BC-SIM-TR-025 HRIC
ICO3 REPORT

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Approvation

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Document change record

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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

[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

[RD.5] BC-SIM-PL-004_-_SIMBIO-SYS_Checkout_02_Test_Summary_Issue1_Revision0, 10.20371/INAF/TechRep/100

[RD.6] BC-SIM-TN-008_-_SIMBIO-SYS_FOP_update_after_ICO#02, 10.20371/INAF/TechRep/162

[RD.7] BC-SIM-TR-024_-_EGSE_ICO#03_report, 10.20371/INAF/TechRep/185

1.3 Acronyms

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

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

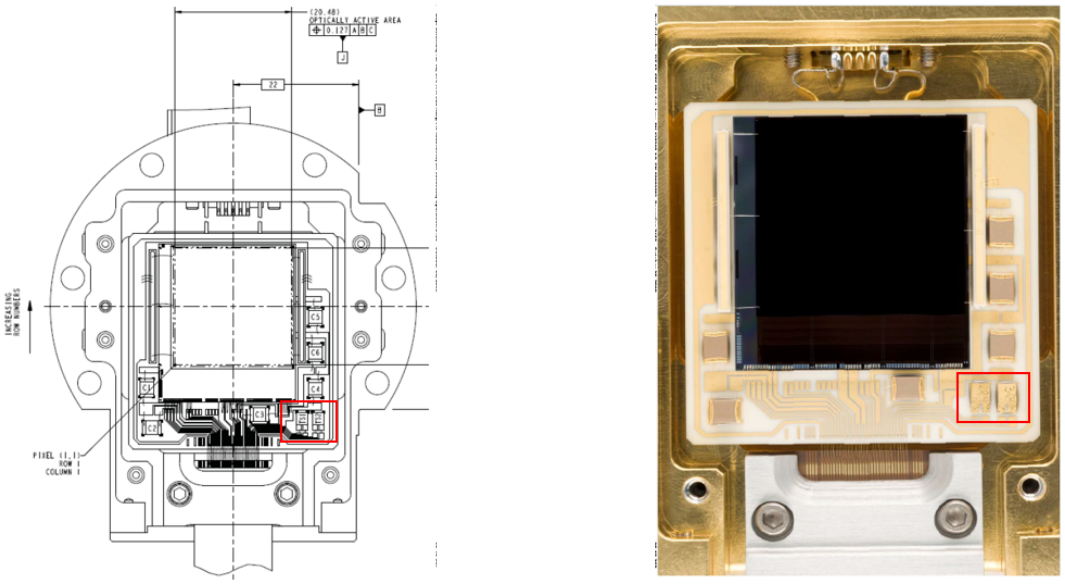
Param.ID	Param Name	Unit	Calibration
NSS11040	HRIC Temperature FPA1	K	CSSP0010TM
NSS11041	HRIC Temperature FPA2	K	CSSP0011TM
NSS11042	HRIC Temperature PE	K	CSSP0012TM
NSS11043	HRIC Temp Tele1	K	CSSP0013TM
NSS11044	HRIC Temp Tele2	K	CSSP0014TM
NSS11050	HRIC PE 3.3V Measured	V	CSSP0015TM
NSS11051	HRIC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



(a) (b)

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.

