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# BC-SIM-TR-025 HRIC ICO3 REPORT

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## Index

|                                                      |          |
|------------------------------------------------------|----------|
| <b>APPROVATION .....</b>                             | <b>3</b> |
| <b>DOCUMENT CHANGE RECORD .....</b>                  | <b>3</b> |
| <b>1 INTRODUCTION.....</b>                           | <b>4</b> |
| 1.1 SCOPE .....                                      | 4        |
| 1.2 REFERENCE DOCUMENTS.....                         | 4        |
| 1.3 ACRONYMS.....                                    | 4        |
| 1.4 DOCUMENT FORMAT AND REPOSITORY .....             | 5        |
| 1.5 DOCUMENT ORGANIZATION .....                      | 5        |
| <b>2 DEFINITIONS AND ASSUMPTIONS.....</b>            | <b>6</b> |
| 2.1 HRIC SENSORS .....                               | 6        |
| 2.2 BEPICOLOMBO CF SENSORS .....                     | 7        |
| <b>3 HRIC-ICO3 TESTS.....</b>                        | <b>9</b> |
| 3.1 HRIC FUNCTIONAL TEST .....                       | 10       |
| 3.1.1 <i>Test description</i> .....                  | 10       |
| 3.1.2 <i>Commanding</i> .....                        | 10       |
| 3.1.3 <i>HKs interpretation and discussion</i> ..... | 11       |
| 3.1.4 <i>Images Analysis</i> .....                   | 13       |
| 3.2 HRIC PERFORMANCE TEST .....                      | 15       |
| 3.2.1 <i>Test description</i> .....                  | 15       |
| 3.2.2 <i>Commanding</i> .....                        | 15       |
| 3.2.3 <i>HKs interpretation and discussion</i> ..... | 16       |
| 3.2.4 <i>Images analysis</i> .....                   | 17       |

## Approval

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## Document change record

| Issue | Revision | Date       | Affected Pages | Change description |
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# 1 Introduction

## 1.1 Scope

The present document has been issued to describe the Instrument Check Out Phase (ICO#3) Tests of HRIC, channel of the Spectrometers and Imagers for MPO BepiColombo Integrated Observatory SYSTEM (SIMBIO-SYS).

## 1.2 Reference Documents

- [RD.1] BC-SIM-TN-003\_- \_Reports\_and\_Note\_Layout\_and\_Flow,  
[10.20371/INAF/TechRep/179](https://doi.org/10.20371/INAF/TechRep/179)
- [RD.2] BC-ALS-TN-00099 MPO PFM Monitoring Thermistors Location
- [RD.3] BC-SIM-GAF-MA-002 rev.8\_SIMBIO-SYS FM User Manual, 2017
- [RD.4] BC-SIM-PL-005\_- \_SIMBIO-  
SYS\_Checkout\_03\_Test\_Summary\_Issue1\_Revision0,  
[10.20371/INAF/TechRep/172](https://doi.org/10.20371/INAF/TechRep/172)
- [RD.5] BC-SIM-PL-004\_- \_SIMBIO-  
SYS\_Checkout\_02\_Test\_Summary\_Issue1\_Revision0,  
[10.20371/INAF/TechRep/100](https://doi.org/10.20371/INAF/TechRep/100)
- [RD.6] BC-SIM-TN-008\_- \_SIMBIO-SYS\_FOP\_update\_after\_ICO#02,  
[10.20371/INAF/TechRep/162](https://doi.org/10.20371/INAF/TechRep/162)
- [RD.7] BC-SIM-TR-024\_- \_EGSE\_ICO#03\_report,  
[10.20371/INAF/TechRep/185](https://doi.org/10.20371/INAF/TechRep/185)

## 1.3 Acronyms

|             |                                         |
|-------------|-----------------------------------------|
| <b>ACK</b>  | Acknowledgment                          |
| <b>ADC</b>  | Analogical Digit Converter              |
| <b>APID</b> | Application Process IDentifier          |
| <b>ASW</b>  | Application SoftWare                    |
| <b>CM</b>   | Color Mode                              |
| <b>CSV</b>  | Comma Separated Values                  |
| <b>DSNU</b> | Dark Signal Not Uniformity              |
| <b>FOP</b>  | Flight Operation Procedure              |
| <b>FPA</b>  | Focal Plane Assembly                    |
| <b>HK</b>   | HouseKepping                            |
| <b>HRIC</b> | High spatial Resolution Imaging Channel |
| <b>ICO</b>  | Instrument CheckOut                     |

|                   |                                                                                |
|-------------------|--------------------------------------------------------------------------------|
| <b>IT</b>         | Integration Time                                                               |
| <b>ME</b>         | Main Electronics                                                               |
| <b>NECP</b>       | Near Earth Commissioning Phase                                                 |
| <b>OBCP</b>       | On-Board Control Procedure                                                     |
| <b>OB</b>         | Optical Bench                                                                  |
| <b>OBSW</b>       | On Board Software                                                              |
| <b>PDOR</b>       | Payload Direct Operation Request                                               |
| <b>POR</b>        | Payload Operation Request                                                      |
| <b>PDS</b>        | Planetary Data System                                                          |
| <b>PE</b>         | Proximity Electronics                                                          |
| <b>PNG</b>        | Portable Network Graphics                                                      |
| <b>PSC</b>        | Packet Sequence Control                                                        |
| <b>RT</b>         | Repetition Time                                                                |
| <b>SIMBIO-SYS</b> | Spectrometers and Imagers for MPO<br>BepiColombo Integrated Observatory SYStem |
| <b>SSC</b>        | Source Sequence Count                                                          |
| <b>SSMM</b>       | Solid State Mass Memory                                                        |
| <b>STC</b>        | STereo imaging Channel                                                         |
| <b>S/C</b>        | SpaceCraft                                                                     |
| <b>TC</b>         | TeleCommand                                                                    |
| <b>TEC</b>        | Thermo-Electric Cooler                                                         |
| <b>TM</b>         | Telemetry                                                                      |
| <b>VIHI</b>       | VIsible and Hyper-spectral Imaging channel                                     |
| <b>XML</b>        | eXtensible Markup Language                                                     |

## 1.4 Document Format and Repository

This document is compliant with the SIMBIO-SYS Report and Note Layout and Flow [RD.1] and will be archived both on the INAF Open Access repository and the SIMBIO-SYS team Archive.

