on-board calculated
EAFILVMN	filament voltage monitor
EAHVMOD_	module select monitor
EAHVMON_	high voltage monitor
EAIONC0_ through EAIONC9_	ion current monitor
EALASTCM	last command
EATOTC0_ through EATOTC9_	total current monitor

Additional parameters to be checked in feedback modes (mainly by the PI):

PARAMETER	DESCRIPTION
EADWPNUM	number of DWP words received
EAEFWOF1	no. of 1st valid and new potential
EAEFWOF2	no. of 2nd valid and new potential
EAEFWPT1	S/C potential EFW
EAEFWPT2	2nd S/C potential EFW
EAEFWRX1	S/C potential EFW received
EAEFWRX2	2nd S/C potential EFW received
EAPEAPOT	S/C potential PEACE
EAPEAPT2	2nd S/C potential PEACE
EAPEARX1	S/C potential PEACE received flag
EAPEARX2	2nd S/C potential PEACE received flag
EAPEATI1	timing PEACE
EAPEATI2	2nd timing PEACE
EAPEPOTS	PEACE potential status
EAPEPT2S	2nd PEACE potential status
EATIMOT3	calculated ion current

6.2.12.4 Parameters to be checked by JSOC for scientific performance monitoring

Difference between measured and commanded emitter temperature

The PI software shall output a table of a new parameter DTEMP_xx, xx being the module and emitter identifications (A1,A2,...,B4) defined as:

DTEMP_xx = EAFILTEM - EAFILOTS

during periods with active ion emission. During standby mode (EAOPMODE=0), active startup (EASU_ACT=1), and within 5 minutes after completion of the startup, the output value is forced to zero.

The parameter name in the output table (and the display window at JSOC) shall contain the module and emitter ID (A1,A2,A3,A4,B1,B2,B3,B4) in the form DTEMP_ID.

JSOC action: JSOC shall issue a warning to the PI if | EAFILTEM - EAFILOTS | > 20 deg C.

Trend of high voltage

The PI software shall output a table of the parameter:

EAHVMON_

JSOC action: JSOC shall issue a warning to the PI if:

a) the parameter is between 7.0 and 7.5 kV and shows an increasing trend with time (variations on the time scale shorter than 2-3 minutes may be ignored)

b) the parameter exceeds the value of 7.5 kV for longer than 5 minutes outside the start-up phase. The out-of-limit case with EAHVMON_ > 8.5 kV is also covered by monitoring at ESOC.

Stability of total current

The PI software shall output a table of the parameter:

EATOTC0_

during periods with active ion emission in one of the feedback modes (FEFW or FPEA, EAOPMODE=3 or EAOPMODE=7, respectively). Elsewhere the output value is forced to -1 µA.

JSOC action: JSOC shall issue a warning to the PI if the parameter shows signatures of oscillations.

Loss current

The PI software shall output a table of a new parameter I_LOSS defined as:

I_LOSS = 100 * (EATOTC0_ - EAIONC0_) / EATOTC0_

which is the loss current normalised to the total current, in percent. It should be less than a few percent for low currents, and less than about 30% within the full current range. If EATOTC0_ < 4 µA the output is forced to 0 %, as the measurement becomes inaccurate. The major part of this loss current flows through the extraction electrode.

JSOC action: JSOC shall issue a warning to the PI if the parameter exceeds the limit given in the table below (constant percentage below 20 µA and above 40 µA, and linear interpolation between 20 and 40 µA) for longer than one minute. (Short exceedings are expected and tolerable immediately after start-up).

EATOTC0_	UPPER LIMIT of PARAMETER
4 µA	25%
20 µA	25%
24 µA	30%
28 µA	35%
32 µA	40%
36 µA	45%
40 µA	50%
80 µA	50%

6.2.12.5 Parameters to be checked by JSOC for inter-experiment calibration

Inter-experiment calibration shall be understood as the monitoring of the spacecraft potential in two ways.

1) Monitoring of the spacecraft potentials of EFW and PEACE, as contained in the ASPOC HK data:

EAEFWPT1	S/C potential EFW (measured)
EAPEAPOT	S/C potential PEACE (measured)

The PI software shall output a table of EAEFWPT1 and EAPEAPOT.

JSOC actions:

a) JSOC shall issue a warning to the PI's of EFW, PEACE and ASPOC if the potentials are systematically different between spacecraft or between EFW and PEACE. This comparison should be made away from plasma boundaries.

b) JSOC shall issue a warning to the PI's of EFW, PEACE and ASPOC if the potentials exceed +10 V despite ASPOC is in one of its active modes (IION, ITOT, FEFW, FPEA).

2) Monitoring of a parameter, which is derived from the spacecraft potential measured by EFW, as contained in the ASPOC HK data, and the ASPOC ion current. This parameter represents a crude estimate of the spacecraft potential which would be observed if ASPOC would emit a reference ion current. In this way several EFW spacecraft potential data can be compared even if the associated ion currents should be different.

The PI software shall output a table of a new parameter called

NORM_POT

which is the spacecraft potential measured by EFW, normalised to some reference ion current. if the algorithm does not converge, the output is forced to -1 V.

See Annex A.3 for a full description of all procedures referenced in this section 6.2:

QEADCHAR	detailed measurement of U/I-characteristics
QEAEMCYC	use other emitter (cycling between emitters)
QEAMODES	generic mode switch
QEARCHAR	routine measurement of U/I-characteristics

6.3 Command Sequences

The commanding of ASPOC will consist in many single commands (e.g. to select another ion beam current at a scheduled plasma boundary crossing).

The set-up of the instrument after power-off requires a few commands (typically 5). Feedback modes (FEFW, FPEA) and the test and commissioning mode (FT&C), if scheduled in a particular orbit, require additional commands (typically 5 each). The exact number is depending on the number of parameters which can remain at the default value after power-on. This number will be determined during the commissioning phase.

The selection of an emitter and the preparation of an active mode requires 5 commands, one single-command command sequence defining the operating mode, and a TBD number of commands to change parameters from their power-on default.

It is hoped that the majority of parameters may remain at their power-on default value forever. The command sequences listed here set a typical number and selection of these parameters.

For all Command Sequences listed in this section there are no hardware requirements on the delay between individual telecommands. However, in order to maintain the correct sequence of TCs, a nominal delay of 1 second between each command must be maintained. Table 6.1 contains the Command Sequences, their parameters and telecommands, Table 6.2 contains the new timing information. Note that the actual execution of the commands is carried out at each reset pulse. This must be taken into account only for defining the total duration of IBMD's at JSOC.

Table 6.1: ASPOC Command Sequences (for internal timing see Table 6.2)

CSEQ	PARAM.	FUNCTION	TELECOMMAND(S)
ASPEXPMS	expms	select experiment mode	ZEAEXPMS,expms
		expms=experiment mode code	
		0 = standby mode	
		1 = constant total current mode	
		2 = constant beam current mode	
		3 = feedback mode from EFW	
		4 = hot standby mode	
		5 = test and commissioning mode	
		6 = technical mode	
		7 = feedback mode from PEACE	
ASPBAKSET	f(p)	set backup mode p	
	p f(p)	description	
	1 0	backup mode 1 sel (standby)	ZEABAKMS,0
	2 1	backup mode 2 sel (total I)	ZEABAKMS,1
	3 2	backup mode 3 sel (beam I)	ZEABAKMS,2
	4 4	backup mode 4 sel (hot stdby)	ZEABAKMS,4
	5 3	backup mode 5 sel (fdbk EFW)	ZEABAKMS,3
	6 7	backup mode 6 sel (fdbk PEACE)	ZEABAKMS,7
ASPEMCHG	e,m	select emitter and module	
		e=filament number code (0-3)	
		m=module number code (0,1)	
		This CSEQ has also been proposed	
		as on-board macro in 8 variations	
			ZEAEXPMS,0
			ZEAFILMS,e
			ZEAMODUS,m
ASPSETIBEAM	i	set beam current	ZEAIISVS,i
		i=beam current	
ASPSETITOT	c	set total current	ZEAITSVS,c
		c=total current	
ASPSETPOT	v	set spacecraft potential	ZEASPSVS,v
		v=spacecraft potential	
		(this is a minimum version of	
		the CSEQ ASPPREPFEED)	

CSEQ	PARAM.	FUNCTION	TELECOMMAND(S)
ASPSETINIT	i,t,s	initialise after power-on i=beam current t=filament impedance, normal s=filament impedance, start-up	
			ZEAIISVS,i ZEAFISVS,t ZEAFISUS,s ZEAFIL_E ZEAHV__E
ASPPREPT_C	c,l,u,z,r	prepare test&commiss. mode c=initial total current l=lower current limit u=upper current limit z=step size (0=small,1=large) r=step period (0=short,1=long)	
			ZEAITSVS,c ZEAITSLS,l ZEAITSUS,u ZEASTESS,z ZEASTELS,r
ASPPREPFEED	v,l,u,g,d,w,p		
		prepare feedback mode v=spacecraft potential l=lower current limit u=upper current limit g=gain Kv d=delay Tv w=WHISPER code table p=backup mode	
			ZEASPSVS,v ZEAITSLS,l ZEAITSUS,u ZEACLKVS,g ZEACLTVS,d ZEAWHISS,w ZEABAKMS,f(p)
		p f(p) name 1 0 hex STDB 2 1 hex ITOT 3 2 hex IION 4 4 hex HOTS 5 3 hex FEFW 6 7 hex FPEA	
SCASPPOWEROF		power off	(no ASPOC TC's)
SCASPPOWERON		power on	(no ASPOC TC's)

Additional single-command command sequences for corrective actions:

CSEQ	PARAM.	FUNCTION	TELECOMMAND(S)
ASPCLKCS	kc	set control loop coeff. Kc	ZEACLKCS,kc
ASPCLKVS	kv	set control loop coeff. Kv	ZEACLKVS,kv
ASPCLTVS	tv	set control loop coeff. Tv	ZEACLTVS,tv
ASPCLTXS	tx	set ctrl loop coeff. Tx	ZEACLTXS,tx
ASPEFWNS		set EFW inverse polarity	ZEAEFWNS
ASPEFWPS		set EFW default polarity	ZEAEFWPS
ASPFIDAS	ftech	set filam. value/tech mode	ZEAFIDAS,ftech
ASPFIL_D		disable filaments	ZEAFIL_D
ASPFIL_E		enable filaments	ZEAFIL_E
ASPFILID		set filament converter off	ZEAFILID
ASPFILIE		set filament converter on	ZEAFILIE
ASPFISUS	fisu	set filam. temperature: startup	ZEAFISUS,fisu
ASPFISVS	fisv	set filam. temp.: set value	ZEAFISVS,fisv
ASPHLINE		set HV off	ZEAHLINE
ASPHLIND		set HV on	ZEAHLIND
ASPHV__D		disable HV	ZEAHV__D
ASPHV__E		enable HV	ZEAHV__E
ASPHVDAS	hvtech	HV set value/tech mode	ZEAHVDAS,hvtech
ASPHVIMS		set current control	ZEAHVIMS
ASPHVTHR	u	set high voltage threshold	ZEAHVTHR,u
ASPHVUMS		set voltage control	ZEAHVUMS
ASPITSLS	itll	set total current lower limit	ZEAITSLS,itll
ASPITSUS	itul	set total current upper limit	ZEAITSUS,itul
ASPMODUS	modul	module select	ZEAMODUS,modul
ASPPOFFS	peaoff	set offset for PEACE data	ZEAPOFFS,peaoff

CSEQ	PARAM.	FUNCTION	TELECOMMAND(S)
ASPSTEPS		step size and length select	
	steps	step size	
	stepl	step length	
			ZEASTESS,steps
			ZEASTELS,stepl
ASPTECHS		technical mode	ZEAEXPMS,6
ASPWHISS	whiscode	WHISPER code table	ZEAWHISS,whiscode

Table 6.2: Internal Timing of ASPOC Command Sequences (for parameters see Table 6.1)

CSEQ	NOMINAL TIME(s)	TELECOMMANDS
ASPEXPMS		
	0	ZEAEXPMS,expms
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPBAKSET		
	0	ZEABAKMS,f(p)
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPEMCHG		
	0	ZEAEXPMS,0
	1	ZEAFILMS,e
	2	ZEAMODUS,m
Number of TCs:		3
Nominal Duration (s):		3
Actual Duration (s):		15.6
ASPSETIBEAM		
	0	ZEAIISVS,i
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPSETITOT		
	0	ZEAITSVS,c
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPSETPOT		
	0	ZEASPSVS,v
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2