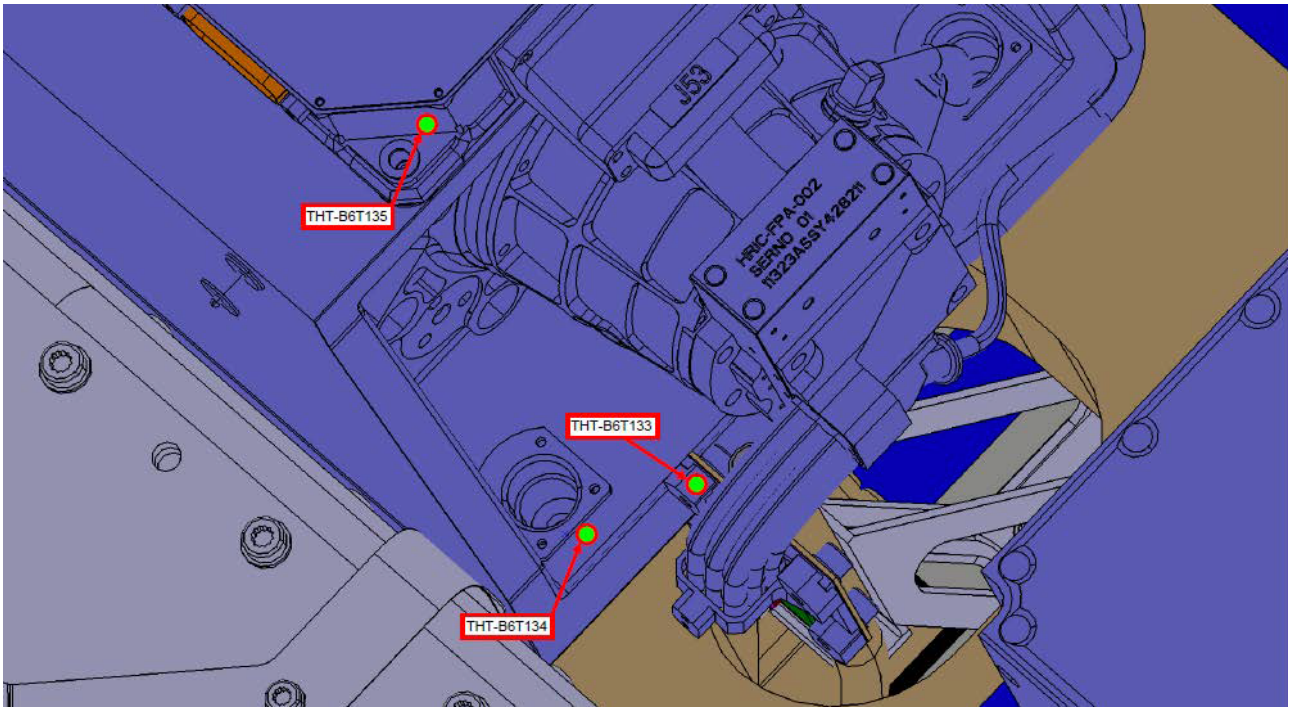


Figure 2: The MPO-TEMP-SIMBIO-HRIC-CF (NRUD2079, here THT-B6T133) as reported in [RD.2].

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.

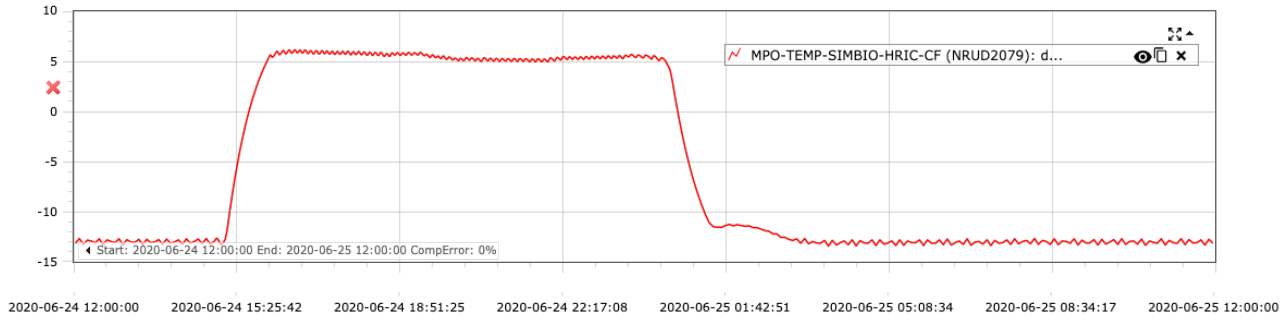


Figure 3: HRIC Cold Finger temperature evolution during the ICO#03 tests. Temperature is reported in °C.

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; - 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 [#]	First_Acq [UTC]	Duration [s]	NACQ [#]	IT [ms]	RT [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).