## 1.5 Document Organization

This document is organized in sections whose topics are listed as follows:

- Section 2– sensor definition, with a brief description of the HRIC sensors used to monitor the environment in which the channel executes the tests
- Section 3– ICO#03-HRIC tests, with a brief description of the executed tests and a report on obtained HKs and data

## 2 Definitions and assumptions

In this section the main physical and technical terms are defined. The physical and instrumental assumptions are also included.

### 2.1 HRIC Sensors

Table 1 reports the main HRIC sensors covering the temperature measurement of the Focal Plane Assembly (FPA), the Proximity Electronics (PE), the backside of the detector and the HRIC Optical Bench (OB), the Current and the Voltage measurement of the Thermo-Electric Cooler (TEC) and the PE.

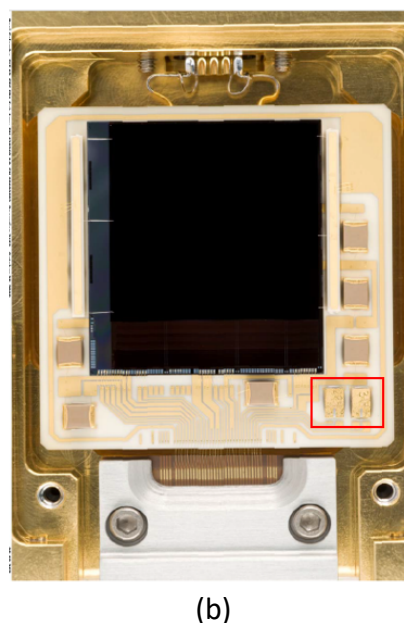
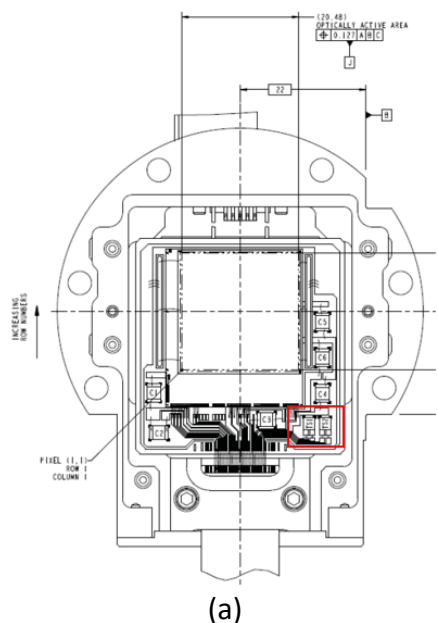
| Param.ID | Param Name            | Unit | Calibration |
|----------|-----------------------|------|-------------|
| NSS11040 | HRIC Temperature FPA1 | K    | CSSP0010TM  |
| NSS11041 | HRIC Temperature FPA2 | K    | CSSP0011TM  |
| NSS11042 | HRIC Temperature PE   | K    | CSSP0012TM  |
| NSS11043 | HRIC Temp Tele1       | K    | CSSP0013TM  |
| NSS11044 | HRIC Temp Tele2       | K    | CSSP0014TM  |
| NSS11050 | HRIC PE 3.3V Measured | V    | CSSP0015TM  |
| NSS11051 | HRIC TEC Current      | A    | CSSP0016TM  |
| NSS11051 | HRIC TEC Current      | A    | CSSP0016TM  |

**Table 1:** Main HRIC temperature sensors of the FPA, PE, the backside of the detector and the HRIC OB as reported in [RD.2]. All HKs are part of the Packet YSS40001.

Table 2 and Figure 1 report the position of the above listed sensors.

| Unit          | Instrument Controlled Thermistors | Temp.  | Location    | Parameter        |
|---------------|-----------------------------------|--------|-------------|------------------|
| HRIC Optics 1 | PT1000                            | -40/65 | TIRD filter | HRIC_Temp_Tele_1 |
| HRIC Optics 2 | PT1000                            | -40/65 | FPA package | HRIC_Temp_Tele_2 |
| HRIC SCA 1    | DT470                             | -40/65 | FPA SCA     | HRIC_Temp_FPA_1  |
| HRIC SCA 2    | DT470                             | -40/65 | FPA SCA     | HRIC_Temp_FPA_2  |
| HRIC PE       | PT1000                            | -40/65 | PE hot spot | HRIC_Temp_PE     |

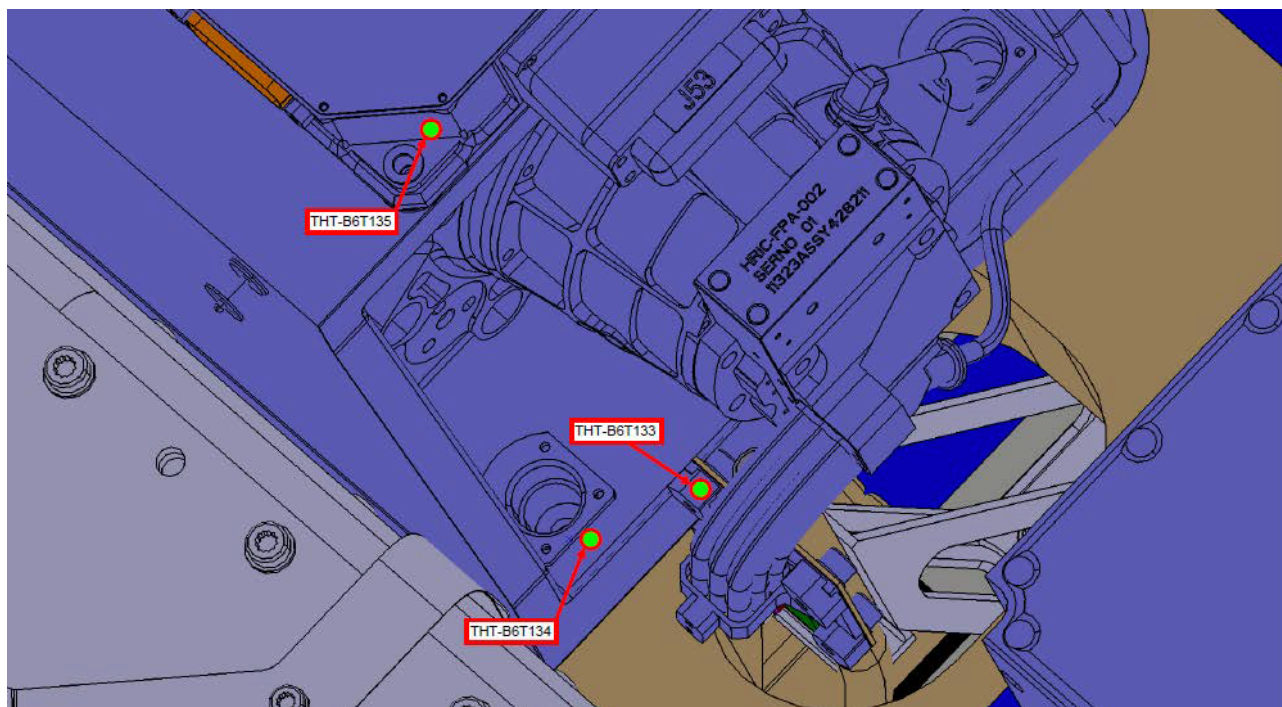
**Table 2:** HRIC temperature sensor position.