CSEQ	NOMINAL TIME(s)	TELECOMMANDS
ASPSETINIT		
	0	ZEAIISVS,i
	1	ZEAFISVS,t
	2	ZEAFISUS,s
	3	ZEAFIL_E
	4	ZEAHV__E
Number of TCs:		5
Nominal Duration (s):		5
Actual Duration (s):		25.7
ASPPREPT_C		
	0	ZEAITSVS,c
	1	ZEAITSLS,l
	2	ZEAITSUS,u
	3	ZEASTESS,z
	4	ZEASTELS,r
Number of TCs:		5
Nominal Duration (s):		5
Actual Duration (s):		25.7
ASPPREPFEED		
	0	ZEASPSVS,v
	1	ZEAITSLS,l
	2	ZEAITSUS,u
	3	ZEACLKVS,g
	4	ZEACLTVS,d
	5	ZEAWHISS,w
	6	ZEABAKMS,f(p)
Number of TCs:		7
Nominal Duration (s):		7
Actual Duration (s):		36
SCASPPOWEROF		
	(no ASPOC TC's)	
Nominal Duration (s):		0
Actual Duration (s):		0
SCASPPOWERON		
	(no ASPOC TC's)	
Nominal Duration (s):		0
Actual Duration (s):		0
ASPCLKCS		
	0	ZEACLKCS,kc
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2

CSEQ	NOMINAL TIME(s)	TELECOMMANDS
ASPCLKVS		
	0	ZEACLKVS,kv
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPCLTVS		
	0	ZEACLTVS,tv
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPCLTXS		
	0	ZEACLTXS,tx
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPEFWNS		
	0	ZEAEFWNS
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPEFWPS		
	0	ZEAEFWPS
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPFIDAS		
	0	ZEAFIDAS,ftech
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPFIL_D		
	0	ZEAFIL_D
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPFIL_E		
	0	ZEAFIL_E
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2

CSEQ	NOMINAL TIME(s)	TELECOMMANDS
ASPFILID		
	0	ZEAFILID
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPFILIE		
	0	ZEAFILIE
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPFISUS		
	0	ZEAFISUS,fisu
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPFISVS		
	0	ZEAFISVS,fisv
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHLINE		
	0	ZEAHLINE
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHLIND		
	0	ZEAHLIND
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHV__D		
	0	ZEAHV__D
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHV__E		
	0	ZEAHV__E
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2

CSEQ	NOMINAL TIME(s)	TELECOMMANDS
ASPHVDAS		
	0	ZEAHVDAS,hvtech
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHVIMS		
	0	ZEAHVIMS
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHVTHR		
	0	ZEAHVTHR,hv
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPHVUMS		
	0	ZEAHVUMS
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPITSLS		
	0	ZEAITSLS,itll
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPITSUS		
	0	ZEAITSUS,itul
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPMODUS		
	0	ZEAMODUS,modul
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPPOFFS		
	0	ZEAPOFFS,peaoff
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2

CSEQ	NOMINAL TIME(s)	TELECOMMANDS
ASPSTEPS		
	0	ZEASTESS,steps
	1	ZEASTELS,stepl
Number of TCs:		2
Nominal Duration (s):		2
Actual Duration (s):		10.3
ASPTECHS		
	0	ZEAEXPMS,6
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2
ASPWHISS		
	0	ZEAWHISS,whiscode
Number of TCs:		1
Nominal Duration (s):		1
Actual Duration (s):		5.2

7. Critical Operations

7.1 Short Eclipses

7.1.1 General approach

If EFW is in a mode which provides spacecraft potential, the preferred mode is constant beam current mode (IION),
else the preferred mode is standby (STDB). This approach is the contents of the procedure QEASHECL.

7.1.2 Preparation of the instrument before the eclipse

If any feedback mode has been active before the eclipse: switch into the preferred eclipse mode (IION or STDB).

7.1.3 Monitoring or activities during the eclipse

Same as during normal operations.

7.1.4 Conditioning after the eclipse

No special conditioning, just switch into required mode after eclipse.

7.1.5 Constraints

The status of EFW determines the preferred mode (See 7.1.1).

7.1.6 Resources

See 6.1.4 for mode IION or 6.1.6 for standby mode.

7.1.7 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 7.1:

QEAMODES	generic mode switch
QEASHECL	short eclipse operation

7.2 Long Eclipses

7.2.1 General approach

If the spacecraft power resources permit, and as long as temperatures stay within the nominal range:

proceed as during short eclipses (QEASHECL)

else:

turn off the instrument (QEAPOWOF).

7.2.2 Preparation of the instrument before the eclipse

Switch into the preferred eclipse mode (IION or STDB) or turn off instrument power (QEAPOWOF), depending on the general approach.

7.2.3 Monitoring or activities during the eclipse

If the instrument is on, same as during normal operation. is the instrument is off, none.

7.2.4 Conditioning after the eclipse

If the instrument has been on, just switch into the required mode after the eclipse.

If the instrument has been off, turn on power and uplink any necessary parameters which have been lost from on-board memory (procedure QEANORMP).

7.2.5 Constraints

If the instrument is on during the eclipse, the status of EFW determines the preferred mode (see 7.1.1).

7.2.6 Resources

Depending on the selected mode: See 6.1.4 for mode IION or 6.1.6 for standby mode (STDB). No resources are required in the power-off case.

7.2.7 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 7.2:

QEANORMP	restore routine operating parameters
QEAPOWOF	turn power off
QEASHECL	short eclipse operation

7.3 Perigee Passages

7.3.1 General approach

Because of the higher radiation during perigee passages the instrument power should be turned off.

This recommendation is based on the assumption that the statistically probable lifetime of the instrument will be increased by that. It is not meant that the operation of ASPOC within the belts exerts an immediate danger to the instrument. Therefore, if the SWT should decide that occasional measurements within the radiation belts have high scientific value, this decision would override the recommended switch-off.

The following rules for ASPOC flight operations planning are derived from the above:

1 If payload operations are planned near perigee, the planning should include ASPOC as long as there is no contradicting experience. It is expected that in the worst case the natural equilibrium potential would be very low and the ion emission by ASPOC would not change the potential significantly.

If it turns out that ASPOC may practically always be switched off near perigee, the updates of the PIOR files or even late changes are easier than the introduction of an active ASPOC period at a late stage.

If JSOC could acquire some good plasmasphere model, it would be possible for later planning periods (for orbits say, after the first year) to turn off ASPOC within the modelled plasmasphere.

2 During gaps between acquisition periods which are shorter than 30 minutes, and if ion emission by ASPOC is planned for both periods, ASPOC shall be switched into hot standby mode during the gap. Rationale: For short gaps the avoidance of thermal stress on the emitters is counted higher than any other effect.

3 If a gap between two payload data acquisition periods spans across perigee, ASPOC shall be switched off during this gap and re-initialised before the next acquisition period.

4 During all other gaps between acquisition periods (longer than 30 minutes and not across perigee) ASPOC shall remain in standby mode.

7.3.2 Preparation of the instrument before perigee

Turn off instrument power (procedure QEAPOWOF).

7.3.3 Monitoring or activities during perigee passage

None

7.3.4 Conditioning after perigee

If power has been switched off: turn on power and uplink any necessary parameters which have been lost from on-board memory (procedure QEANORMP).

Switch into any active mode using a routine procedure if required (QEAMODES), otherwise no special operations.

7.3.5 Constraints

The preferred mode is off. However, limitations on the master command schedule may dictate that the instrument shall occasionally remain in standby mode in oder to save the number of commands required to set up the instrument after the power off state (typically 5 commands).

7.3.6 Resources

See 6.1.6 for standby mode.

7.3.7 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 7.3:

QEAMODES	generic mode switch
QEANORMP	restore routine operating parameters
QEAPOWOF	turn power off

7.4 Manoeuvres

7.4.1 General approach

The instrument shall not be in an active mode (= with ion beam emission) during main engine operation. The preferred mode is standby mode in this case.

ASPOC can operate normally during the nutation damping period.

7.4.2 Preparation of the instrument before the manoeuvre

Switch into standby mode (QEAMODES).

7.4.3 Monitoring or activities during the manoeuvre

During the nutation damping period: Switch into any active mode using a routine procedure if required (QEAMODES), otherwise no special operations.

7.4.4 Conditioning after the manoeuvre

Switch into any active mode using a routine procedure if required (QEAMODES) if not already done during the manoeuvre; otherwise no special operations.

7.4.5 Constraints

No active instrument mode during main engine operation.

7.4.6 Resources

Same as in normal operations.

7.4.7 Procedures

See Annex A.3 for a full description. Procedures referenced in this section 7.4:

QEAMODES	generic mode switch
QEAPOWOF	turn power off

7.5 Patching SW

7.5.1 General approach

Function is not available.

7.5.2 Loading the Patch

See 7.5.1

7.5.3 Validation and verification

See 7.5.1

Function is not available.

7.5.4 Configuration control of patching

See 7.5.1

7.5.5 Reload of software after e.g. powering off

See 7.5.1

7.5.6 Constraints

See 7.5.1

7.5.7 Resources

See 7.5.1

7.5.8 Procedures

See 7.5.1

8. Contingency Operations

8.1 Failure Analysis (FMECA)

The failure codes given below are not available in TM. They are used for cross-references within this Section 8.

8.1.1 General failures

FAILURE MODE: Cover of a emitter module did not open

FAILURE CODE: G1

DESCRIPTION: The opening mechanism for an emitter module cover is to be activated by a spacecraft powered pyro piston actuator. After the firing pulse the HK data show that the cover is still closed.

VERIFICATION: The status monitor of the cover is in "closed" status (EACAP_A_=0 or EACAP_B_=0).

A more detailed analysis of housekeeping data during the start-up procedure of an emitter in the affected module may show a different behaviour if the module is still filled with gas than in vacuum. Thereby the data given by the status monitor can be verified.

Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

EFFECTS: The affected emitter module must not be operated in active modes which involve high voltage (ITOT, IION, FEFW, FPEA, T&C).

MODE CHANGE BY ON-BOARD SOFTWARE: none

CRITICALITY: A redundant emitter module is available.

FAILURE MODE: Partial failure of DPU

FAILURE CODE: G2

DESCRIPTION: The effects of any failure of the DPU or its interfaces are so complex that a complete description is impossible.

8.1.2 Ion emitter failures

FAILURE MODE: No ignition during start-up procedure

FAILURE CODE: E1

DESCRIPTION: In the start-up procedure of an emitter, which is activated automatically when an ion emission mode is commanded and no emitter is active at the time of the command, at first the temperature of the emitter is brought to start-up temperature, and then high voltage is applied to the emitter, slowly rising from 5 kV to maximum voltage. The failure has occurred if no ignition (beam current > 2.3 µA) has taken place within 20 minutes. The reason may be:
- emitter empty (no indium left)
- emitter contaminated
- temperature too low

VERIFICATION: The ion current monitor (EAIONC0_) shows zero or noise level data, the timeout flag EAT1MOUT is set.

MODE CHANGE BY ON-BOARD SOFTWARE:
standby mode (STDB)
Condition name: IGN (see also section 1.3.6.3)

EFFECTS: Experiment remains in standby mode until the next mode command. The emitter may be re-startable if the failure reason was a thermal one. If not, all attempts to re-start this emitter will fail, but there is no effect on other parts of the experiment.

CRITICALITY: Re-start capability is possible. If re-start fails, seven redundant emitters are available.

FAILURE MODE: Emitter current goes to zero during operation

FAILURE CODE: E2

DESCRIPTION: The internal resistance of the emitter has increased, and because it is operated in a current controlled mode, the high voltage has at first risen to the maximum value, and then the beam current emission stopped.
High voltage then remains at maximum level during 255 seconds after the decrease of the total current below the limit EATOTCLL (default value 2 µA), until on-board software finally reacts by turning off high voltage. The reason may be:

- emitter empty (no indium left)
- emitter contaminated
- temperature too low

Note that this failure mode is different from the case that in a feedback mode the control loop requires that the ion current be set to zero.

VERIFICATION:
- The total current monitor (EATOTC0_) shows zero or noise level data,
- the timeout flag EAT2MOUT is set,
- high voltage monitor (EAHVMON_) before the event was below maximum.