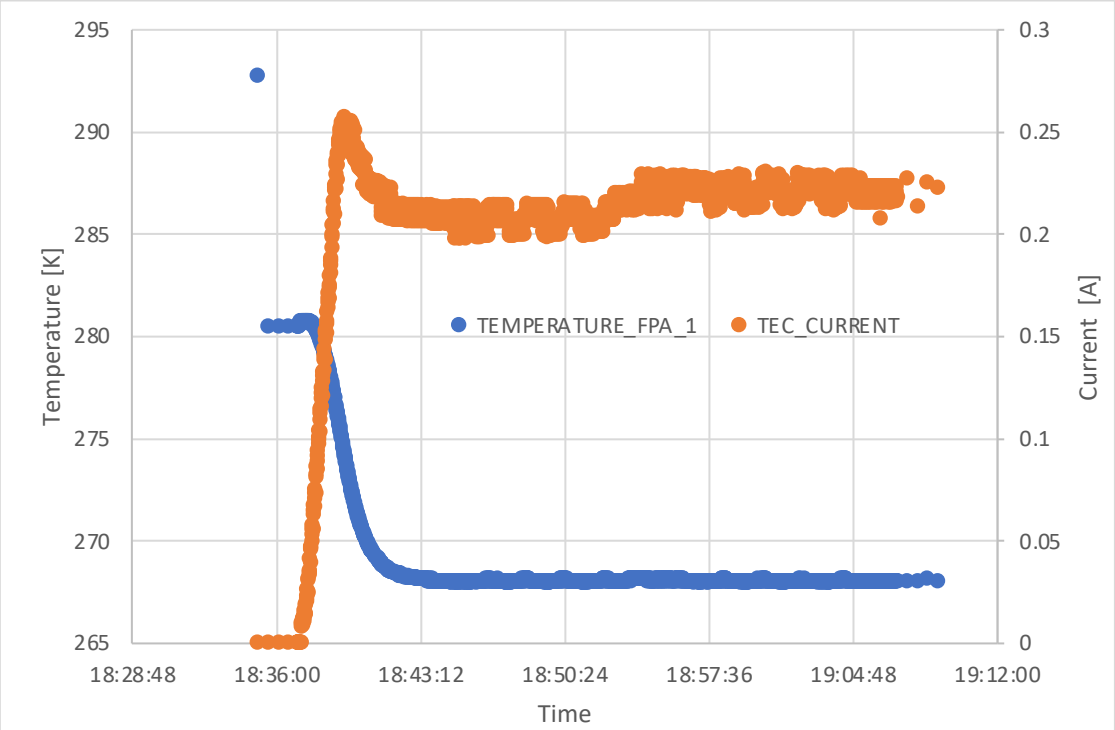


Figure 4: HRIC TEC current and focal plane temperature trends at the switch on during the functional test of HRIC.

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).

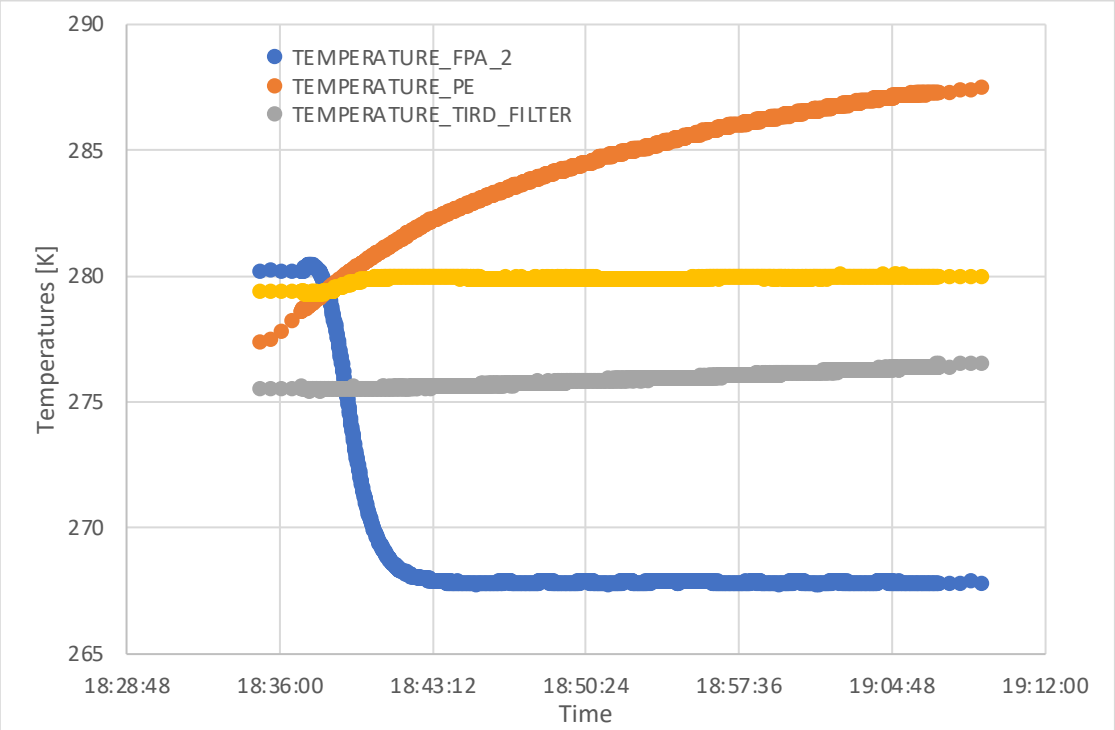


Figure 5: Temperatures trends of the HRIC monitoring thermometers after the switch on.