**Figure 1:** HRIC-FPA temperature sensors [RD.3] next to the FPA, called SCA1 (on the left) and SCA2 (on the right) and associated respectively to the NSS11040 and NSS11041.

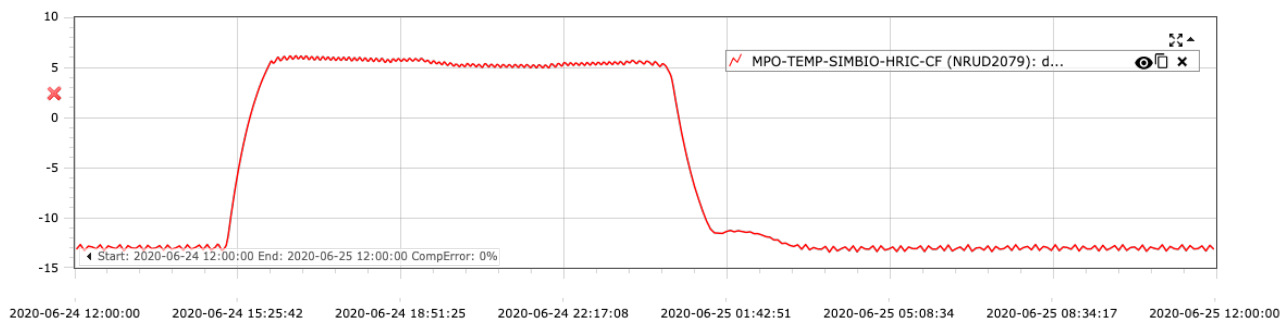
## 2.2 BepiColombo CF Sensors

HRIC Cold Finger (CF) temperature sensor is placed as indicated in Figure 2.



**Figure 2:** The MPO-TEMP-SIMBIO-HRIC-CF (NRUD2079, here THT-B6T133) as reported in [RD.2].

During the execution of the ICO#03 tests its value was monitored with a 5-minute frequency; the obtained trend is reported in Figure 3.



**Figure 3:** HRIC Cold Finger temperature evolution during the ICO#03 tests. Temperature is reported in °C.

The HRIC CF reached the temperature thresholds after 2 h of heating.

### 3 HRIC-ICO3 Tests

As reported in [RD.4], the ICO#03 SIMBIO-SYS tests had the scope to verify the health status of the instrument at channel and system level after 1.5 year after launch. A functional and a performance test are planned to monitor the evolution of some key instrument parameters (see Table 3 for more details).

| Test name                  | Monitoring                               | UTC first Image            |
|----------------------------|------------------------------------------|----------------------------|
| HRIC Functional Test       | PE, TEC, memory, acquisition, capability | 2020-06-24T18:52:50.088279 |
| HRIC Performance Test      | DC Verification                          | 2020-06-24T19:09:20.087813 |
| HRIC-STC interference Test | Long period bias oscillation check       | 2020-06-24T23:51:30.087583 |

**Table 3:** Table of the Tests as reported in [RD.4].

As for the ICO#02 tests (see planning [RD.4]) the channel switch-on was performed after two main steps:

1. The usage of S/C Thermal Adjustment settings procedures (i.e., usage of SS-FCP-015 – see [RD.6]) with updated thresholds
2. the upload of the nominal TEC activation parameters (see [RD.3]) to put the instrument in the correct thermal environment (i.e., the one for which the TEC parameters were defined).

The summary of the HRIC TEC activation parameters used in ICO#03 phases is reported in following table.

| Name         | Data-kind                                     | Meaning                                                                        | ICO#03 Phase |
|--------------|-----------------------------------------------|--------------------------------------------------------------------------------|--------------|
| NP           | [16 bit uint]                                 | Proportional gain                                                              | 77           |
| NI           | [16 bit uint]                                 | integral gain                                                                  | 33           |
| N_E          | [16 bit uint] (only 12 lsb's may be not zero) | PI operation threshold                                                         | 112 (10K)    |
| NSS          | [16 bit uint] (only 14 lsb's may be not zero) | Soft start Ramp slope                                                          | 12289        |
| BSS o BSTART | [2 bits]                                      | - bit 15= 0/1 : anti- windup ON/OFF;<br>- bit 14= 0/1 : P-only/ramp soft start | 11           |
| T_REF        | [16 bit uint]                                 | Reference FPA commanded temperature (only 12 lsb's may be not zero)            | 2799 (268 K) |

**Table 4:** HRIC TEC Soft-Start parameters.

## 3.1 HRIC Functional Test

### 3.1.1 Test description

During ICO#03 the HRIC functionality has been verified by means of dedicated Functional Test procedures with the aim of verifying the PE, TEC and detector activation, the memory/registers status and the science acquisition capability.

