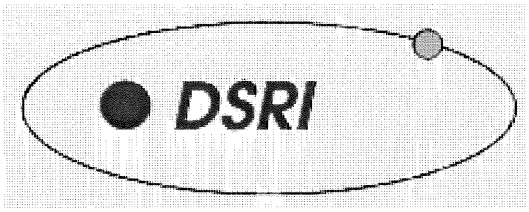


# DANISH SPACE RESEARCH INSTITUTE

JEM-X FM 1 Functional Test Report
(IN-TP-JEM-0031)

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## 1. SCOPE OF THE TEST

This document has been written in order to summarize all the test activities concerning the functional verification of the JEM-X FM1 Instrument.

The test has been executed in DSRI (Copenhagen) performing the activities by means of the Satellite Interface Simulator (SIS).
Such a list of command sequences have been created (all the TC have been translate in raw format) in order to command the instrument for operational mode transitions, parameters setting and functional checks.
The test has been without the Alenia facilities like Database, Synoptic and Tesla Sequences.

Thus, detailed requirements and methodologies for the test execution to gether with the test instruments configuration will be provided within this document

## 2. TEST OBJECTIVE

Purpose of the ISST activity was the verification of proper functioning and performance of the INTEGRAL JEM-X FM1 Scientific Experiment after completion of its electrical integration.
The following things have been verified:

- Telecommand and telemetry management
- Transition to/from all the applicable Operative modes and their functionality
- The features of the DPE software both IASW and CSSW
- The interaction of equipment and subsystems between themselves and with the P-PDU and P-RTU
    - Scientific data acquisition

## 3. REFERENCE DOCUMENTS

This section contains a list of documents filled with electrical interfaces necessary to organize and to detail the operative execution of the test activities.

| | |
|---|---|
| • JEM-X EID-B Issue 5.2 (March 2000) | JEMX/EID-B_5.2 |
| • JEM-X User Manual 4.2 | JEMX/UM_4.2 |
| • IASW Software Specification Document | IASW DPE JEM-X 1.15 |

## 4. HARDWARE CONFIGURATION

In order to carry out the activity detailed in this procedure, the following hardware configuration was available:

- Spacecraft Interface Simulator (RTU, PDU);
- On-Board Data Handling Sub-System (OBDH FEE);
- DPE EM;
- DFEE FM1;
- Detector & DAE FM1;
- ECOE (instrument software monitoring);

## 5. SOFTWARE CONFIGURATION

The JEM-X FM1 On-board Software can be divided into two major components: the DFFE Software and the DPE Software that is furthermore split in two components the Common Service Software and the Instrument Application Software.
The SW versions used for this acceptance were:

| | |
|---|---|
| CSSW | 1.9 B |
| IASW | 1.61 |
| DFEE SW | 4.0 |

In order to carry out the functional test, the following series of command sequences have been implemented in the SIS (which contain the TC sending in the same order of each functional procedure sections):

- CAL_test.pkt (Start-up Test)
- DT2_test (Data Taking Test)
- GR_FILT.pkt (Grey Filter Selection Test)
- ANOD_SET.pkt (Performance Check Test)
- SV_CONF.pkt (Save/Load Configuration Test)
- MEM_test.pkt (Patch & Dump)
- BCPK_CMD.pkt (Broadcast Packet Interpretation Test)
- DET_PRES.pkt (mRTU Data Override Check)

## 6. ANOMALIES and NCR

No anomalies have been discovered during the test activities and no NCR have been issued.

# 7. TEST EVALUATION

## 7.1 START-UP TEST

Scope:

The aim of this test was to check the start-up procedure. This means that the correct initialisation of the DPE and DFEE FM1 is verified, monitoring the HK parameters on the OBDH FEE until the final state is reached.
Moreover the test checks also the Calibration performances verifying the Calibration operative Mode.

Results:

At the power up of the DPE and DFEE FM1 the correct OEM has been delivered and checked on the OBDH FEE HK packet.

After that the TC **C55-1** (Start of IASW) has been sent the IASW has started.

The transition to Safe Mode has been verified always looking at the HK packet and a request of IASWversion has been asked sending the TC **IASW_ver** (the version has been check by means of the on-request packet 1541).

Successively, the TC I55_5 has been sent to bring up the instrument in Setup Mode and also in this case has been possible verify the correct switching of the "DFEE status" parameter to the value 5 in the HK packet.

The CPU Status has been changed from 8 to 16 MHz by means of the TC **CPU_STAT**.

Low Level Discriminator and the Anode Configuration have been set at the nominal values (respectively $0A_{16}$ and all anode sections enabled) and always verified in the HK telemetry packet.