EFFECTS: The experiment remains in standby mode until the next mode command. The emitter may be re-startable if the failure reason was a thermal one. If not, all attempts to re-start this emitter will fail, but there is no effect on other parts of the experiment.

MODE CHANGE BY ON-BOARD SOFTWARE:
standby mode (STDB)
Condition name: I=0 (see also section 1.3.6.3)

CRITICALITY: Re-start capability is possible. If re-start fails, seven redundant emitters are available.

FAILURE MODE: High voltage permanently near maximum (> 7.5 kV)

FAILURE CODE: E3

DESCRIPTION: The internal resistance of the emitter has increased, and because it is operated in a current controlled mode, the high voltage has at first risen to a value above 7.5 kV, but below maximum. The high voltage increase is not a short-term effect, but continuous over about 15 minutes.

VERIFICATION: The high voltage monitor (EAHVMON_) permanently shows values near maximum (> 7.5 kV).

EFFECTS: No immediate effect, but the ion emission is in danger to stop if the voltage increases further to maximum.

MODE CHANGE BY ON-BOARD SOFTWARE: none

CRITICALITY: Risk of permanent loss of this emitter, if a "cleaning" procedure does not improve the situation.

FAILURE MODE: High leakage current

FAILURE CODE: E4

DESCRIPTION: The leakage current of an emitter (= the difference between total current and ion beam current) has increased significantly and permanently compared to the values of the commissioning phase.

VERIFICATION: EATOTC0_ - EAIONC0_ has increased significantly and permanently during at least 10 minutes compared to the values of the commissioning phase. Note that the permitted range of EATOTC0_-EAIONC0_ is a function of EATOTC0_.

EFFECTS: No immediate effect, but the risk of a high voltage breakdown or flash-over inside the emitter module near the operating emitter is highly increased, and therefore the emitter should no longer be operated unless detailed analysis of the data shows the harmlessness of the effect.

MODE CHANGE BY ON-BOARD SOFTWARE: none

CRITICALITY: Risk of permanent loss of this emitter.
Redundant emitters and emitter module available.

FAILURE MODE: Time variations of beam focussing

FAILURE CODE: E5

DESCRIPTION: The shape of the ion beam cone is varying in time because of bad indium flow to the tip due to indium shortage, contamination, or low temperature. The fraction of the beam current hitting the extraction electrodes is varying.

VERIFICATION: The variability of the quantity EATOTC0_ - EAIONC0_ has increased significantly compared to the values of the commissioning phase.

EFFECTS: Extra noise in the ion beam current.

MODE CHANGE BY ON-BOARD SOFTWARE: none

CRITICALITY:
- Reduced scientific performance.
- This mode may also indicate a future risk of permanent loss of this emitter
- In both cases redundant emitters are available.

FAILURE MODE:	**High voltage of a single module is open**
FAILURE CODE:	E6
DESCRIPTION:	The high voltage supply provides high voltage, but there is no emission at any of the four emitters of one module.
VERIFICATION:	The high voltage monitor (EAHVMON_) shows data up to the maximum value, but no emitter of the module can be started.
EFFECTS:	See failure modes E1 and E2 for more effects and their criticality.
CRITICALITY:	One redundant emitter module is available.

FAILURE MODE:	**High voltage of a single module is short**
FAILURE CODE:	E7
DESCRIPTION:	The high voltage supply provides high voltage together with the other emitter module, but there is no voltage at one module.
VERIFICATION:	The high voltage monitor (EAHVMON_) remains near zero, at least below about 3 kV together with one emitter module, but shows normal data up to the maximum value with the other module.
EFFECTS:	See failure modes E1 and E2 for more effects and their criticality.
CRITICALITY:	One redundant emitter module is available.

FAILURE MODE:	**General high voltage failure**
FAILURE CODE:	E8
DESCRIPTION:	The high voltage supply does not produce sufficient voltage to operate the emitters.
VERIFICATION:	The high voltage monitor (EAHVMON_) remains significantly below the nominal range together with both emitter modules.
EFFECTS:	For maximum voltages at about 5 kV or above one may try to operate all emitters. It may well be that one or the other emitter can be operated at this voltage.
CRITICALITY:	Partial or total loss of experiment

FAILURE MODE: Filament temperature stays below set value

FAILURE CODE: F1

DESCRIPTION: The filament temperature does not reach the commanded set value. The reason may be increased thermal losses from the emitter to the support structure, and/or failure of the filament power supply to provide the required power.

VERIFICATION: Deviation of the filament temperature monitor (EAFILTEM) from the set value. After start-up (EASU_ACT=0) the set value is in parameter EAFILOTS), during and a few minutes after start-up the temperature is variable.

EFFECTS: No immediate effect. The failure may indicate a future risk of emission failure due to low temperature.

MODE CHANGE BY ON-BOARD SOFTWARE: none

CRITICALITY: This mode may also indicate a future risk of permanent loss of this emitter. Redundant emitters are available.

FAILURE MODE: Emitter filament short-circuit

FAILURE CODE: F2

DESCRIPTION: The filament of an emitter has a short circuit.

VERIFICATION: The filament voltage monitor (EAFILVMN) shows a high value, and the current monitor (EAFILIMN) shows zero or noise level data.

EFFECTS: No ion emission from this emitter is possible. See failure modes E1 and E2 for effects and criticality.

FAILURE MODE: Emitter filament open-circuit

FAILURE CODE: F3

DESCRIPTION: The filament of an emitter has a short circuit.

VERIFICATION: The filament current monitor (EAFILIMN) shows a high value, and the voltage monitor (EAFILVMN) shows zero or noise level data.

EFFECTS: No ion emission from this emitter is possible. See failure modes E1 and E2 for more effects and their criticality.

FAILURE MODE:	**Emitter filament power control instability**
FAILURE CODE:	F4
DESCRIPTION:	The filament power converter can get in an unstable mode if an erroneously commanded change of power drives the filament current above 65 mA.
VERIFICATION:	The filament current monitor (EAFILIMN) and the voltage monitor (EAFILVMN) show significantly higher scatter than during the commissioning phase.
EFFECTS:	- Higher noise level produced by the supply, - reduced controllability of the filament temperature, which will probably leave the emitter too cold for ion emission.
CRITICALITY:	Re-start capability is possible. If re-start fails, seven redundant emitters are available.

8.1.3 Spacecraft potential control loop failures

Note that in the area of spacecraft potential control loop the features built into the experiment software are capable to handle many of the possible failures. See section 1.3.6 for a detailed description.

FAILURE MODE: IEL data flagged invalid

FAILURE CODE: I1

DESCRIPTION: In a feedback loop for the spacecraft potential the data required from EFW or PEACE over the IEL link are flagged as invalid by that instrument. On-board software may react in many different ways to this condition, depending on the exact condition and the commanded condition handling parameters. See section 1.3.6.3 for details. In some cases the on-board software switches the experiment mode into standby (STDB), in some cases into the commanded backup mode. Unlike with changes into backup mode, a switching into standby mode leaves the experiment waiting in passive status for another mode command.

VERIFICATION: The experiment mode is standby (EAOPMODE=0), although another mode has been commanded,
and one of the timeout flags (EAT3MOUT, EAT4MOUT, EATIMOT2) is set.

MODE CHANGE BY ON-BOARD SOFTWARE:
standby mode (STDB)
Condition names: ENV, PNV, FWX (see also section 1.3.6.3)

EFFECTS: The experiment remains in standby mode until the next mode command. There is no other permanent effect.

CRITICALITY: Re-start of ion emission is possible even in the same mode, if the IEL status or the ambient plasma conditions have changed. If not, another mode should be selected.
Two redundant data sources (EFW, PEACE), and modes without IEL requirements are available.

FAILURE MODE: IEL total failure (no data)

FAILURE CODE: I2

DESCRIPTION: No data are received from one of the instruments EFW or PEACE over the IEL link.

VERIFICATION: The "data received" flags (EAEFWRX1 or EAPEARX1) are zero at all times.
As a secondary effect, any attempt to operate the experiment in a feedback mode will cause the on-board failure detection to switch the instrument into standby mode.

EFFECTS: The experiment cannot be operated in feedback modes for spacecraft potential with the IEL instrument in failure.

CRITICALITY: Redundant data sources (EFW, PEACE), and modes without IEL requirements are available.

FAILURE MODE: IEL data invalid due to interference

FAILURE CODE: I3

DESCRIPTION: Data flagged as "valid" are received from one of the instruments EFW or PEACE over the IEL link, but the commissioning phase has shown that the spacecraft potential data are in error at any time or in certain configurations.

VERIFICATION: by scientific data analysis

EFFECTS: The experiment cannot be operated in feedback modes for spacecraft potential with the IEL instrument in failure at any time or in a certain configuration.

CRITICALITY: Redundant data sources (EFW, PEACE), and modes without IEL requirements are available.

FAILURE MODE: Control loop cannot handle IEL data properly

FAILURE CODE: I4

DESCRIPTION: Data flagged as "valid" are received from one of the instruments EFW or PEACE over the IEL link, but due to large data gaps or unforeseen characteristics of the control loop the control algorithm does not produce an almost stable spacecraft potential and a smoothly varying ion current.

VERIFICATION: The ion current emitted by the experiment (EAIONC0_) shows large variations, probably at spin frequency.

EFFECTS: The ion current oscillations cause the spacecraft potential to vary accordingly.

MODE CHANGE BY ON-BOARD SOFTWARE: none

CRITICALITY: The ion current oscillations cause the spacecraft potential to vary accordingly, thereby reducing the scientific value of the output of some other instruments.
If parameter changes do not improve the situation, modes without IEL requirements are available.

8.2 Instrument Failure Recovery

8.2.1 General recovery procedure

STEP DESCRIPTION

1 analyse failure

case of:

2 emitter problem, but emitter still operating:
- 2.1 try cleaning procedure once per orbit

3 no success of cleaning, total emitter failure or high voltage failure:
- 3.1 if mode not standby command standby mode
- 3.2 determine redundant emitter or emitter module
- 3.3 if no redundant emitter available: loss of experiment
- 3.4 select new emitter
- 3.5 re-start

4 IEL data failures:
- 4.1 if mode not standby command standby mode
- 4.2 determine redundant data source or safe operating mode which avoids this data source (in this order)
- 4.3 re-start

5 IEL control loop failures:
- 5.1 if mode not standby command standby mode
- 5.2 determine safe operating parameters or redundant data source or safe operating mode (in this order)
- 5.3 re-start

The standby command (ZEASTDBS or ZEAEXPMS,0) always brings the instrument into a safe mode.

Automatic on-board recovery actions by the OBDH are not feasible because the DPU of ASPOC already carries out automatic mode changes as far as possible. The ASPOC DPU is, however, NOT capable to perform the following tasks which therefore involve PI/JSOC/ESOC interaction:

Small emitter problem: cleaning procedure

This procedure involves the switching into constant total current mode, setting of a high current value, and the return to the previous mode and its settings.

A simplified version of this procedure may not return to the previous mode, but rather stay in constant total current mode with a normal setting of the current until the end of the scheduled operation with the emitter.

Total emitter or high voltage failure:

The full procedure implies switching to standby mode, then re-start with another emitter.

On-board software does not maintain a list of "good" emitters and therefore cannot select the new emitter. Further, the re-start requires knowledge of the previous mode as in the previous paragraph for small emitter problems.

IEL data failures:

These failures are basically handled by ASPOC software (backup mode etc.) unless the signatures of the failure are too difficult to determine on-board (e.g. noisy data on the IEL causing irregular ion beam current variations).

8.2.2 Redundancy concept

The redundancy concept is described in many places in this manual.

For failures at one emitter module with four emitters and common high voltage there is
- module redundancy by two emitter modules

For failures at one emitter (filament or indium flow) there is
- emitter redundancy by four emitters in each module

For failures with one instrument interfaced over the IEL there is
- IEL redundancy by two independent instruments interfaced via the IEL

For failures with both instrument interfaced over the IEL or general problems with feedback control of the spacecraft potential there is
- mode redundancy by stand-alone experiment modes

See section 1.3 for a description of all modes.

8.2.3 TM parameters monitored

The applicable housekeeping TM parameters are given:

- for high voltage and emitter failures in section 4.2.4
- for IEL failures in section 4.5.2.

8.2.4 Troubleshooting chart

The general recovery procedure under 8.2.1 may also serve as a troubleshooting chart.