In particular, the HRIC functionality will be tested by means of the following TCs sequence:

- PE switch-on
- Detector switch-on
- TEC switch-on (optimized TEC parameters)
- Test of the reading and writing of a specific memory address
- The following science acquisitions:
  - 360 FPAN acquisitions with null integration and RT=1s,
  - 360 FPAN acquisitions with long integration and RT=1s,
  - 10 FPAN acquisitions with RT=1s,
- TEC switch-off
- Detector switch-off
- PE switch-off

### 3.1.2 Commanding

The functional test was commanded by a Payload Operation Request (POR) whose details and updates can be found in [RD.4]. All planned science TCs were nominally executed. The summary of the TCs and the consequent images dataset generated is reported in Table 5 and Table 6.

| Timeline | Relative | TC       | Scope                                 | Notes                                                                                                          |
|----------|----------|----------|---------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 00:00:00 | 00:00:00 | ZSSK4000 | ME switch-on via OBCP                 |                                                                                                                |
| 00:05:00 | 00:05:00 | ZSS17101 | HRIC PE switch-on                     |                                                                                                                |
| 00:06:00 | 00:01:00 | ZSS17105 | SIMB HRIC Upload parameters           |                                                                                                                |
| 00:06:05 | 00:00:05 | ZSS17104 | SIMB HRIC Confirm Command             |                                                                                                                |
| 00:06:10 | 00:00:05 | ZSS17105 | SIMB HRIC Upload parameters           |                                                                                                                |
| 00:06:15 | 00:00:05 | ZSS17104 | SIMB HRIC Confirm Command             |                                                                                                                |
| 00:06:20 | 00:00:05 | ZSS17105 | SIMB HRIC Upload parameters           | To upload the nominal activation parameters for HRIC TEC soft-start                                            |
| 00:06:25 | 00:00:05 | ZSS17104 | SIMB HRIC Confirm Command             |                                                                                                                |
| 00:06:40 | 00:00:15 | ZSS17105 | SIMB HRIC Upload parameters           |                                                                                                                |
| 00:06:45 | 00:00:05 | ZSS17104 | SIMB HRIC Confirm Command             |                                                                                                                |
| 00:06:50 | 00:00:05 | ZSS17105 | SIMB HRIC Upload parameters           |                                                                                                                |
| 00:06:55 | 00:00:05 | ZSS17104 | SIMB HRIC Confirm Command             |                                                                                                                |
| 00:07:00 | 00:00:05 | ZSS00329 | Set HK to 1 s                         |                                                                                                                |
| 00:07:05 | 00:00:05 | ZSS17110 | Send SIMB HRIC Detector On/Off        | Switch On HRIC PE (Channel) (to restore after ASW update with correct TEC initialization). TEC set point: 268K |
| 00:07:10 | 00:00:05 | ZSS17103 | Send SIMB HRIC Thermal Control On/Off |                                                                                                                |
| 00:22:10 | 00:15:00 | ZSS17106 | Send SIMB HRIC Read Addr              | Read memory present status                                                                                     |
| 00:22:25 | 00:00:15 | ZSS17106 | Send SIMB HRIC Read Addr              |                                                                                                                |
| 00:22:30 | 00:00:05 | ZSS17107 | Send SIMB HRIC Write Addr             | Test Writing Memory                                                                                            |
| 00:22:35 | 00:00:05 | ZSS17104 | Send SIMB HRIC Confirm Command        |                                                                                                                |

|          |          |          |                                     |                               |
|----------|----------|----------|-------------------------------------|-------------------------------|
| 00:22:40 | 00:00:05 | ZSS17107 | Send SIMB HRIC Write Addr           | Test STC science test pattern |
| 00:22:45 | 00:00:05 | ZSS17104 | Send SIMB HRIC Confirm Command      |                               |
| 00:22:50 | 00:00:05 | ZSS17101 | Start HRIC Science (Short Int FPAN) | Science                       |
| 00:28:50 | 00:06:00 | ZSS17109 | Stop HRIC Science                   |                               |
| 00:28:55 | 00:00:05 | ZSS171B1 | Start HRIC Science (Long Int FPAN)  |                               |
| 00:34:55 | 00:06:00 | ZSS17109 | Stop HRIC Science                   |                               |
| 00:35:00 | 00:00:05 | ZSS17102 | Start HRIC Science (Short Int FPAN) | End test.                     |
| 00:37:00 | 00:02:00 | ZSS00329 | Set HK to 10 s                      |                               |

**Table 5:** Timeline of the Functional Tests with the references to the commanded ZSS.

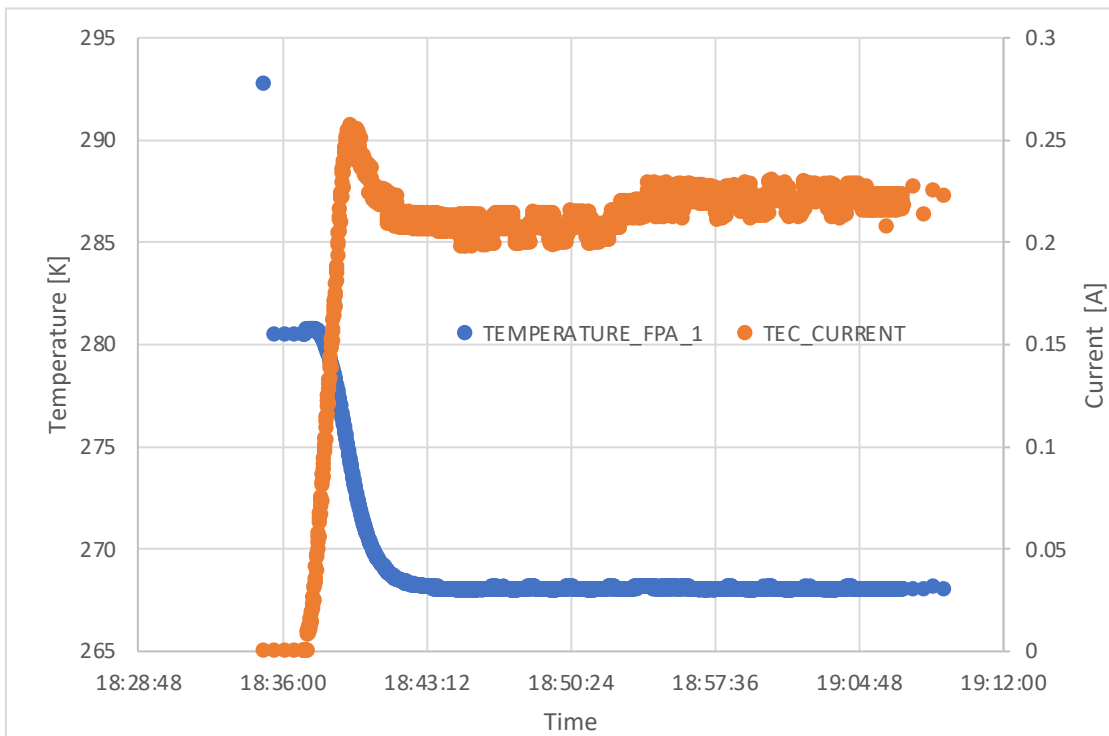
The resulting database derived by EGSE telemetry to raw pipeline (see [RD.7]) is reported in Table 6. All science TCs were in continuous mode.