In order to identify the calibration event by means of number of pulses send to the amplifiers for each of the calibration levels, the instrument has been sent in Calibration Mode by means of the TC **I55_CAL** and the acquisition of the correct TM packet has been verified looking at the "DFEE status" changed in the HK packet and receiving the TMSP with APID 1601 (the analysis has been performed off line looking at the results by means of the IDL software tool).

In conclusion is it possible to say that the test has been successfully performed.

## 7.2 DATA TAKING TEST

Scope:

The aim of this test was to verify the capability of JEM-X FM1 to go in Data Taking mode starting from the Setup configuration, the switching from Primary to Secondary format (related to the Grey Filter functionality), the correct acquisition of the scientific packets, the scientific performances for each of the five different science formats, the X and Y event position calculation (with the new look-up table) and the different spectrum energy linearization.

Results:

The CPU Status has been changed from 8 to 16 MHz by means of the TC **CPU_STAT**.

Low Level Discriminator and the Anode Configuration have been set at the nominal values (respectively $0A_{16}$ and all anode sections enabled) and always verified in the HK telemetry packet.

The HV have been switched-on setting the Cathode Voltages to the value $70_{16}$ and the Delta Voltages to the value $57_{16}$.

In order to reach in a correctly way the Data Taking Mode, it has been possible set the parameters about the Primary or Secondary Imaging Format (at the beginning set to Full Imaging for the Primary one and to Restricted Imaging for the Secondary one). The proper choice has been easily verified looking at the HK TM packet.

Then the instrument has been commanded back to Setup Mode in order to return in Data Taking by means of a command (PREV_DT) which gave the possibility to have the same Formats previously set. The proper functionality has been verified looking at the parameters inside the HK packet.

After that the instrument has been commanded back to Setup Mode in order to return in Data Taking by means of a command (DFLT_DT) which gave the possibility to set the Formatsas default (Primary and Secondary set to Full Imaging). The proper functionality has been verified looking at the parameters inside the HK packet.

Then, an $Am^{241}$ radioactive source has been positioned over the collimator to increase the event count rate having the possibility to start the DPE buffer filling-up. When the DPE buffer have been filled over the 50% of its capacity, the Grey Filter has started to decrease. When the Grey Filter went down under 30%, the switching functionality from Primary to Secondary Format have been verified in the HK packet.

The same test has been repeated changing the percentage value of the Grey Filter when the switching occurred.

Then, all the five different scientific formats have been tested with success receiving all the packets with the right APIDs.

Two run in Data Taking of five minutes each have been performed, first with the default values and then with the table values changed in order to see, in an off line analysis, how the detector image is corrected. This correction table has been introduced due to an error on the mounting of few capacitors on the amplifier board: this cause a not linear line on the detector imaging monitoring.

Finally, to see the different spectra resolution, all the values on the energy linearization table have been changed. A dump of the memory areas where the table resides, have been done to show the difference before and after the changing. An off line analysis, by means of IDL software, have been performed.

In conclusion is it possible to say that the test has been successfully performed.

### 7.3 GREY FILTER SELECTION TEST

Scope:

The purpose of this test was to check the correctness of the grey filter selection, in which the amount of accepted or rejected events depends on the Grey Filter (fraction of events accepted) selected.
It has to be point out that the Grey Filter can be automatically selected or choose by the user.

Results:

The CPU Status has been changed from 8 to 16 MHz by means of the TC **CPU_STAT**.

Low Level Discriminator and the Anode Configuration have been set at the nominal values (respectively $0A_{16}$ and all anode sections enabled) and always verified in the HK telemetry packet.

The HV have been switched-on setting the Cathode Voltages to the value $70_{16}$ and the Delta Voltages to the value $57_{16}$.

In order to test the start of the Grey Filter decreasing, a different set of the parameter for automatic Grey Filter selection has been implemented (against the default ones) to a percentage of 20% for extra low level, 40% for normal low level, 60% for normal high level and 80% for extra high level.
When the DPE buffer has been filled-up over the 60% of its capacity, has been correctly noted that the Grey Filter has start to decrease as expected.

After that, a fixed Grey Filter value (0A hex) has been selected to see if the instrument accepts and correctly interprets the chosen value.
Actually, a reduced number of accepted events have been noted looking at the same synoptic mentioned above.

Finally, in order to come to an automatic Grey Filter selection, the FFFF value has been inserted.
Depending on the events stored in the DPE buffer, the Grey Filter set itself to a reasonable value.

In conclusion is it possible to say that the test has been successfully performed.