8.3 Contingency Recovery Procedures

In general, on-board software is intelligent enough to find back-up modes for some of the possible IEL problems.

All other procedures in general have to involve JSOC for mainly two reasons:

- If a change of an emitter is involved, only the experimenter team or JSOC as its delegate has full knowledge about the characteristics of all emitters and the rationale for this change,

- Mode changes between IEL feedback and stand-alone modes also affect the scientific output not only of ASPOC, but also of some other experiments on Cluster-II.

The five different recovery procedures (CRP) listed below require:

- knowledge of the initial mode of the instrument, the emitter and emitter module selection in order to command this mode including the selection after successful completion of the main body of the CRP. This requirement can be dropped at the expense that the instrument remains in passive (standby) mode until the next mode command in the master schedule.

  Affected procedures: QEACLEAN, QEAEMTRY, QEAEMCYC, QEAHLEAK (calls QEACLEAN), QEAMODES

- knowledge of a prioritised list of redundant emitters. Many of the CRP's require the selection of another emitter and/or emitter module. The alternative to these procedures is to command standby mode and inhibit further master schedule commanding until the updated emitter selection has been entered into the timeline.

  Affected procedures: QEAEMTRY, QEAEMCYC, QEAHLEAK (calls QEAEFAID), QEAMODES

Responsibilities

The experimenter needs full control over the selection of alternative instrument modes and alternative emitters which is implicit to the recovery procedures. The reasons are possible emitter- and mode-dependent instrument parameter settings (by additional or modified commands) which can only be defined after some experience with the instrument has been gathered in orbit.

Therefore the experimenter is involved in these procedures at some stage unless it is feasible to provide ESOC with very detailed instructions (based on experience in orbit).

The simplified approach for all CRP's listed here, which however sacrifices active operation of ASPOC until an update of the master command schedule has occurred, is:

- ESOC sends the standby command (ZEASTDBS or ZEAEXPMS,0)

- ESOC inhibits further commanding of ASPOC through the master schedule

- ESOC informs the experimenter

- The experimenter develops a new command timeline with the help of JSOC and ESOC

The table below lists the failure modes of section 8.1 and the relevant contingency recovery procedures. The procedures are partly the same as used during commissioning etc. See Annex A.3 for a full description.

FAILURE MODE: Cover of a emitter module did not open
FAILURE CODE: G1
CRP: none (use redundant module)

FAILURE MODE: Partial failure of DPU
FAILURE CODE: G2
CRP: none (detailed analysis required)

FAILURE MODE: No ignition during start-up procedure
FAILURE CODE: E1
CRP: QEAEMTRY

FAILURE MODE: Emitter current goes to zero during operation
FAILURE CODE: E2
CRP: QEAEMTRY

FAILURE MODE: High voltage permanently near maximum (> 7.5 kV)
FAILURE CODE: E3
CRP: QEACLEAN

FAILURE MODE: High leakage current
FAILURE CODE: E4
CRP: QEAHLEAK

FAILURE MODE: Time variations of beam focussing
FAILURE CODE: E5
CRP: QEAHLEAK

FAILURE MODE: High voltage of a single module is open
FAILURE CODE: E6
CRP: QEAEMCYC

FAILURE MODE: High voltage of a single module is short
FAILURE CODE: E7
CRP: QEAEMCYC

FAILURE MODE: General high voltage failure
FAILURE CODE: E8
CRP: QEAEMCYC

FAILURE MODE: Filament temperature stays below set value
FAILURE CODE: F1
CRP: QEAEMCYC

FAILURE MODE: Emitter filament short-circuit
FAILURE CODE: F2

CRP: QEAEMCYC

FAILURE MODE: Emitter filament open-circuit
FAILURE CODE: F3
CRP: QEAEMCYC

FAILURE MODE: Emitter filament power control instability
FAILURE CODE: F4
CRP: QEAEMTRY

FAILURE MODE: IEL data flagged invalid
FAILURE CODE: I1
CRP: QEAMODES

FAILURE MODE: IEL total failure (no data)
FAILURE CODE: I2
CRP: QEAMODES

FAILURE MODE: IEL data invalid due to interference
FAILURE CODE: I3
CRP: QEAMODES

FAILURE MODE: Control loop cannot handle IEL data properly
FAILURE CODE: I4
CRP: QEAMODES

A. Annexes

A.1 Databases

A.1.1 HK-TC Cross-check

A.1.1.1 General Commands

Command	Code	Changes Parameter	into
ZEAEXPMS	0x1x00	EAOPMODE	x
ZEASTDBS	0x1000	EAOPMODE	0
ZEAITOTS	0x1100	EAOPMODE	1
ZEAIIONS	0x1200	EAOPMODE	2
ZEAFEFWS	0x1300	EAOPMODE	3
ZEAHOT_S	0x1400	EAOPMODE	4
ZEAT&C_S	0x1500	EAOPMODE	5
ZEATECHS	0x1600	EAOPMODE	6
ZEAFPEAS	0x1700	EAOPMODE	7
ZEABAKMS	0x2x00	EABKMODE	x
ZEABAK1S	0x2000	EABKMODE	0
ZEABAK2S	0x2100	EABKMODE	1
ZEABAK3S	0x2200	EABKMODE	2
ZEABAK5S	0x2300	EABKMODE	3
ZEABAK4S	0x2400	EABKMODE	4
ZEABAK6S	0x2700	EABKMODE	7
ZEAFILMS	0x3x00	EAFILSEL	x
		EAFILSLD	1
ZEAFIL1S	0x3000	EAFILSEL	0
		EAFILSLD	1
ZEAFIL2S	0x3100	EAFILSEL	1
		EAFILSLD	1
ZEAFIL3S	0x3200	EAFILSEL	2
		EAFILSLD	1
ZEAFIL4S	0x3300	EAFILSEL	3
		EAFILSLD	1
ZEAMODUS	0x4x00	EAMODULE	x
ZEAMODAS	0x4000	EAMODULE	0
ZEAMODBS	0x4100	EAMODULE	1
ZEASTELS	0x4x00	EASTEPL_	x (see TC definition for exact mask)
ZEASTESS	0x4x00	EASTEPS_	x (see TC definition for exact mask)
ZEASTSSS	0x4800	EASTEPS_	0
ZEASTSLS	0x4900	EASTEPS_	1
ZEASTLSS	0x4A00	EASTEPL_	0
ZEASTLLS	0x4B00	EASTEPL_	1
ZEAEFWPS	0x5000	EAEFWINV	0
ZEAEFWNS	0x5100	EAEFWINV	1

A.1.1.2 Direct switch commands (for technical mode)

Command	Code	Changes Parameter	into
ZEAFR1OS	0xC101	-	
ZEAFR1XS	0xC102	-	
ZEAFR2OS	0xC103	-	
ZEAFR2XS	0xC104	-	
ZEAFR3OS	0xC105	-	
ZEAFR3XS	0xC106	-	
ZEAFR4OS	0xC107	-	
ZEAFR4XS	0xC108	-	
ZEAM1ONS	0xC10B	-	
ZEAM2ONS	0xC10C	-	
ZEAH1ONS	0xC10D	-	
ZEAH2ONS	0xC10E	-	

A.1.1.3 High voltage control

Command	Code	Changes Parameter	into
ZEAHLINE	0x7000	EAHVSHST	1
ZEAHLIND	0x7100	EAHVSHST	0
ZEAHV__D	0x8000	EAHVSWEN	0
ZEAHV__E	0x8100	EAHVSWEN	1
ZEAHVUMS	0x9000	EAHVCNMD	1
ZEAHVIMS	0xA000	EAHVCNMD	0

A.1.1.4 Filament control

Command	Code	Changes Parameter	into
ZEAFIL_D	0x6000	EAFILENB	0
ZEAFIL_E	0x6100	EAFILENB	1
ZEAFILID	0xB000	-	
ZEAFILIE	0xB100	-	

A.1.1.5 Parameter commands

Command	Code	Changes Parameter	into
ZEAFIDAS	0xC2xx	EAFILOUT	"xx" (hex)
ZEAHVDAS	0xC3xx	EAHV_OUT	"xx" (hex)
ZEAFISUS	0xC4xx	EAFILISU	"xx" (hex)
ZEAFISUS	0xC4xx	EAFILTSU	"xx" (hex)
ZEAFISVS	0xC5xx	EAFILOSV	"xx" (hex)
ZEAFISVS	0xC5xx	EAFILOTS	"xx" (hex)
ZEAPOFFS	0xC6xx	EAPEAOFF	"xx" (hex)
ZEAITSVS	0xC7xx	EATOTCSV	"xx" (hex)
ZEAITSUS	0xC8xx	EATOTCUL	"xx" (hex)
ZEAITSLS	0xC9xx	EATOTCLL	"xx" (hex)
ZEASPSVS	0xCAxx	EAPOT_SV	"xx" (hex)
ZEAWHISS	0xCBxx	EAWISTAB	"xx" (hex)
ZEACLTXS	0xCCxx	EACOEFTX	"xx" (hex)
ZEACLKCS	0xCDxx	EACOEFKC	"xx" (hex)
ZEAIISVS	0xCExx	EAIONCSV	"xx" (hex)
ZEAHVTHR	0xCFxx	EAHVTHRE	"xx" (hex)
ZEACLTVS	0xD0xx	EACOEFTV	"xx" (hex)
ZEACLKVS	0xD1xx	EACOEFKV	"xx" (hex)

A.2 Macrocommands

The following macrocommands are proposed:

1) Macro Name: SELECT_A1
Function: selects emitter 1 in module A

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODAS	0x4000
	ZEAFIL1S	0x3000

2) Macro Name: SELECT_A2
Function: selects emitter 2 in module A

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODAS	0x4000
	ZEAFIL2S	0x3100

3) Macro Name: SELECT_A3
Function: selects emitter 3 in module A

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODAS	0x4000
	ZEAFIL3S	0x3200
	ZEAFIL_E	0x6100
	ZEAHV__E	0x8100

4) Macro Name: SELECT_A4
Function: selects emitter 4 in module A

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODAS	0x4000
	ZEAFIL4S	0x3300

5) Macro Name: SELECT_B1
Function: selects emitter 1 in module B

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODBS	0x4100
	ZEAFIL1S	0x3000

6) Macro Name: SELECT_B2
Function: selects emitter 2 in module B

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODBS	0x4100
	ZEAFIL2S	0x3100

7) Macro Name: SELECT_B3
Function: selects emitter 3 in module B

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODBS	0x4100
	ZEAFIL3S	0x3200

8) Macro Name: SELECT_B4
Function: selects emitter 4 in module B

Commands:	LABEL	HEX
	ZEASTDBS	0x1000
	ZEAMODBS	0x4100
	ZEAFIL4S	0x3300

A.3 Procedures

Table of procedures

CODE	CRP USE	FUNCTION
QEACLEAN	YES	emitter cleaning
QEADCHAR		detailed measurement of U/I-characteristics
QEAEFAID	YES	possible emitter failure detected on board
QEAEMCYC	YES	use other emitter (cycling between emitters)
QEAEMOPT		optimisation of emitter operations
QEAEMTRY	YES	try to re-start, then change emitter
QEAFPYRO		fire both pyros
QEAFTEFW		feedback test with EFW
QEAFTPEA		feedback test with PEACE
QEAHLEAK	YES	irregular high voltage leakage current
QEAHVTST		HV test during Initialization
QEAINITL		initial experiment turn-on
QEAINITH		initial high voltage turn-on
QEAMODES	YES	generic mode switch
QEANORMP		restore routine operating parameters
QEAPOWOF	YES	turn power off
QEAPOWON		turn power on
QEAPRVER		verify pressure in module
QEARCHAR		routine measurement of U/I-characteristics
QEASHECL		short eclipse operation
QEASTART		start-up test of one emitter
QEASTDBS	YES	set standby mode
QEAWHIFB		test effect of WHISPER on feedback loop

PROCEDURE: QEACLEAN

TITLE: emitter cleaning

PURPOSE: to improve the indium flow near the tips of the emitters and thereby to lower the voltage

APPLICABILITY: if there is a continuous (> 15 minutes) increase of high voltage above 7.5 kV

RESPONS.: ESOC + experimenter

CONSTRAINTS: experiment in an active mode (ITOT, IION, FEFW, FPEA, T&C)
Desirable is a low plasma density to have the full beam current range available without risk of negative spacecraft charging

RESOURCES: no change from initial active mode

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
some active mode (ITOT, IION, FEFW, FPEA, T&C)

FINAL STATUS OF EXPERIMENT:
same as initial

INPUT PARAMETERS:
<mo> = number of initial mode (EAOPMODE)
<du> = duration of high current peak in seconds
<it> = value of high total current peak in μA
<ip> = initial value of total current setting

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
Switch from initial mode to constant total current mode,
apply total current <it> during <du> seconds to remove contaminating layers from the tip of the ion emitter,
return to original mode.