| EGSE_NTC<br>[#] | First_Acq<br>[UTC]         | Duration<br>[s] | NACQ<br>[#] | IT<br>[ms] | RT<br>[s] | Windows |
|-----------------|----------------------------|-----------------|-------------|------------|-----------|---------|
| 1               | 2020-06-24T18:52:50.088279 | 360             | 360         | 0.03840    | 1         | FPAN    |
| 2               | 2020-06-24T18:58:55.085957 | 360             | 360         | 314.88     | 1         | FPAN    |
| 3               | 2020-06-24T19:05:00.084077 | 10              | 10          | 0.03840    | 1         | FPAN    |

**Table 6:** Resulting database of the ICO#03 Functional Test. All TCs were commanded with the CBD = 128x128 and, nominally, the IBR was set to 32.

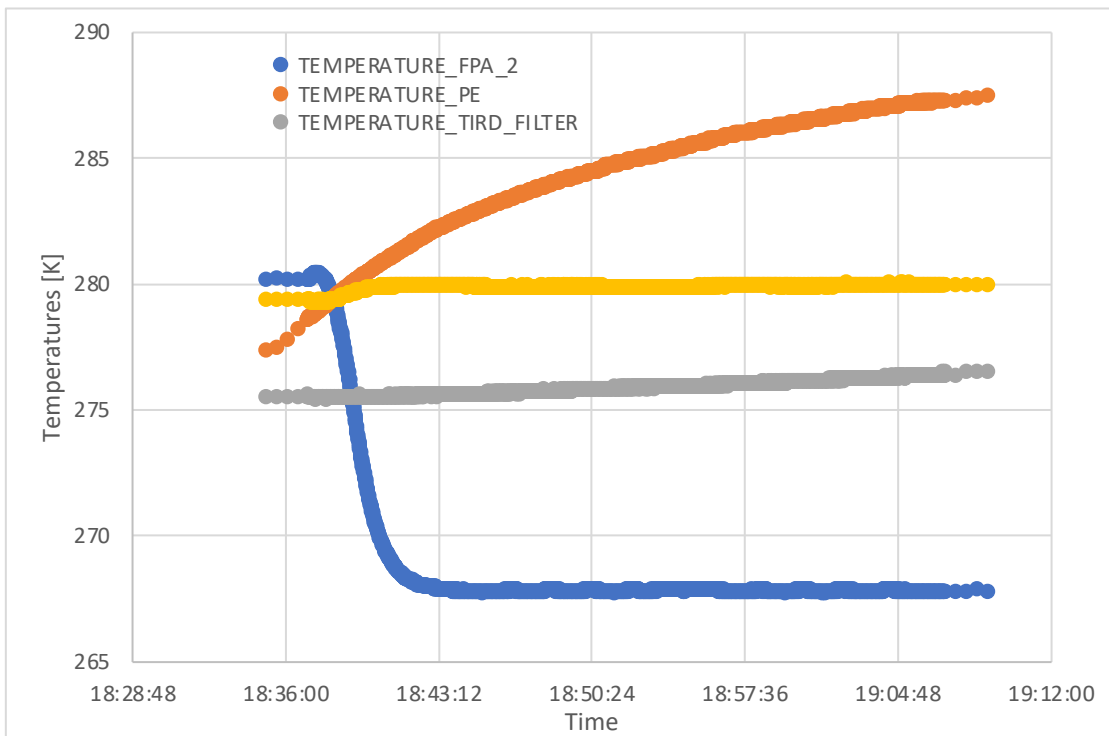
### 3.1.3 HKs interpretation and discussion

The test was performed using the nominal parameters for the TEC and imposing a difference between the target temperature for the detector and the external interface larger than the values need to activate the soft start for the PID control of the TEC. The analysis of the HKs shows a nominal trend for the FPA temperature and TEC current (Figure 4).



**Figure 4:** HRIC TEC current and focal plane temperature trends at the switch on during the functional test of HRIC.

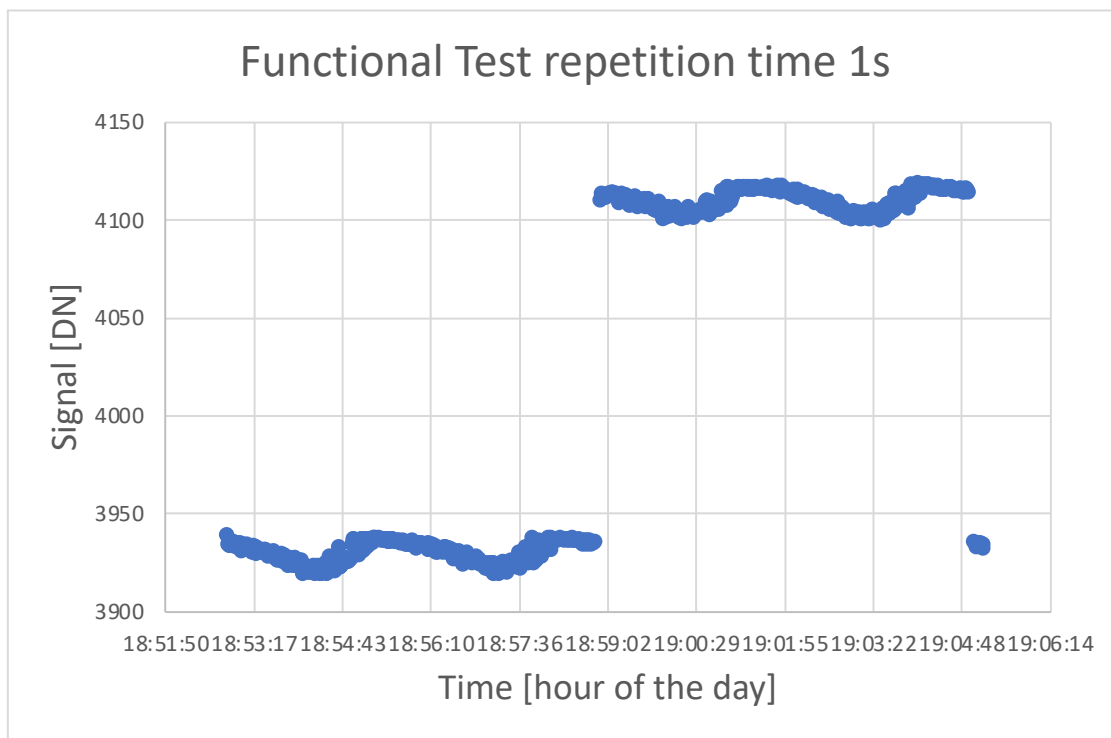
The temperatures trends for the other monitoring thermometers (FPA2, PE and TIRD filter) show a nominal behaviour with an increasing temperature for the PE and a more limited increase for the TIRD due to the heating of the unit after the switch on (Figure 5).