### 7.4 PERFORMANCE CHECK TEST

Scope:

The purpose of this test was to check the correctness of the diagnostic calibration, one for each anode element. The generation of the electronic pulses with four different anode configurations has been checked.

Results:

The CPU Status has been changed from 8 to 16 MHz by means of the TC **CPU_STAT**.

Low Level Discriminator and the Anode Configuration have been set at the nominal values (respectively $0A_{16}$ and all anode sections enabled) and always verified in the HK telemetry packet.

In order to verify the correct anode section calibration, it has been possible set the Anode configuration (only the first section enabled) by means of the TC **ANODE_7**. The proper choice has been easily verified looking at the HK packet.

Same procedure has been repeated concerning the setting of the other three Anode configuration enabling. Also in this case the proper choice has been easily verified looking at the HK packet.

After that all the anode sections have been calibrated (each at a time), all them have been enabled and the instrument has been sent to the Diagnostic/Dump Mode verifying the correct acquisition of the telemetry packet (APID 1602) and looking in an off line analysis the proper scientic information acquisition.

In conclusion is it possible to say that the test has been successfully performed.

### 7.5 SAVE / LOAD CONFIGURATION TEST

Scope:

The aim of this test was to check the correctness of the loading of the previously saved configuration after the instrument switching-off.

Results:

The CPU Status has been changed from 8 to 16 MHz by means of the TC **CPU_STAT**.

Low Level Discriminator and the Anode Configuration have been set at the nominal values (respectively $0A_{16}$ and all anode sections enabled) and always verified in the HK telemetry packet.

After that the two DFEE parameter tables (integer and float values) have been updated patching few words. A report has been requested and verified to check the insertion of the new values (TM packet APID 1541).

The context (with the previous modifications) has been then saved in the DPE memory from Setup Mode and the DFEE FM1 has been switched-off.

The instrument has been switched-on again and, before to go in Safe Mode, the context stored in DPE memory has been loaded in DFEE.
The verification of the parameters previously saved has been checked dumping the DFEE memory areas for what concern the integer and float parameter tables and checking the HK packet for what concern the Low Level Discriminator and the Anode Configuration.

In conclusion is it possible to say that the test has been successfully performed

### 7.6 PATCH & DUMP TEST

Scope:

The aim of this test was to check the correctness of the memory patch and dump of the DFEE.

Results:

The DFEE patch and dump has been checked, while the instrument was in Memory P&D Mode.
First of all a dump of the DFEE FM1 memory area, as it was as default, has been required, setting the start address ($8500_{16}$) and the length of the memory.
Then, a patch with different values has been performed on the same memory address for the same length.

Again, a new dump has been required verifying the correct performance looking at the TM packet APID 1542.

In conclusion is it possible to say that the test has been successfully performed

### 7.7 BROADCAST PACKET INTERPRETATION TEST

Scope:

The main aim of this test was to verify the correct interpretation of the information contained in the BCPKT passing trought eleven different scenarios and the capability of JEM-X FM1 to undertake the correct reactions.

The scenarios were:

1. Entry and Exit from Eclipse (restore Data Taking, High Voltages and context);
2. Entry and Exit from Eclipse (restore context only);
3. Entry and Exit from Radiation Belts (during Data Taking Mode);
4. IREM (during Data Taking Mode);
5. IREM and DRMC set to "1";
6. Instrument Imminent switch-off;
7. ESAM flag set to "1";
8. On Target Flag;
9. Eclipse Entry, Radiation Entry, Eclipse Exit and Radiation Exit;
10. Radiation Entry, Eclipse Entry, Eclipse Exit and Radiation Exit;
11. Complete override capability for a Broadcast Packet fully set;

Results:

1. Entry and Exit time from Eclipse;
   - The Automatic Recovery Enable flag has been set to "9" (restore Data Taking, High Voltages and DFEE FM1 context).
   - By means of BP_ECLIP TC the Entry and the Exit Time from Eclipse have been set.
   - After the Eclipse entry time the instrument has correctly gone in Safe Mode and the DFEE FM1 has been switched-off.
   - After the Eclipse exit time, the DFEE FM1 has been switched-on again, and the instrument cames automatically back in Data Taking Mode.

2. Entry and Exit time from Eclipse;
   - The Automatic Recovery Enable flag has been set to "3" (restore DFEE FM1 context only).
   - By means of BP_ECLIP TC the Entry and the Exit Time from Eclipse have been set.
   - After the Eclipse entry time the instrument has correctly gone in Safe Mode and the DFEE FM1 has been switched-off.