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.

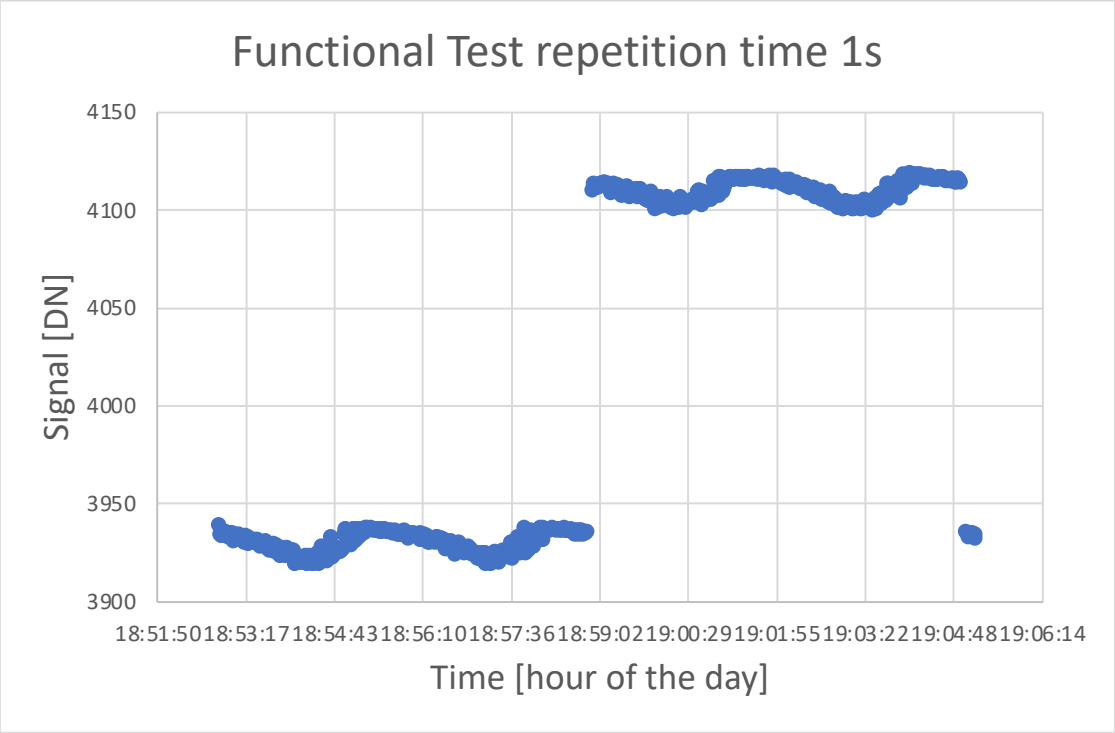


Figure 6: Functional test averages of acquired frames.

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).