**Figure 5:** Temperatures trends of the HRIC monitoring thermometers after the switch on.

### 3.1.4 Images Analysis

As for the test in the previous ICOs a slow oscillation in the level of the frames is present, the period of this oscillation remains of about 180s (Figure 6). All other parameters in the acquired frames remain nominal.



**Figure 6:** Functional test averages of acquired frames.

## 3.2 HRIC Performance Test

### 3.2.1 Test description

The HRIC performance test in ICO#03 was related in the monitoring of the Dark Current (DC) with respect to the nominal integration times for both the Panchromatic and the Broad Band filters.

### 3.2.2 Commanding

The test was executed by means of a dedicated POR (see [RD.4] for details) whose science TCs were nominally executed. The summary of the TCs and the consequent images dataset generated is reported in Table 7 and Table 8.

| Timeline | Fop Names | [#] TCs | Min IT [ms] | Max It [ms] | RT [s]          |
|----------|-----------|---------|-------------|-------------|-----------------|
| 00:00:00 | ASSF101   | 13      | 0           | 96          | 1               |
| 00:02:10 | ASSF201   | 4       | 480         | 5760        | Between 2 and 8 |
| 00:04:50 | ASSF102   | 13      | 0           | 96          | 1               |
| 00:09:10 | ASSF201   | 4       | 480         | 5760        | Between 2 and 8 |

**Table 7:** Timeline of the 4 sets of Science TCs of the PERFORMANCE TEST with the references to the commanded FOPs (see [RD.6] for more details).

The resulting database derived by EGSE telemetry to raw pipeline (see [RD.7]) is reported in Table 8.