- After the Eclipse exit time, the DFEE FM1 has been switched-on again, and the instrument cames automatically back in Data Taking Mode.

3. Entry and Exit time from Radiation Belts;
   - The Automatic Recovery Enable flag has been set to "9" (restore Data Taking, High Voltages and DFEE FM1 context).
   - By means of BP_RBELT TC the Entry and the Exit Time from Radiation Belts have been set.
   - After the Radiation Belts entry time the instrument has correctly gone in Safe Mode.
   - After the Radiation exit time the instrument cames automatically back in Data Taking Mode.

4. IREM 1;
   - The Automatic Recovery Enable flag has been set to "9" (restore Data Taking, High Voltages and DFEE FM1 context).
   - The Radiation thresholds have been set to the value "8888 hex" and "9999 hex".
   - By means of BP_IREM1 TC the High Radiation Count has been set major than the maximum threshold.
   - The instrument has correctly gone in Safe Mode after 2 HK packets.
   - By means of BP_RESET TC the High Radiation Count has been set minor than the minimum threshold.
   - The instrument cames automatically back in Data Taking Mode after 75 HK packets.
   - The Automatic Recovery Enable flag has been set to "6" (restore High Voltages and DFEE FM1 context).
   - The delay in reaction on high/low radiation monitor count rate have been set equal to "0A hex" for high RMCR and "14 hex for low RMCR
   - By means of BP_IREM1 TC the High Radiation Count has been set major than the maximum threshold.
   - The instrument has correctly gone in Safe Mode after about 80 seconds.
   - By means of BP_RESET TC the High Radiation Count has been set minor than the minimum threshold.
   - The instrument cames correctly back in Data Taking Mode after about 160 seconds.

5. IREM 1 and Disregard Monitor Count Rate;
   - By means of BP_DRMC1 TC High Radiation Count has been set major than the maximum threshold and the DRMC set to "1".
   - The instrument did not react as expected.

6. Instrument Imminent switch-off;
   - By means of BP_IMOFF the Imminent switch-off flag has been set to "1".
   - The instrument has correctly gone in Safe Mode with a shutdown procedure in progress.
   - By means of BP_RESET the Imminent switch-off flag has been set to "0".

- The instrument has remained in Safe Mode as expected.
- Safe Mode command has been sent in order to clear the shutdown procedure.
- The operator override for broadcast packet data (conerning the disability of the imminent switch-off flag) has been set.
- By means of BP_IMOFF TC the Imminent switch-off flag has been set to "1".
- The instrument has correctly remained in Data Taking Mode.

7. ESAM;
   - By means of BP_ESAM TC the ESAM flag has been set to "1".
   - The instrument has correctly gone in Safe Mode with a shutdown procedure in progress.
   - By means of BP_RESET TC the ESAM flag has been set to "0".
   - The instrument has remained in Safe Mode as expected.
   - Safe Mode command has been sent in order to clear the shutdown procedure.

8. On Target Flag;
   - By means of BP_OTF_0 TC the OTF flag has been set to "0" and the Pointing ID to "0".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_OT_PI TC the OTF flag has been set to "0" and the Pointing ID to "64 hex".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_OTF_1 TC the OTF flag has been set to "1" and the Pointing ID to "64 hex".
   - The instrument has remained in Data Taking Mode and an On-Event Message has been displayed (New Pointing-Restart of Data Taking Mode).
   - By means of BP_OT_PI TC the OTF flag has been set to "0" and the Pointing ID to "64 hex".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_OTF_0 TC the OTF flag has been set to "0" and the Pointing ID to "0".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_PI_65 TC the OTF flag has been set to "0" and the Pointing ID to "65 hex".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_1_65 TC the OTF flag has been set to "1" and the Pointing ID to "65 hex".
   - The instrument has remained in Data Taking Mode and an On-Event Message has been displayed (New Pointing-Restart of Data Taking Mode).
   - By means of BP_PI_65 TC the OTF flag has been set to "0" and the Pointing ID to "65 hex".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_OTF_0 TC the OTF flag has been set to "0" and the Pointing ID to "0".
   - The instrument has remained in Data Taking Mode as expected.
   - By means of BP_O1_P0 TC the OTF flag has been set to "1" and the Pointing ID to "0".
   - The instrument has remained in Data Taking Mode as expected.