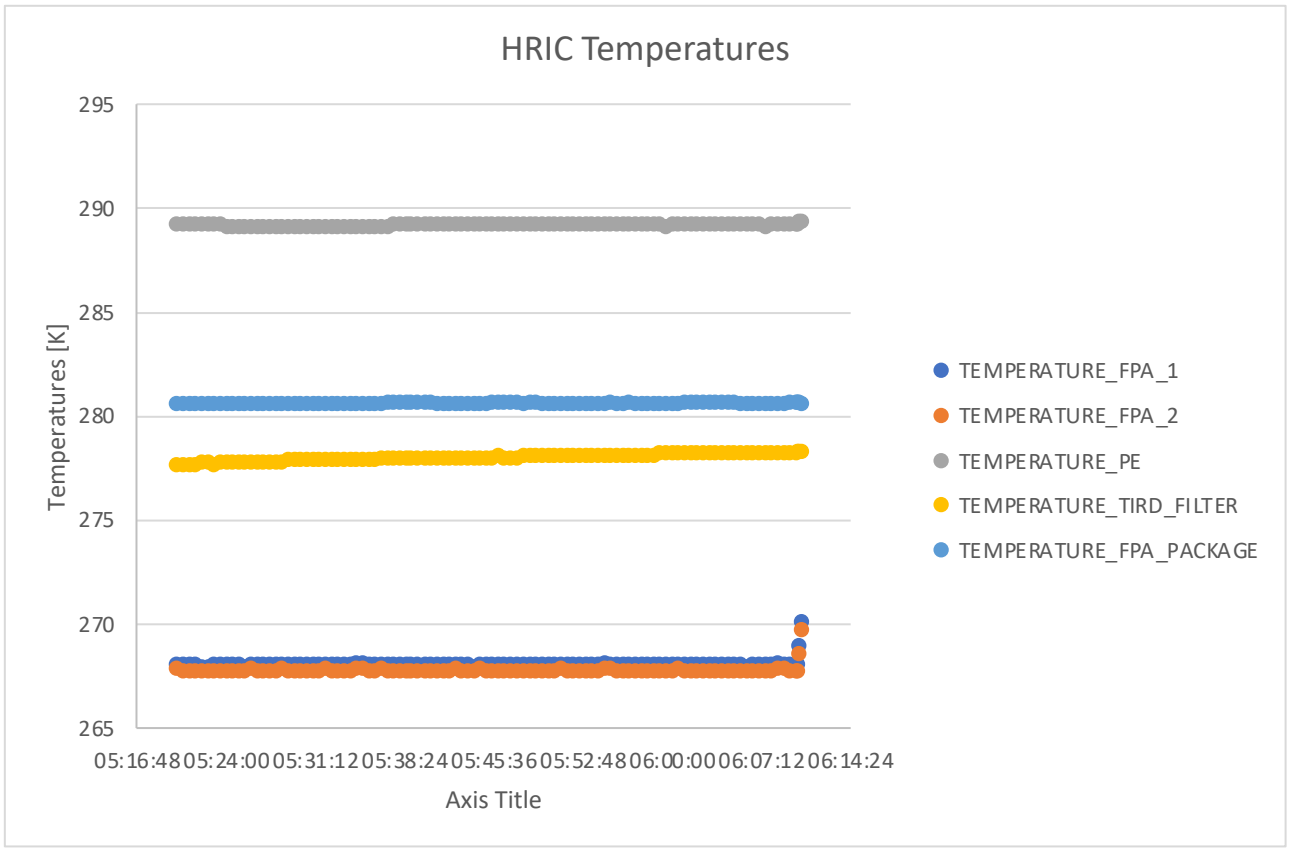


Figure 7: Temperatures of HRIC during performance tests.