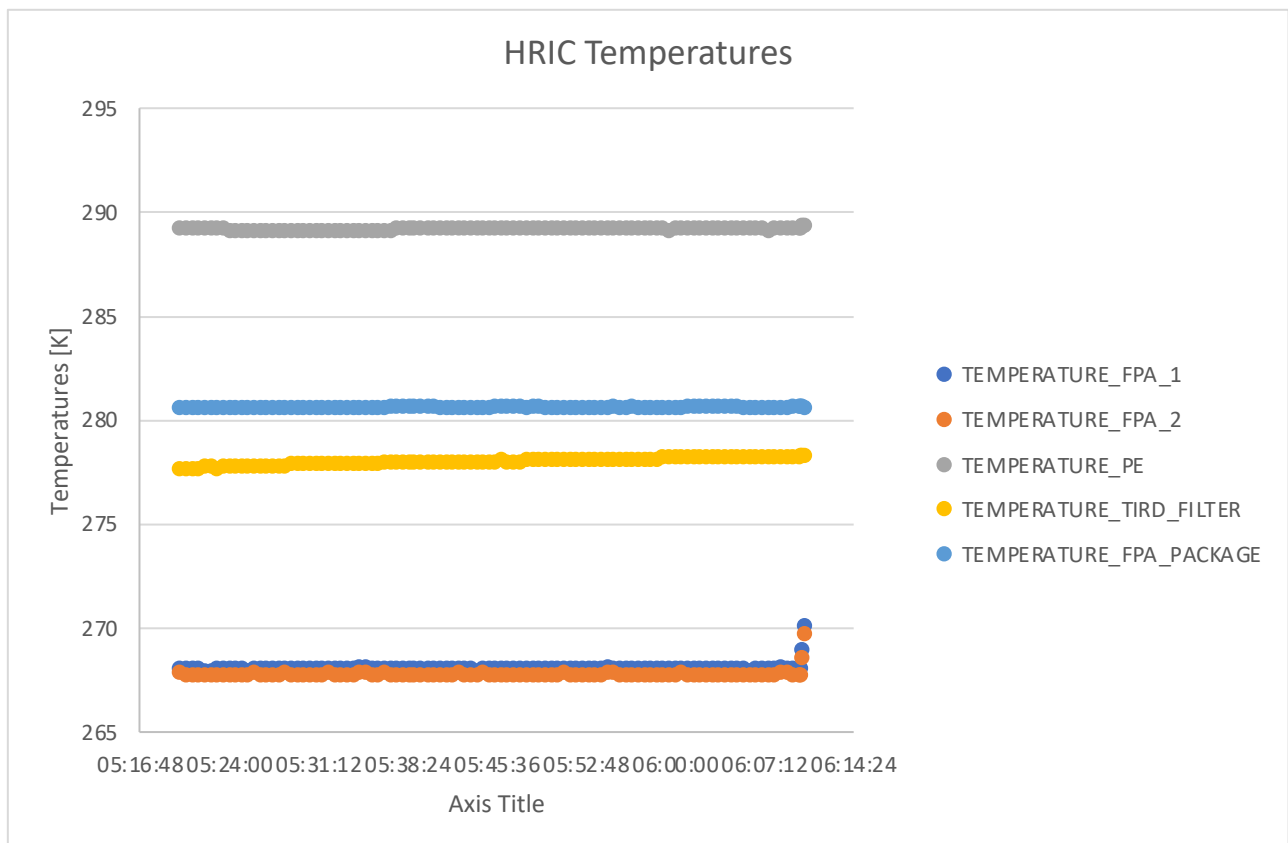
| EGSE_NTC | First_Acq [UTC]            | Duration [s] | IT [ms]   | RT [s]      | Windows |
|----------|----------------------------|--------------|-----------|-------------|---------|
| 1        | 2020-06-24T19:07:10.083588 | 9.999909043  | 0.0004    | 0.999993232 | FPAN    |
| 2        | 2020-06-24T19:07:20.088379 | 10.00001502  | 0.0096    | 0.999994887 | FPAN    |
| 3        | 2020-06-24T19:07:30.088272 | 9.999922991  | 0.0192    | 0.999984662 | FPAN    |
| 4        | 2020-06-24T19:07:40.088150 | 10.00006104  | 0.048     | 1.000001775 | FPAN    |
| 5        | 2020-06-24T19:07:50.088104 | 9.999862909  | 0.48      | 0.999986437 | FPAN    |
| 6        | 2020-06-24T19:08:00.088150 | 10.00003004  | 0.96      | 0.999984781 | FPAN    |
| 7        | 2020-06-24T19:08:10.088012 | 9.999833107  | 1.92      | 0.99999502  | FPAN    |
| 8        | 2020-06-24T19:08:20.088119 | 10.00003004  | 2.88      | 1.000005007 | FPAN    |
| 9        | 2020-06-24T19:08:30.087905 | 9.999953985  | 3.84      | 1.000001669 | FPAN    |
| 10       | 2020-06-24T19:08:40.087981 | 10           | 4.8       | 0.999996556 | FPAN    |
| 11       | 2020-06-24T19:08:50.087829 | 9.999923944  | 9.6       | 0.999988106 | FPAN    |
| 12       | 2020-06-24T19:09:00.087798 | 9.999862075  | 48        | 0.999993112 | FPAN    |
| 13       | 2020-06-24T19:09:10.087813 | 10.00012195  | 96        | 1.00001355  | FPAN    |
| 14       | 2020-06-24T19:09:20.087813 | 19.99989774  | 0.48      | 1.999989774 | FPAN    |
| 15       | 2020-06-24T19:09:40.087645 | 19.99984768  | 0.96      | 1.999984768 | FPAN    |
| 16       | 2020-06-24T19:10:00.087660 | 39.99974555  | 2.88      | 3.999974555 | FPAN    |
| 17       | 2020-06-24T19:10:40.087324 | 79.9996433   | 5.76      | 7.99996433  | FPAN    |
| 18       | 2020-06-24T19:12:00.087110 | 19.99972887  | 0.0000004 | 1.999972887 | BB      |
| 19       | 2020-06-24T19:12:20.086957 | 19.99976224  | 0.0000096 | 1.999976224 | BB      |
| 20       | 2020-06-24T19:12:40.086881 | 19.99972781  | 0.0000192 | 1.999972781 | BB      |
| 21       | 2020-06-24T19:13:00.086652 | 19.99994874  | 0.000048  | 1.999994874 | BB      |
| 22       | 2020-06-24T19:13:20.086606 | 19.99993218  | 0.00048   | 1.999993218 | BB      |
| 23       | 2020-06-24T19:13:40.086575 | 19.99989774  | 0.00096   | 1.999989774 | BB      |
| 24       | 2020-06-24T19:14:00.086483 | 19.9998645   | 0.00192   | 1.99998645  | BB      |
| 25       | 2020-06-24T19:14:20.086392 | 19.99986331  | 0.00288   | 1.999986331 | BB      |
| 26       | 2020-06-24T19:14:40.086285 | 19.99981337  | 0.00384   | 1.999981337 | BB      |
| 27       | 2020-06-24T19:15:00.086162 | 19.99989894  | 0.0048    | 1.999989894 | BB      |
| 28       | 2020-06-24T19:15:20.086117 | 19.99981218  | 0.0096    | 1.999981218 | BB      |
| 29       | 2020-06-24T19:15:40.086086 | 19.99976211  | 0.048     | 1.999976211 | BB      |

|    |                            |             |       |             |    |
|----|----------------------------|-------------|-------|-------------|----|
| 30 | 2020-06-24T19:16:00.085994 | 19.99979668 | 0.096 | 1.999979668 | BB |
| 31 | 2020-06-24T19:16:20.085826 | 19.99984768 | 0.48  | 1.999984768 | BB |
| 32 | 2020-06-24T19:16:40.085765 | 39.99979668 | 0.96  | 3.999979668 | BB |
| 33 | 2020-06-24T19:17:20.085505 | 59.99986437 | 2.88  | 5.999986437 | BB |
| 34 | 2020-06-24T19:18:20.085413 | 79.99959217 | 5.76  | 7.999959217 | BB |