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	test total current setting <ip> and store value for resetting at the end of the procedure		EATOTCSV
t0	2	test initial mode setting <mo> and store value for resetting at the end of the procedure		EAOPMODE
t0	3	set constant total current to <it> µA	ZEAITSVS	EATOTCSV
t0	4	switch to constant total current mode	ZEAEXPMS,1	EAOPMODE=1
t0+10+ <du> s	5	return to previous current setting with <ip> µA	ZEAITSVS	EATOTCSV
t0+10+ <du> s	6	if <mo> <> 1: return to initial mode <mo>: <mo>=2: IION <mo>=3: FEFW <mo>=5: T&C_ <mo>=7: FPEA	ZEAEXPMS,mo	EAOPMODE

PROCEDURE:	**QEADCHAR**
TITLE:	detailed measurement of U/I-characteristics
PURPOSE:	measure a detailed measurement of the U/I-characteristics of the spacecraft
APPLICABILITY:	1) at the beginning of the first data acquisition period in every special (3rd) orbit 2) part of the commissioning
RESPONS.:	experimenter
CONSTRAINTS:	EFW in voltage mode (in special orbits) EFW is very desirable, but not absolutely necessary when this procedure is executed during the commisioning phase, because the purpose is different in this case. Desirable: PEACE providing spacecraft potential data See description of telecommand ZEAFILMS for constraints on the emitter selection.
RESOURCES:	active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
total current mode (EAOPMODE=0), ion beam emission

FINAL STATUS OF EXPERIMENT:
same as initial status

INPUT PARAMETERS:
<ip> = initial value of total current setting

RELATED PROCEDURES:
QEARCHAR

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
Switch from initial mode to constant total current mode,
apply various total current steps during about 5 minutes,
return to original mode.

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	test total current setting <ip> and store value for resetting at the end of the procedure		EATOTCSV
t0	2	test initial mode setting <mo>. If EAOPMODE<>1, exit the procedure		EAOPMODE
t0	6	prepare routine test&commissioning mode with initial total current c=12 µA, lower current limit l=4 µA, upper current limit u=40 µA, large step size z=1, and short period r=0	ASPPREPT_C,c,l,u,z,r (CSEQ) ZEAITSVS,c ZEAITSLS,l ZEAITSUS,u ZEASTESS,z ZEASTELS,r	 EATOTCSV EATOTCLL EATOTCUL EASTEPS_ EASTEPL_
t0+60s	7	wait for completion of execution of the previous commands and command test&commissioning mode	ZEAEXPMS,5	
t0+180s	8	prepare detailed test&commissioning mode with initial total current c=12 µA, lower current limit l=2 µA, upper current limit u=50 µA, small step size z=0, and short period r=0	ASPPREPT_C,c,l,u,z,r (CSEQ) ZEAITSVS,c ZEAITSLS,l ZEAITSUS,u ZEASTESS,z ZEASTELS,r	 EATOTCSV EATOTCLL EATOTCUL EASTEPS_ EASTEPL_
t0+480s	9	command constant total current mode	ZEAEXPMS,1	
t0+480s	10	return to previous current setting with <ip> µA	ZEAITSVS	EATOTCSV

PROCEDURE: QEAEFAID

TITLE: possible emitter failure detected on board

PURPOSE: to select a new ion emitter if the initial emitter had a failure which was detected by on-board software which has set the experiment mode to standby

APPLICABILITY: contingency

RESPONS.: ESOC + experimenter

CONSTRAINTS: see description of telecommand ZEAFILMS for constraints on the emitter selection.

RESOURCES: no particular constraints

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
same as initial status, possibly new emitter selection

INPUT PARAMETERS:
<mo> = number of initial mode (EAOPMODE)
<ne> = number of initial emitter (EAFILSEL) (0-3)
<nm> = number of initial module (EAMODULE) (0-1)

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
analyse housekeeping data and switch into standby mode,
based on this analysis and on the logbook with previous emitter operations select new emitters for future operations and update the emitter and/or module numbers and/or filament temperature settings in the command timeline

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	test initial mode setting <mo> and store value for resetting at the end of the procedure		EAOPMODE
t0	2	test emitter number setting <ne> and store value for resetting at the end of the procedure		EAFILSEL
t0	3	test emitter module setting <nm> and store value for resetting at the end of the procedure		EAMODULE
t0	4	command standby mode	ZEAEXPMS,0	
t0	5	analyse HK data and choose redundant emitter		
t0+TBD	6	select the new emitter, with e=<ne> and m=<nm>	ASPEMCHG,e,m (CSEQ): ZEAEXPMS,0 ZEAFILMS,e ZEAMODUS,m	 EAOPMODE=0 EAFILSEL EAMODULE
t0+TBD	7	if <mo> <> 0: return to initial mode <mo>: <mo>=1: ITOT <mo>=2: IION <mo>=3: FEFW <mo>=5: T&C_ <mo>=7: FPEA	ZEAEXPMS,mo	EAOPMODE

PROCEDURE: **QEAEMCYC**

TITLE: use other emitter (cycling between emitters)

PURPOSE: to switch from one emitter to another

APPLICABILITY: failure of initial emitter or cycling between emitters at regular intervals; these intervals range from 1 hour to about 10 hours and will be determined in the commissioning phase and afterwards updated regularly.

RESPONS.: ESOC + experimenter

CONSTRAINTS: see description of telecommand ZEAFILMS for constraints on the emitter selection.

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
same as initial status, but with new emitter selection

INPUT PARAMETERS:
<mo> = number of initial mode (EAOPMODE)
<ne> = number of initial emitter (EAFILSEL) (0-3)
<nm> = number of initial module (EAMODULE) (0-1)

RELATED PROCEDURES:
QEAEMTRY

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
Stop initial mode,
switch from one emitter to another,
return to original mode.

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	test initial mode setting <mo> and store value for resetting at the end of the procedure		EAOPMODE
t0	3	set standby mode, select the new emitter, with e=<ne> and m=<nm>, increase high voltage threshold to 8.5 kV during start-up phase	ASPEMCHG,e,m (CSEQ): ZEAEXPMS,0 ZEAFILMS,e ZEAMODUS,m ZEAHVTHR,0xd9	 EAOPMODE=0 EAFILSEL EAMODULE EAHVTHRE
t0+30s	4	if <mo> = 1,2,3,5, or 7: return to initial mode <mo>: <mo>=1: ITOT <mo>=2: IION <mo>=3: FEFW <mo>=5: T&C_ <mo>=7: FPEA	ZEAEXPMS,mo	EAOPMODE
t0+2030	5	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE

PROCEDURE: **QEAEMOPT**

TITLE: optimisation of emitter operations

PURPOSE: procedure called after the basic commissioning of the instrument, in order to determine the maximum operation time of the ion emitters without signatures of contamination effects on neighbouring emitters.

APPLICABILITY: after initial commissioning, and in between or after intercalibration and interference tests

RESPONS.: experimenter

CONSTRAINTS: The following steps may be carried out in parallel on all spacecraft.

It is permitted that the emitter cycling is interrupted by other commissioning operations. If ASPOC remains inactive during these periods, the emitter cycling can be resumed afterwards without change. If the other commissioning operations require ASPOC to turn on one ion emitter, the accumulated operation time of this emitter has to be taken into account when the cycling period are calculated.

There are no requirements on the time intervals between the individual emitter operation periods: anything between immediate continuation with the next emitter (especially for short emitter operation periods) and pauses from one orbit to the next are allowed.

In particular, it is also possible to operate the active emitter in some on-off cycle, as required by some inter-expderiment calibration and interference tests, as long as the accumulated operating time follows the cycling test requirements.

The item under test is the accumulated operating time of neighbouring emitters before an increase of the ignition voltage of an emitter can be observed.

NOT included in the following timeline are commands to turn the instruments on and off, and the usual command sequence after turn-on (ASPSETINIT). The whole sequence is based on time-tagged commands and intermediate HK data analysis. As soon as the analysis shows that the maximum single emitter operation time has been reached, the procedure shall be interrupted and further time-tagged commands shall be disabled.

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:

NO real-time HK telemetry required

INITIAL STATUS OF EXPERIMENT:

standby mode, and after execution of the instrument turn-on command sequence (ASPSETINIT).

FINAL STATUS OF EXPERIMENT:

standby mode

INPUT PARAMETERS:

<t> = operating time of one emitter in minutes <t>
<sel> = selection module ID's and emitter numbers to be operated; possible entries are: A1,A2,A3,A4,B1,B2,B3,B4
<it> = initial value of total current setting

RELATED PROCEDURES:

none

CALLED PROCEDURES:

none

FUNCTIONAL CHARACTERISTICS:

This procedure consists of command sequences only.
1) select the first emitter and module of the selection parameter
2) command "total current mode" with the total current specified as the parameter <it>
3) operate during the time specified as the parameter <t>
4) set standby mode
5) repeat steps 1-3 for all emitters in the selection

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set total current	ZEAITSVS,<it>	EATOTCSV
t0	1a	set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0	2	select next emitter e and module m from the parameter list	ASPEMCHG,e,m (CSEQ) ZEAEXPMS,0 ZEAFILMS,e ZEAMODUS,m	 EAOPMODE=0 EAFILSEL EAMODULE
t0	3	set constant total current mode	ZEAEXPMS,1	EAOPMODE=1
t0+2000	3a	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE
t0+<t-0.5>*60	3b	set total current to 50 µA during 30 seconds before the standby command,	ZEAITSVS,0x80	EATOTCSV

		for cleaning purposes	
t0+<t>*60	4	set standby mode	ZEAEXPMS,0 EAOPMODE=0
t0+<t>*60	5	go to step 2 until last emitter and module is reached	
end	6	reset total current to value for continuous operation	ZEAITSVS,<it> EATOTCSV

PROCEDURE: **QEAEMTRY**

TITLE: try to re-start, then change emitter

PURPOSE: to try a restart of the current emitter and in case of failure to switch to another emitter

APPLICABILITY: failure of initial emitter with a chance of re-start capability

RESPONS.: ESOC + experimenter

CONSTRAINTS: see description of telecommand ZEAFILMS for constraints on the emitter selection.

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
standby mode

FINAL STATUS OF EXPERIMENT:
constant total current mode, possibly with a different emitter selection

INPUT PARAMETERS:
<ne1> = number of initial emitter (EAFILSEL)
<nm1> = letter of initial module (EAMODULE)
<ne2> = number of redundant emitter (EAFILSEL)
<nm2> = letter of redundant module (EAMODULE)
<ts> = start-up temperature
<it> = total current setting

RELATED PROCEDURES:
QEAEMCYC

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
Try to start constant total current mode,
if no success switch from one emitter to another
remain in constant total current mode

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set (rather high) total current c=<it>	ASPSETITOT,c (CSEQ) ZEAITSVS,c	 EATOTCSV
t0	2	set (rather high) start-up impedance <ts>	ZEAFISUS,<ts>	EAFILISU
t0	3	select the initial emitter, with e=<ne1> and m=<nm1>	ASPEMCHG,e,m (CSEQ): ZEAEXPMS,0 ZEAFILeS ZEAMODmS	 EAOPMODE=0 EAFILSEL EAMODULE
t0	3a	set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0	4	set constant total current mode	ZEAEXPMS,1	EAOPMODE
t0+30min	5	test operating mode if EAOPMODE<>0 the attempt was successful, the procedure ends. if EAOPMODE=0: try redundant emitter		EAOPMODE
t0+30min	6	set default total current c=15 µA	ASPSETITOT,c (CSEQ) ZEAITSVS,c	 EATOTCSV
t0+30min	7	set default start-up impedance <td>=0xb9	ZEAFISUS,<td>	EAFILISU
t0+30min	8	select the redundant emitter, with e=<ne2> and m=<nm2>	ASPEMCHG,e,m (CSEQ): ZEAEXPMS,0 ZEAFILeS ZEAMODmS	 EAOPMODE=0 EAFILSEL EAMODULE
t0+30min	9	set constant total current mode	ZEAEXPMS,1	EAOPMODE
t0+60min	10	test operating mode if EAOPMODE<>0 the attempt was successful, the procedure ends anyhow.		EAOPMODE
t0+60min	11	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE

PROCEDURE: **QEAFPYRO**

TITLE: fire both pyros

PURPOSE: fire both pyros of emitter covers

APPLICABILITY: before first high voltge turn-on,
immediately after final orbit has been reached

RESPONS.: ESOC

CONSTRAINTS: no particular constraints

RESOURCES: spacecraft powered pyro line

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
off

FINAL STATUS OF EXPERIMENT:
off
Note that the pyro harness on spacecraft FM7 (ASPOC FM-008) has been SWAPPED between the two emitter modules, so that the fire command to module A actually fires module B, and vice versa. Consequently also the verification in the parameters EACAP_A_ and EACAP_B_ is affected.