- By means of BP_1_66 TC the OTF flag has been set to "1" and the Pointing ID to "66 hex".
- The instrument has remained in Data Taking Mode and an On-Event Message has been displayed (New Pointing-Restart of Data Taking Mode).
- By means of BP_O1_P0 TC the OTF flag has been set to "1" and the Pointing ID to "0".
- The instrument has remained in Data Taking Mode as expected.
- By means of BP_OTF_0 TC the OTF flag has been set to "0" and the Pointing ID to "0".
- The instrument has remained in Data Taking Mode as expected.
- By means of BP_PI_67 TC the OTF flag has been set to "0" and the Pointing ID to "67 hex".
- The instrument has remained in Data Taking Mode as expected.
- By means of BP_1_67 TC the OTF flag has been set to "1" and the Pointing ID to "67 hex".
- The instrument has remained in Data Taking Mode and an On-Event Message has been displayed (New Pointing-Restart of Data Taking Mode).
- By means of BP_OTF_0 TC the OTF flag has been set to "0" and the Pointing ID to "0".
- The instrument has remained in Data Taking Mode as expected.

9. Eclipse Entry, Radiation Entry, Eclipse Exit and Radiation Exit;
   - The Automatic Recovery Enable flag has been set to "9" (restore Data Taking, High Voltages and DFEE FM1 context).
   - By means of BP_ERER TC the Eclipse Entry, the Radiation Belts Entry, the Eclipse Exit and Radiation Belts Exit have been set.
   - After the Eclipse entry time the instrument has correctly gone in Safe Mode and the DFEE FM1 has been switched-off.
   - After the Radiation Belts entry time nothing has happened as expected.
   - After the Eclipse exit time the instrument has been switched on again and the instrument set itself to Safe Mode as expected.
   - After the Radiation Belts exit time the instrument cames automatically back to Data Taking Mode.

10. Radiation Entry, Eclipse Entry, Eclipse Exit and Radiation Exit;
    - The Automatic Recovery Enable flag has been set to "9" (restore Data Taking, High Voltages and DFEE FM1 context).
    - By means of BP_REER TC the Radiation Belts Entry, the Eclipse Entry, the Eclipse Exit and Radiation Belts Exit have been set.
    - After the Radiation Belts entry time the instrument has gone in Safe Mode as expected.
    - After the Eclipse entry time the instrument has been switched off.
    - After the Eclipse exit time the DFEE FM1 has been switched on again and the instrument set itself to Safe Mode as expected.
    - After the Radiation Belts exit time the instrument cames automatically back to Data Taking Mode.

11. Complete override capability for a Broadcast Packet fully set;
    - The Automatic Recovery Enable flag has been set to "9" (restore Data Taking, High Voltages and DFEE FM1 context).
    - By means of OV_ALL_B TC all the BCPKT parameters have been overriden.
    - By means of BP_FULL TC the Eclipse Entry, Radiation Belts Entry, Eclipse Exit, Radiation Belts Exit, DRMC=1, OTF=1, PI=64 hex, Imminent Off=1, ESAM=1, IREM#1=AAAA, IREM#2=AAAA, IREM#3=AAAA, AOCS=IPM mode have been set.
    - The instrument has remained in Data Taking Mode as expected.

In conclusion is it possible to say that the test has been successfully performed

### 7.8 mRTU DATA OVERRIDE CHECK

Scope:

The aim of this test was to verify the correct reaction of the instrument while the detector pressure drop down under the set threshold and the detector temperature exceed the set threshold.

Results:

The CPU Status has been changed from 8 to 16 MHz by means of the TC **CPU_STAT**.

Low Level Discriminator and the Anode Configuration have been set at the nominal values (respectively $0A_{16}$ and all anode sections enabled) and always verified in the HK telemetry packet.

The HV have been switched-on to the minimum values.

After that a threshold level flag (concerning the DP#2) for detector pressure has been set and reported to a value of 64 hex.
The instrument reaction has been correct, so it came back to the Safe Mode and a shutdown procedure began.
The threshold level has been reset and to clear the shutdown level, the instrument has been commanded in Safe Mode and then in Setup switching-on again the HV.

Another command has been checked: the ones whose overrides the mRTU data (in this case the DP#2 flag has been chosen to continue the test on the pressure check). The threshold levels have been set again to the value 64 hex and, due to the override action, the instrument did not react as expected.

The same test performed for the detector pressure has been repeated for the detector temperature. A threshold level flag (concerning the DT#2) for detector temperature has been set and reported to a value of 32 hex.
The instrument reaction has been correct, so it came back to the Safe Mode and a shutdown procedure began.

In conclusion is it possible to say that the test has been successfully performed

## 8. AS-RUN PROCEDURE

The functional verification has been executed following the Test Procedure IN-TP-JEM-0011 document.
The as-run, which contains all the numerical results and the monitored packets, is following attached.