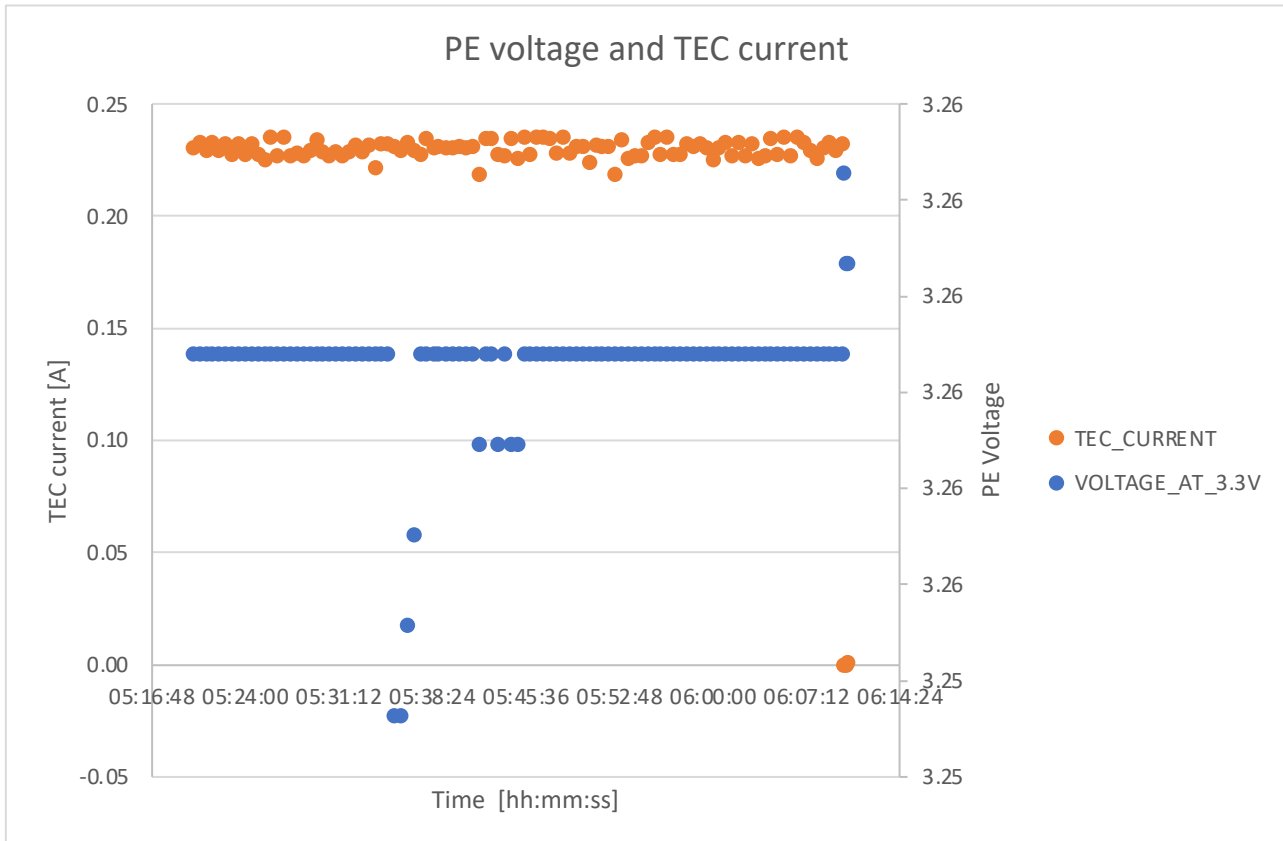
**Table 8:** Database derived by EGSE. All TCs commanded 10 acquisitions with IBR=0 and CBD=128x128.

### 3.2.3 HKs interpretation and discussion

The analysis of the HK collected during performance test for HRIC shows a nominal behaviour both for temperatures (Figure 7) and Voltage and TEC current (Figure 8).



**Figure 7:** Temperatures of HRIC during performance tests.

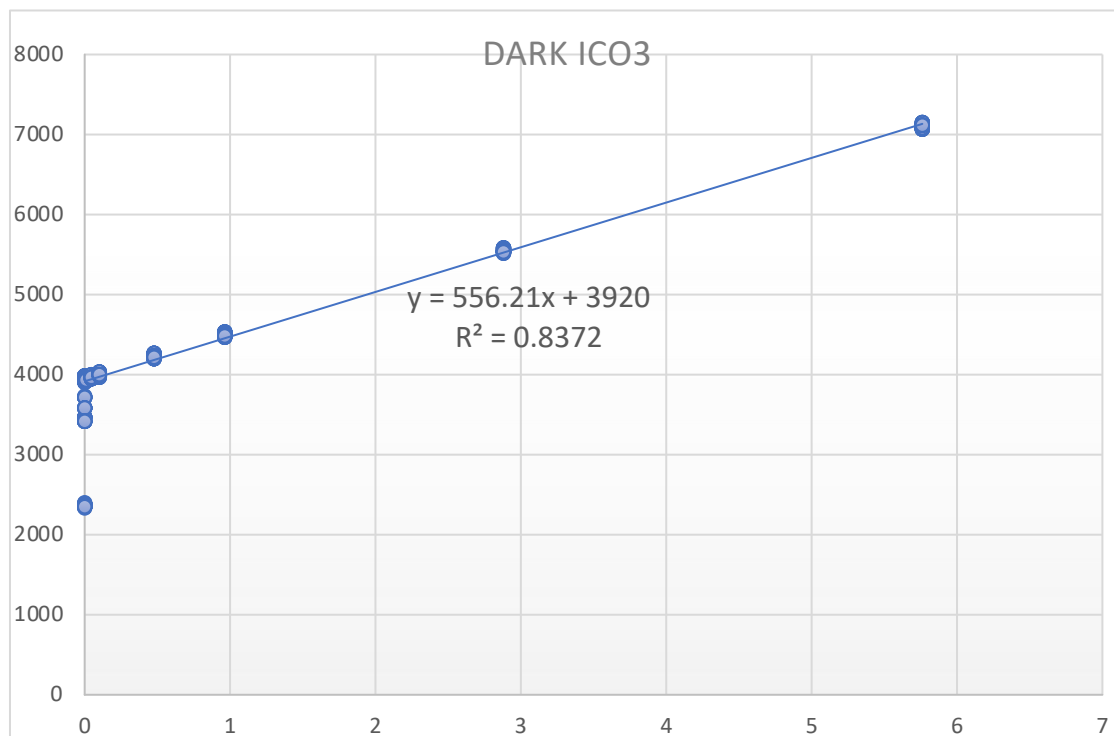


**Figure 8:** HRIC PE TEC current and Voltage.

### 3.2.4 Images analysis

The performance test for HRIC channel consists in a series of acquisition to check the DARK current behavior. The acquisitions have been performed with the same sequence performed in the previous ICOs. In order to compare results of the test the averages of the frames acquired were plotted vs the integration times used and a linear fit have been evaluated (Figure 9).

The values of the fit parameters have been reported in (Table 9) to compare with the values obtained during the previous ICOs. The dark current parameters show a good stability between the different tests performed up to now during the cruise.



**Figure 9:** DARK current vs integration time (in DN) for the HRIC channel, in the plot reported the average value of the acquired frames.

| ICO | Slope of Dark Current Trend | Intercept of Dark current trend | Correlation parameter $R^2$ |
|-----|-----------------------------|---------------------------------|-----------------------------|
| 1   | 544.36                      | 3929                            | 0.9999                      |
| 2   | 553.87                      | 3920                            | 0.8364                      |
| 3   | 556.21                      | 3920                            | 0.8372                      |

**Table 9:** List of the DARK current fit parameters obtained with the performance test carried out during the cruise phase.