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
fire pyro 1,
fire pyro 2

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	fire both pyro's (spacecraft powered)	-	EACAP_A_ EACAP_B_
t0+TBD	2	check spacecraft HK TM		

PROCEDURE: **QEAFTEFW**

TITLE: feedback test with EFW

PURPOSE: perform an initial test of the spacecraft potential control loop with EFW

APPLICABILITY: commissioning

RESPONS.: experimenter

CONSTRAINTS: BEFORE THE TEST:
successful previous commissioning of stand-alone modes,
IEL link checked
(reasonable spacecraft potential data received),
EFW calibrated,
data of spacecraft potential during one full ion current sweep available and analysed,
data of spacecraft potential without ion beam from various locations on the orbit available,
data of spacecraft potential with constant beam current from some locations on the orbit available

DURING THE TEST:
EFW providing spacecraft potential data over IEL,
booms must be fully deployed, spin conditions stable
Interference of other instruments on the spacecraft potential measurement by EFW shall be avoided. This can be achieved by switching off possibly disturbing instruments (WHISPER in active mode, EDI), or by confirming the absence of such interference by susceptibility measurements of effects by EDI and WHISPER on EFW.
real-time HK required
slowly varying predicted plasma conditions (strong and rapid fluctuations of the spacecraft potential should be avoided during the first test of the control loop)

DESIRABLE DURING THE TEST:
PEACE providing spacecraft potential data for comparison
low plasma density preferred (inside the magnetosphere)

TIME CONSTRAINTS:
Only one spacecraft tested at a time: operation requires full attention of experienced personnel

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:

real-time HK required

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none
RELATED PROCEDURES:
QEAFTPEA

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
set parameters for constant beam current mode
set constant beam current mode (may take up to 33 minutes if initial mode was standby)

set initial parameters for feedback mode EFW
call feedback mode with EFW
set various parameters for the feedback loop and test the response in HK data
return to standby mode

total duration: 1 hour

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set beam current to 20 µA	ZEAIISVS,0x66	EAIONCSV
t0	2	select emitter e=1 in module m=A	ASPEMCHG,e,m (CSEQ)	
			ZEAEXPMS,0	EAOPMODE=0
			ZEAFILeS	EAFILSEL=0
			ZEAMODmS	EAMODULE=0
t0	2a	set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0	3	set constant beam current mode	ZEAEXPMS,2	EAOPMODE=2
t0	4	analyse EFW data in ASPOC HK TM		EAEFWPT1
				EAEFWPT2
				EAEFWTI1
				EAEFWTI2
				EAEFWRX1
				EAEFWRX2

t0+2000	4a	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE
t0+2400	5	allow 40 minutes to start up emitter and analyse data, then		
		prepare feedback mode with parameters:	ASPPREPFEED,v,l,u,g,d,w,p (CSEQ):	
		set spacecraft potential v to mean value between observation (parameter EAEFWPT1) with 0 µA beam current and 20 µA beam current	ZEASPSVS,v	EAPOT_SV
			ZEAITSLS,l	EATOTCLL
			ZEAITSUS,u	EATOTCUL
			ZEACLKVS,g	EACOEFKV
		set lower current limit l=5 µA	ZEACLTVS,d	EACOEFTV
		set upper current limit u=80 µA	ZEAWHISS,w	
		set gain Kv g=0.63 (default)		EACLNDSB
		set delay Tv d=1.3 (default)		EACLNHWL
		set WHISPER code table to no action (w=0)		EAWISCO2 EAWISCO3
		set backup mode p=3 (constant beam current)		EAWISSDW EAWISSOR
			ZEABAKMS,p	EABKMODE=2
t0+2400	6	set feedback mode from EFW	ZEAEXPMS,3	EAOPMODE=3
t0+2400	7	analyse data over 5 minutes		EAEFWPT1 EAEFWPT2 EAIONC0_ EATOTC0_ EAHVMON_
t0+2700	8	change setting of spacecraft potential v to 50% of previous value	ZEASPSVS,v	EAPOT_SV
t0+2700	9	monitor ion current, potential and high voltage; if the ion current EAIONC0_ is at the upper limit and high voltage EAHVMON_ well below upper limit, then do steps 10 and 11.		EAIONC0_ EAEFWPT1 EAHVMON_
t0+3000	10	set total current upper limit to 100 µA	ZEAITSUS,0xFF	EATOTCUL
t0+3000	11	monitor ion current, potential and high voltage		EAIONC0_ EAEFWPT1 EAHVMON_
t0+3300	12	depending on the analysis of the data, change a few parameters for the feedback control and monitor the response as before. Possible		

		commands/parameters are the same as in the CSEQ ASPPREPFEED:		
			ZEASPSVS,v	EAPOT_SV
			ZEAITSLS,l	EATOTCLL
			ZEAITSUS,u	EATOTCUL
			ZEACLKVS,g	EACOEFKV
			ZEACLTVS,d	EACOEFTV
			ZEAWHISS,w	EAWISTAB
t0+4500	13	set standby mode	ZEAEXPMS,0	EAOPMODE=0

PROCEDURE:	**QEAFTPEA**
TITLE:	feedback test with PEACE
PURPOSE:	perform an initial test of the spacecraft potential control loop with PEACE
APPLICABILITY:	commissioning
RESPONS.:	experimenter

CONSTRAINTS:

BEFORE THE TEST:
successful previous commissioning of stand-alone modes,
IEL link checked
(reasonable spacecraft potential data received),
PEACE software checked,
data of spacecraft potential during one full ion current sweep available and analysed,
data of spacecraft potential without ion beam from various locations on the orbit available,
data of spacecraft potential with constant beam current from some locations on the orbit available,
comparisons EFW-PEACE data on spacecraft potential available

DURING THE TEST:
PEACE providing spacecraft potential data over IEL,
Interference of other instruments on the spacecraft potential measurement by EFW shall be avoided. This can be achieved by switching off possibly disturbing instruments (WHISPER in active mode, EDI), or by confirming the absence of such interference by susceptibility measurements of effects by EDI and WHISPER on EFW.
real-time HK required
slowly varying predicted plasma conditions (strong and rapid fluctuations of the spacecraft potential should be avoided during the first test of the control loop)

DESIRABLE DURING THE TEST:
EFW providing spacecraft potential data for comparison
low plasma density preferred (inside the magnetosphere)

TIME CONSTRAINTS:
Only one spacecraft tested at a time: operation requires full attention of experienced personnel

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:

real-time HK required

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none
RELATED PROCEDURES:
QEAFTEFW

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
set parameters for constant beam current mode
set constant beam current mode (may take up to 33 minutes if initial mode was standby)

set initial parameters for feedback mode PEACE
call feedback mode for PEACE
set various parameters for the feedback loop and test the response in HK data
return to initial mode

total duration: 1 hour

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set beam current to 20 µA	ZEAIISVS,0x66	EAIONCSV
t0	2	select emitter e=2 in module m=A	ASPEMCHG,e,m (CSEQ) ZEAEXPMS,0 ZEAFILeS ZEAMODmS	 EAOPMODE=0 EAFILSEL=1 EAMODULE=0
t0	2a	set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0	3	set constant beam current mode	ZEAEXPMS,2	EAOPMODE=2
t0	4	analyse PEACE data in ASPOC HK TM		EAPEAPT1 EAPEAPT2 EAPEATI1 EAPEATI2 EAPEARX1 EAPEARX2

t0+2000	4a	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE
t0+2400	5	allow 40 minutes to start up emitter and analyse data, then prepare feedback mode with parameters: set spacecraft potential v to mean value between observation (parameter EAPEAPT1) with 0 µA beam current and 20 µA beam current set lower current limit l=5 µA set upper current limit u=80 µA set gain Kv g=0.63 (default) set delay Tv d=1.3 (default) set WHISPER code table to no action (w=0) set backup mode p=3 (constant beam current)	ASPPREPFEED,v,l,u,g,d,w,p (CSEQ): ZEASPSVS,v ZEAITSLS,l ZEAITSUS,u ZEACLKVS,g ZEACLTVS,d ZEAWHISS,w ZEABAKMS,p	EAPOT_SV EATOTCLL EATOTCUL EACOEFKV EACOEFTV EACLNDSB EACLNHWL EAWISCO2 EAWISCO3 EAWISSDW EAWISSOR EABKMODE=2
t0+2400	6	set feedback mode from PEACE	ZEAEXPMS,7	EAOPMODE=7
t0+2400	7	analyse data over 5 minutes		EAPEAPT1 EAPEAPT2 EAIONC0_ EATOTC0_ EAHVMON_
t0+2700	8	change setting of spacecraft potential v to 50% of previous value	ZEASPSVS,v	EAPOT_SV
t0+2700	9	monitor ion current, potential and high voltage; if the ion current EAIONC0_ is at the upper limit and high voltage EAHVMON_ well below upper limit, then do steps 10 and 11.		EAIONC0_ EAPEAPT1 EAHVMON_
t0+3000	10	set total current upper limit to 100 µA	ZEAITSUS,0xFF	EATOTCUL
t0+3000	11	monitor ion current, potential and high voltage		EAIONC0_ EAPEAPT1 EAHVMON_
t0+3300	12	depending on the analysis of the data, change a few parameters for the feedback control and monitor the response as before. Possible		

		commands/parameters are the same as in the CSEQ ASPPREPFEED:		
			ZEASPSVS,v	EAPOT_SV
			ZEAITSLS,l	EATOTCLL
			ZEAITSUS,u	EATOTCUL
			ZEACLKVS,g	EACOEFKV
			ZEACLTVS,d	EACOEFTV
			ZEAWHISS,w	EAWISTAB
t0+4500	13	set standby mode	ZEAEXPMS,0	EAOPMODE=0

PROCEDURE: **QEAHLEAK**

TITLE: irregular high voltage leakage current

PURPOSE: perform a cleaning procedure of the active emitter if the leakage current shows anomalies

APPLICABILITY: contingency,
signatures of a leakage current anomaly

RESPONS.: ESOC + experimenter

CONSTRAINTS: experiment in an active mode

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
same as initial status

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
QEACLEAN, QEAEMCYC

FUNCTIONAL CHARACTERISTICS:
call procedure QEACLEAN
test leakage current again
if cured:
    end of procedure
else:
    call procedure QEAEMCYC

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	call procedure QEACLEAN		
t1		end time of procedure QEACLEAN		
t1	2	test leakage current: monitor ion and total currents		EAIONC0_ EATOTC0_
t1	3	check both parameters agains formula (to be supplied)		
t1	3	test leakage current (or "loss current") defined by: I_LOSS=100*(EATOTC0_-EAIONC0_)/EATOTC0_ if it exceeds the values in the table in section 6.2.12.4 under the heading "loss current":		
t1	4	if OK: end of procedure		
t1	5	if not OK:		
t1	6	call procedure QEAEMCYC		

PROCEDURE: **QEAHVTST**

TITLE: HV test during initialisation

PURPOSE: procedure called during HV test during initialisation

APPLICABILITY: commissioning, first HV turn-on

RESPONS.: experimenter

CONSTRAINTS: real-time HK telemetry
covers open
cover opening at least one week earlier (outgassing), more than two weeks recommended
stable plasma conditions, low plasma density preferred (because of effects on S/C potential)
preferred: EFW, PEACE, CIS operational (to speed up interference and intercalibration experience)
only one spacecraft tested at a time