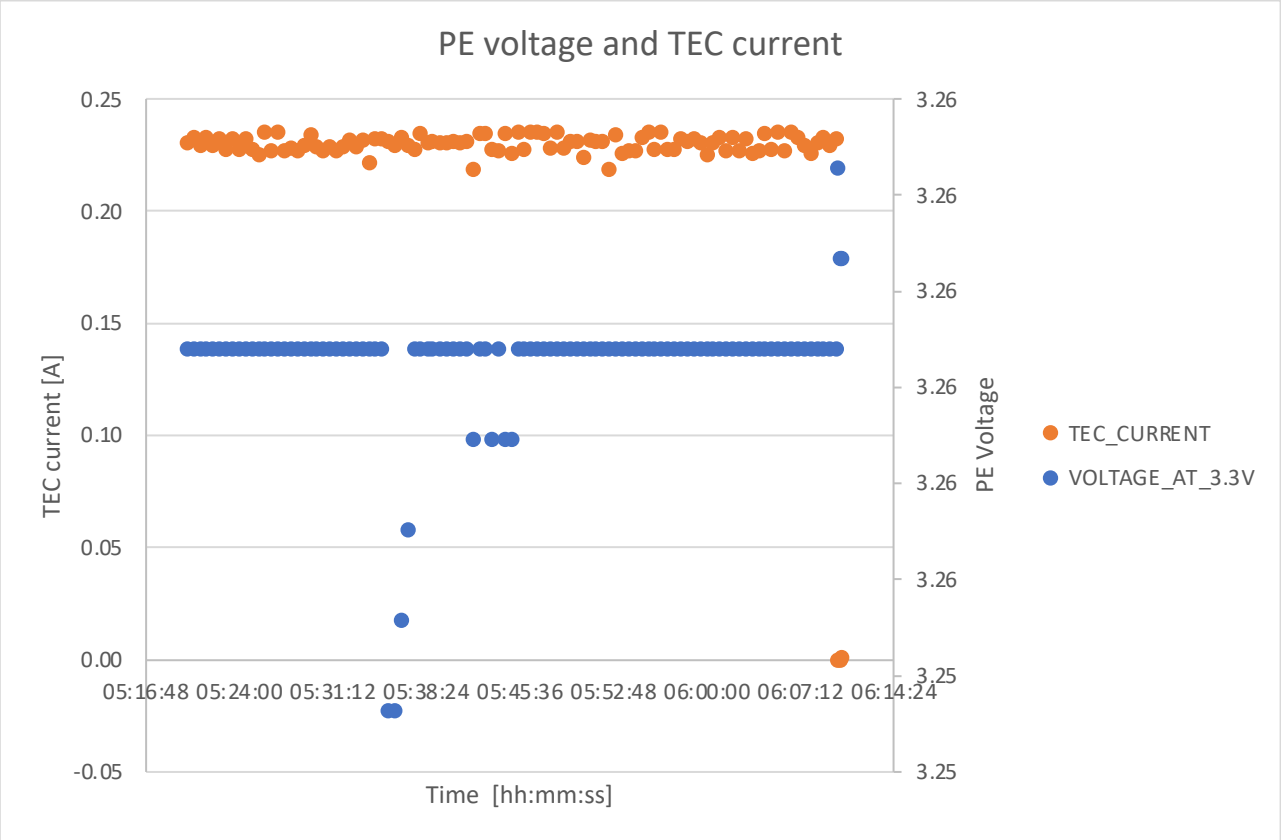


Figure 8: HRIC PE TEC current and Voltage.

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.

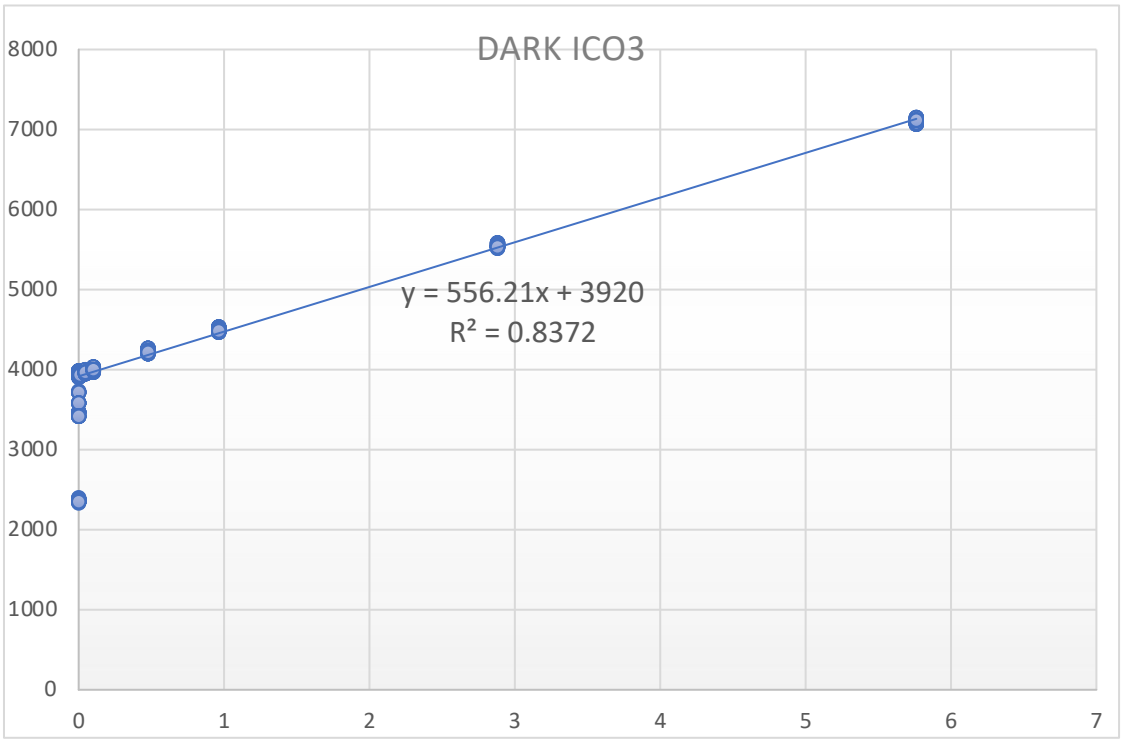


Figure 9: DARK current vs integration time (in DN) for the HRIC channel, in the plot reported the average value of the acquired frames.

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.