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
standby

FINAL STATUS OF EXPERIMENT:
standby

INPUT PARAMETERS:
<nm>=letter of module

RELATED PROCEDURES:
QEAINITH

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
set technical mode,
set voltage mode,
enable high voltage
set HV to 1 kV during 15 s
2 minutes pause

set HV to 4 kV during extended time interval to support outgassing of electronics at elevated temperature (2 to 4 hours TBD)
2 minutes pause
set standby mode

total duration: 5 minutes

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	select module <nm> with <nm>=m=A or B	ZEAMODmS	EAMODULE EASU_ACT=1
t0	2	set technical mode	ZEAEXPMS,6	EAOPMODE=6
t0	3	set voltage mode	ZEAHVUMS	EAHVCNMD=1
t0	4	enable high voltage	ZEAHV__E	EAHVSWEN=1
t0+30	5	set HV to 1 kV during 15 s	ZEAHVDAS,0x33	EAHV_OUT
t0+45	6	set HV on	ZEAHLIND	EAHVSHST=0 EAHVMON_
t0+60	7	set HV off after 15 s	ZEAHLINE	EAHVSHST=1 EAHVMON_
t0+180	8	after 2 minutes set HV to 4 kV during TBD extended time (2 hours inserted as place-holder)	ZEAHVDAS,0xCC	EAHV_OUT
t0+195	9	set HV on	ZEAHLIND	EAHVSHST=0 EAHVMON_
t0+7215	10	set HV off after 2 hours	ZEAHLINE	EAHVSHST=1 EAHVMON_
t0+7215	11	disable HV	ZEAHV__D	EAHVSWEN=0
t0+7215	12	set HV to 0 kV	ZEAHVDAS,0	EAHV_OUT
t0+7300	13	set standby mode	ZEAEXPMS,0	EAOPMODE=0

PROCEDURE: **QEAINITL**

TITLE: initial experiment turn-on

PURPOSE: initial turn-on without high voltage after covers have been opened

APPLICABILITY: commissioning

RESPONS.: experimenter

CONSTRAINTS: real-time HK telemetry
covers opened

RESOURCES: hot standby mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
real-time HK telemetry

INITIAL STATUS OF EXPERIMENT:
power off

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
QEAPOWON

FUNCTIONAL CHARACTERISTICS:
turn on power (call QEAPOWON)

do status check of:
- 4 temperatures within limits
- 3 voltages within limits
- reception of SRP
- 2 cap status flags
- arming plug status

do basic test:
- verify TC
- set technical mode

test filament DAC
test module switching

set standby mode

total duration 25 min.

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	turn on power: call procedure QEAPOWON		
t0+30	2	ASPOC HK TM should be received, check limits and flags: 4 temperatures within limits		EATMPBOX EATMPDPU EATMPMD1 EATMPMD2
		3 voltages within limits		EAV13_5_ EAVN5___ EAVP5___
		reception of SRP		EASUNRX1 EASUNRX2 EASUNTI1 EASUNTI2
		2 cap status flags		EACAP_A_ EACAP_B_
		arming plug status		EAHVPLUG=1
t0+600	3	test filament DAC: select module A	ZEAMODAS	EAMODULE=0 EASU_ACT=1
t0+600	4	select filament 1	ZEAFIL1S	EAFILSEL=0
t0+600	5	set technical mode	ZEAEXPMS,6	EAOPMODE=6
t0+600	6	enable filament converter	ZEAFIL_E	EAFILENB=1
t0+600	7	set filament converter on	ZEAFILIE	
t0+660	8	set filament control output to 1.7 V	ZEAFIDAS,0x57	EAFILOUT EAFILTEM EAFILIMN

				EAFILVMN
t0+780	9	set filament converter off	ZEAFILID	
t0+780	10	disable filament converter	ZEAFIL_D	EAFILENB=0
t0+780	11	set filament control output to 0 V	ZEAFIDAS,0	EAFILOUT EAFILTEM EAFILIMN EAFILVMN
t0+780	12	set standby mode	ZEAEXPMS,0	EAOPMODE=0

PROCEDURE: **QEAININTH**

TITLE: initial high voltage turn-on

PURPOSE: initial high voltage turn-on after first successful checks in passive mode

APPLICABILITY: commissioning

RESPONS.: experimenter

CONSTRAINTS: CONFIGURATION:
real-time HK telemetry
covers open
cover opening at least one day earlier (outgassing)

TIME:
not before 1 week (minimum) after cover opening

REGION:
commissioning of the emitters is possible basically in any plasma region (solar wind or lobe),
desirable: low plasma density (inside magnetosphere) and stable conditions during the test

ADDITIONAL:
only one spacecraft tested at a time
preferred: EFW, PEACE, CIS operational (to speed up interference and intercalibration experience)

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
real-time HK telemetry

INITIAL STATUS OF EXPERIMENT:
standby mode

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
QEAPRVER, QEAHVTST, QEASTART

FUNCTIONAL CHARACTERISTICS:
if cover pyros have been fired, but success is in doubt because HK flags are not correct:
call procedure QEAPRVER for verification

HV test on module 1 (QEAHVTST)
start-up emitter 1 on module 1 (QEASTART)
start-up emitter 2 on module 1 (QEASTART)
start-up emitter 3 on module 1 (QEASTART)
start-up emitter 4 on module 1 (QEASTART)
HV test on module 2 (QEAHVTST)
start-up emitter 1 on module 2 (QEASTART)
start-up emitter 2 on module 2 (QEASTART)
start-up emitter 3 on module 2 (QEASTART)
start-up emitter 4 on module 2 (QEASTART)

total duration: 1 hour per needle (= 8 hours for one instrument)

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	if cover A is closed (EACAP_A_=0), call procedure QEAPRVER for module A (check pressure in module)		
	2	if cover B is closed (EACAP_B_=0), call procedure QEAPRVER for module B (check pressure in module)		
	3	if cover A is opened, perform steps 4-8 with module A: However, if there remain doubts about the module pressure, start with the better module first.		
	4	HV test on module 1=A: call procedure QEAHVTST,A		
	5	start-up emitter 1: call procedure QEASTART,1,A		
	6	start-up emitter 2: call procedure QEASTART,2,A		
	7	start-up emitter 3:		

call procedure QEASTART,3,A

8 start-up emitter 4:
call procedure QEASTART,4,A

9 if cover B is opened, perform steps 10-14 with module B:

10 HV test on module 2=B:
call procedure QEAHVTST,B

11 start-up emitter 1:
call procedure QEASTART,1,B

12 start-up emitter 2:
call procedure QEASTART,2,B

13 start-up emitter 3:
call procedure QEASTART,3,B

14 start-up emitter 4:
call procedure QEASTART,4,B

PROCEDURE: **QEAMODES**

TITLE: generic mode switch

PURPOSE: to switch from one instrument mode into any other mode

APPLICABILITY: universal

RESPONS.: ESOC + experimenter

CONSTRAINTS: depending on target mode,
initial or target mode must not be technical mode

RESOURCES: depending on target mode

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
target mode

INPUT PARAMETERS:
target mode <mode-code>,
(technical mode is not allowed as target mode)
emitter number <ne> (0-3),
module number <nm> (0-1),
parameters of target mode (TBD)

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
if initial mode and target mode = active:
set any parameters of target mode
set target mode
if initial mode = active and target mode = hot standby:
set any parameters of target mode
set target mode
if initial mode = active and target mode = standby:
set target mode

if initial mode = standby and target mode = active:
- set emitter number
- set module number
- enable filaments
- enable high voltage
- set target mode

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	test current mode		EAOPMODE
t0	2	if EAOPMODE=0 (standby) or EAOPMODE=4 (hot standby):		
	2.1	set target mode with xxxx=<mode-code>	ZEAxxxxS	EAOPMODE
	2.2	end of procedure		
t0	3	if EAOPMODE=6 (technical mode):		
	3.1	end of procedure		
t0	4	if EAOPMODE=1,2,3,5,7 (active modes):		
	4.1	set standby mode, select the new emitter, with e=<ne> and m=<nm>	ASPEMCHG,e,m (CSEQ): ZEAEXPMS,0 ZEAFILMS,e ZEAMODUS,m	 EAOPMODE=0 EAFILSEL EAMODULE
	4.2	set mode-specific parameters (TBD) These parameters (if any) will be determined during the commissioning phase. Default = no parameters.		
	4.3	set target mode with xxxx=<mode-code>	ZEAxxxxS	EAOPMODE
	4.4	end of procedure		

PROCEDURE: QEANORMP

TITLE: restore routine operating parameters

PURPOSE: to restore routine operating parameters after power-on

APPLICABILITY: when instrument power has been turned off during eclipses or perigee passages

RESPONS.: ESOC + experimenter

CONSTRAINTS: no particular constraints

RESOURCES: standby mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints; no real-time contact nexessary

INITIAL STATUS OF EXPERIMENT:
standby mode

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
call command sequence ASPSETINIT

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	call CSEQ ASPSETINIT	ASPSETINIT,i,t,s	
		i=beam current	ZEAIISVS,i	
		t=filament impedance, normal	ZEAFISVS,t	
		s=filament impedance, start-up	ZEAFISUS,s	
			ZEAFIL_E	EAFILENB

ZEAHV__E EAHVSWEN

PROCEDURE: QEAPOWOF

TITLE: turn power off

PURPOSE: to turn power off

APPLICABILITY:

RESPONS.: ESOC

CONSTRAINTS: none

RESOURCES: none

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:

FINAL STATUS OF EXPERIMENT:
power off

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
turn power off (no preceding commands required)

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	call command sequence SCASPPOWEROF (power off)		

PROCEDURE: QEAPOWON

TITLE: turn power on

PURPOSE: to turn power on

APPLICABILITY:

RESPONS.:

CONSTRAINTS: wait at least 10 seconds before sending TC's to ASPOC after power-on

RESOURCES: standby mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
power off

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
turn power on,
set default values of parameters

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	call command sequence SCASPPOWERON (power on)		

PROCEDURE: QEAPRVER

TITLE: verify pressure in module

PURPOSE: verify indirectly if gas has remained inside an emitter module, if cover is reported to be closed afer pyro firing

APPLICABILITY: commissioning

RESPONS.: experimenter

CONSTRAINTS: real-time HK telemetry

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
real-time HK telemetry

INITIAL STATUS OF EXPERIMENT:
standby mode

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
emitter module letter <nm>

RELATED PROCEDURES:
none

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
set parameters for constant total current mode
set constant total current mode
interrupt start-up of emitter before high voltage turn on (ca. after 5 minutes)
analyse timeline of temperature to test if gas is in the module
if there is gas:
    cover is indeed closed
if there is no gas:
    cover is probably open, microswitch failure

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set total current to 10 µA	ZEAITSVS,0x20	EATOTCSV
t0	2	select emitter e=1 in module m=<nm>	ASPEMCHG,e,m (CSEQ) ZEAEXPMS,0 ZEAFILeS ZEAMODmS	 EAOPMODE=0 EAFILSEL EAMODULE
t0	3	set constant total current mode	ZEAEXPMS,1	EAOPMODE=1
t0	4	watch filament voltage and current during first part of the start-up only (maximum 5 minutes)		EAFILIMN EAFILVMN EAFILTEM
t0+300	5	set standby mode	ZEAEXPMS,0	EAOPMODE=0
t0+300	6	repeat steps 2-5 for emitter 2		
t0+600	7	repeat steps 2-5 for emitter 3		
t0+900	8	analyse filament data in detail: a low rate of temperature increase may be a signature of gas pressure within the module (= cover closed).		

PROCEDURE: QEARCHAR

TITLE: routine measurement of U/I-characteristics

PURPOSE: to make a short routine measurement of the U/I-characteristics of the spacecraft

APPLICABILITY: once every orbit (at the beginning of the first data acquisition period, if possible simultaneously with the calibration phases of other instruments);
may also be used during commissioning (instead of QEADCHAR)

RESPONS.: experimenter

CONSTRAINTS: EFW in voltage mode
Desirable: PEACE providing spacecraft potential data
See description of telecommand ZEAFILMS for constraints on the emitter selection.

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
total current mode (EAOPMODE=0), ion beam emission

FINAL STATUS OF EXPERIMENT:
same as initial status

INPUT PARAMETERS:
<ip> = initial value of total current setting

RELATED PROCEDURES:
QEADCHAR

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
Switch from initial mode to constant total current mode,
apply various total current steps during about 2 minutes,
return to original mode.

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	test total current setting <ip> and store value for resetting at the end of the procedure		EATOTCSV
t0	2	test initial mode setting <mo>. If EAOPMODE<>1, exit the procedure		EAOPMODE
t0	6	prepare routine test&commissioning mode with initial total current c=12 µA, lower current limit l=4 µA, upper current limit u=40 µA, large step size z=1, and short period r=0	ASPPREPT_C,c,l,u,z,r (CSEQ) ZEAITSVS,c ZEAITSLS,l ZEAITSUS,u ZEASTESS,z ZEASTELS,r	 EATOTCSV EATOTCLL EATOTCUL EASTEPS_ EASTEPL_
t0+60s	7	wait for completion of execution of the previous commands and command test&commissioning mode	ZEAEXPMS,5	
t0+180s	9	command constant total current mode	ZEAEXPMS,1	
t0+180s	10	return to previous current setting with <ip> µA	ZEAITSVS	EATOTCSV

PROCEDURE: **QEASHECL**

TITLE: short eclipse operation

APPLICABILITY: during all short eclipses

RESPONS.: experimenter

CONSTRAINTS: EFW in voltage mode,
duration of eclipse > 3 minutes
See description of telecommand ZEAFILMS for constraints on the emitter selection.

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
same as initial status

INPUT PARAMETERS:
<mo> = number of initial mode (EAOPMODE)
<ne> = number of initial emitter (EAFILSEL) (0-3)
<nm> = number of initial module (EAMODULE) (0-1)
<ip> = initial value of total current setting

RELATED PROCEDURES:
none

CALLED PROCEDURES:
QEARCHAR

FUNCTIONAL CHARACTERISTICS:
Switch from initial mode to constant total current mode before the eclipse,
apply various total current steps during about 5 minutes,
return to original mode.

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0		time 15 minutes before start of eclipse		
t0	1	test total current setting <ip> and store value for resetting at the end of the procedure		EATOTCSV
t0	2	test initial mode setting <mo> and store value for resetting at the end of the procedure		EAOPMODE
t0	3	if <mo> not 2,3,5, or 7: test emitter number setting <ne> and store value for resetting at the end of the procedure		EAFILSEL
t0	4	if <mo> not 2,3,5, or 7: test emitter module setting <nm> and store value for resetting at the end of the procedure		EAMODULE
t0	5	set constant total current to 12 µA	ZEAITSVS	EATOTCSV
t0+5s	6	if <mo> not 2,3,5, or 7: set standby mode	ZEASTSBS	EAOPMODE=0
t0+10s	7	if <mo> not 2,3,5, or 7: prepare switch to constant total current mode with the same emitter (x=<ne>, y=<nm>)	ZEAFILMS,x ZEAMODUS,y ZEAFIL_E ZEAHV__E	EAFILSEL EAMODULE EAFILENB EAHVSWEN
t0+40s	7a	if <mo> not 2,3,5, or 7: set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0+40s	8	if <mo> not 2,3,5, or 7: set constant total current mode	ZEAEXPMS,1	EAOPMODE=1
t0+45	9	wait for end of startup phase, reached if EASU_ACT=0		EASU_ACT
t1	10	now the experiment is in total current mode at 12 µA and the core of the procedure can start.		
t1	10a	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE
t1	11	wait for eclipse at time t=t2		

t2+60s	12	call procedure QEARCHAR		
t3		end time of procedure QEARCHAR		
t3	13	return to previous current setting with <ip> µA	ZEAITSVS	EATOTCSV
t3	14	if <mo> <> 1: return to initial mode <mo>: <mo>=0: STDB <mo>=2: IION <mo>=3: FEFW <mo>=5: T&C_ <mo>=7: FPEA	ZEAEXPMS,mo	EAOPMODE

PROCEDURE: **QEASTART**

TITLE: start-up test of one emitter

PURPOSE: procedure called during first high voltage turn-on during commissioning

APPLICABILITY: commissioning

RESPONS.: experimenter

CONSTRAINTS: real-time HK telemetry

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
real-time HK telemetry

INITIAL STATUS OF EXPERIMENT:
standby mode

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
emitter number <ne> (0-3),
module number <nm> (0-1)
total current setting

RELATED PROCEDURES:
QEAINITH

CALLED PROCEDURES:

FUNCTIONAL CHARACTERISTICS:
command "total current mode" with 10 uA total current
watch filament voltage and current
if anomaly is detected:
    interrupt start-up and continue with next needle
wait for high voltage on (may take 33 minutes)
watch stability of emission and leakage current
if leakage current exceeds the values in the table in section 6.2.12.4 under the heading "loss current":
    perform "cleaning" then continue
step total current from 10 to 50 uA (5 uA steps)
set total current to 10 uA

step total current from 10 to 2 uA (2 uA steps)
set total current to 10 uA
set standby mode

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set total current to 10 µA	ZEAITSVS,0x20	EATOTCSV
t0	1a	set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0	2	select emitter e=<ne> in module m=<nm>	ASPEMCHG,e,m (CSEQ) ZEAEXPMS,0 ZEAFILMS,e ZEAMODUS,m	 EAOPMODE=0 EAFILSEL EAMODULE
t0	3	set constant total current mode	ZEAEXPMS,1	EAOPMODE=1
t0	4	watch filament voltage and current during the start-up (about 25 minutes) if an anomaly is detected: go immediately to step 22 (standby mode)		EAFILIMN EAFILVMN EAFILTEM
t0+1500	5	wait for HV, check parameters		EAHVMON_ EAIONC0_ EATOTC0_
t0+1500	6	watch stability of emission and leakage current (10 minutes)		EATOTC0_ EAIONC0_
t0+2100	7	if leakage current exceeds the values in the table in section 6.2.12.4 under the heading "loss current": perform precedure QEAHLEAK		
t1		end time of procedure QEAHLEAK		
t1	8	step total current from 10 to 50 uA (5 uA steps)	ZEAITSVS,0x25	EATOTCSV
t1	9	set total current to 15 µA		
t1+60	10	set total current to 20 µA	ZEAITSVS,0x32	EATOTCSV
t1+120	11	set total current to 25 µA	ZEAITSVS,0x3E	EATOTCSV
t1+180	12	set total current to 30 µA	ZEAITSVS,0x4B	EATOTCSV

t1+240	13	set total current to 35 µA	ZEAITSVS,0x57	EATOTCSV
t1+300	14	set total current to 40 µA	ZEAITSVS,0x64	EATOTCSV
t1+360	15	set total current to 45 µA	ZEAITSVS,0x72	EATOTCSV
t1+420	16	set total current to 50 µA	ZEAITSVS,0x80	EATOTCSV
t1+480	17	set total current to 10 µA	ZEAITSVS,0x20	EATOTCSV
t1+540	18	set total current to 8 µA	ZEAITSVS,0x14	EATOTCSV
t1+600	19	set total current to 6 µA	ZEAITSVS,0x0F	EATOTCSV
t1+660	20	set total current to 4 µA	ZEAITSVS,0x0A	EATOTCSV
t1+720	21	set total current to 2 µA	ZEAITSVS,0x05	EATOTCSV
t1+780	22	set standby mode	ZEAEXPMS,0	EAOPMODE=0

PROCEDURE: QEASTDBS

TITLE: set standby mode

PURPOSE: to set standby mode

APPLICABILITY:

RESPONS.: ESOC + experimenter

CONSTRAINTS: no particular constraints

RESOURCES: standby mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
no particular constraints

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none

RELATED PROCEDURES:
none

CALLED PROCEDURES:
QEAMODES

FUNCTIONAL CHARACTERISTICS:
call procedure QEAMODES with target mode=standby

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	call procedure QEAMODES with <mode-code>=STDB (standby)		

PROCEDURE: **QEAWHIFB**

TITLE: test effect of WHISPER on feedback loop

PURPOSE: to test the reaction of the feedback loop during active WHISPER modes

APPLICABILITY: commissioning

RESPONS.: experimenter

CONSTRAINTS: WHISPER in active mode and passive mode (alternating)
EFW in voltage mode providing spacecraft potential on the IEL to ASPOC,
EFW fully operational, calibrated
booms fully deployed, stable spin conditions

Successful completion of the feedback test with EFW
Experience with the effect of active WHISPER operation on the spacecraft potential measurements by EFW over a significant amount of time (several tens of hours covering different regions in the magnetosphere and the solar wind).

Only one spacecraft tested at a time: operation requires full attention of experienced personnel

RESOURCES: active mode resources

CONFIGURATION OF SPACECRAFT:
no particular constraints

CONFIGURATION OF GROUND SEG.:
no particular constraints

INITIAL STATUS OF EXPERIMENT:
standby mode

FINAL STATUS OF EXPERIMENT:
standby mode

INPUT PARAMETERS:
none
RELATED PROCEDURES:
QEAFTEFW

CALLED PROCEDURES:
none

FUNCTIONAL CHARACTERISTICS:
ASPOC to start constant beam current mode with 20 µA current (may take up to 33 minutes)

ASPOC switch into feedback mode with EFW
wait 2 minutes to settle the potential
WHISPER to step through all active modes
ASPOC returns to initial mode

total duration: ca. 1 hour

KEYWORDS:

PROCEDURE:

TIME	STEP	DESCRIPTION	TC	HK TM
t0	1	set beam current to 20 µA	ZEAIISVS,0x66	EAIONCSV
t0	2	select emitter e=1 in module m=A	ASPEMCHG,e,m (CSEQ) ZEAEXPMS,0 ZEAFILeS ZEAMODmS	 EAOPMODE=0 EAFILSEL=0 EAMODULE=0
t0	3	operate WHISPER in active and passive mode in intervals of several minutes for each mode		
t0	3a	set HV threshold to 8.5 kV	ZEAHVTHR,0xd9	EAHVTHRE
t0	4	set constant beam current mode	ZEAEXPMS,2	EAOPMODE=2
t0	5	analyse EFW data in ASPOC HK TM		EAEFWPT1 EAEFWPT2 EAEFWTI1 EAEFWTI2 EAEFWRX1 EAEFWRX2
t0+2000	5a	reset HV threshold to 7.5 kV	ZEAHVTHR,0xbf	EAHVTHRE
t0+2400	6	allow 40 minutes to start up emitter and analyse data, then prepare feedback mode with parameters: set spacecraft potential v to mean value between observation (parameter EAEFWPT1) with 0 µA beam current and 20 µA beam current set lower current limit l=5 µA set upper current limit u=80 µA set gain Kv g=0.63 (default) set delay Tv d=1.3 (default) set WHISPER code table to no action (w=0)	 ASPPREPFEED,v,l,u,g,d,w,p (CSEQ): ZEASPSVS,v ZEAITSLS,l ZEAITSUS,u ZEACLKVS,g ZEACLTVS,d ZEAWHISS,w	 EAPOT_SV EATOTCLL EATOTCUL EACOEFKV EACOEFTV EACLNDSB EACLNHWL EAWISCO2 EAWISCO3

		set backup mode p=3 (constant beam current)	ZEABAKMS,p	EAWISSDW EAWISSOR EABKMODE=2
t0+2400	7	set WHISPER into passive mode		
t0+2400	8	set feedback mode from EFW	ZEAEXPMS,3	EAOPMODE=3
t0+2400	9	analyse data over 5 minutes		EAEFWPT1 EAEFWPT2 EAIONC0_ EATOTC0_ EAHVMON_
t0+2700	9	set WHISPER in active mode		
t0+2700	10	monitor ion current and potential;		EAIONC0_ EAEFWPT1 EAIONC0_ EAEFWPT1 EAHVMON_
t0+3000	11	depending on the analysis of the data, change a few parameters for the feedback control and monitor the response as before. Possible commands/parameters are the same as in the CSEQ ASPPREPFEED:	ZEASPSVS,v ZEAITSLS,l ZEAITSUS,u ZEACLKVS,g ZEACLTVS,d ZEAWHISS,w	EAPOT_SV EATOTCLL EATOTCUL EACOEFKV EACOEFTV EAWISTAB
t0+3000	12	If the ion current EAIONC0_ or the spacecraft potential EAEFWPT1 get very unstable:	ZEAEXPMS,2	EAOPMODE=2
t0+3000	12.1	set constant beam current mode		
repeat steps 9-12 for different WHISPER modes			ZEAEXPMS,0	EAOPMODE=0
t0+4500	13	set standby mode		