SPIRE FCU FM ACCEPTANCE

Vibration Tests Report

	Function	Name	Date	Visa
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DOCUMENT STATUS and CHANGE RECORD

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1 Abreviations list

AIV	Acceptance, Integration and Validation
CEA	Commissariat à l'Energie Atomique
DCU	Detector Control Unit
DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
EM	Engineering Model
FCU	Focal Plane Control Unit
FM	Flight Model
FPU	Focal Plane Unit
FS	Flight Spare model
GSE	Ground Support Equipment
H/K	HouseKeeping
I&T	Integration and Test
I/F	Interface
ICD	Interface Control Document
IID	Instrument Interface Document
IRD	Instrument Requirements Document
LAM	Laboratoire d'Astrophysique de Marseille
LETI	Laboratoire d'Electronique, de Technologie et d'Instrumentation
LTU	Local Test Unit
MCU	Mechanism Control Unit
PB	Power Bench
PFM	Proto Flight Model
PSU	Power Supply Unit
QM	Qualification Model
RAL	Rutherford Appleton Laboratory
SAp	Service d'Astrophysique (CEA/DAPNIA)
S/C	SpaceCraft
SCU	Subsystem Control Unit
SEDI	Service d'Electronique et d'Informatique (CEA/DAPNIA)
STB	Simplified Test Board
SPIRE	Spectral and Photometric Imaging REceiver
STM	Structural and Thermal Model
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TC	TeleCommand
TM	TeleMetry

2 Applicable documents

[AD1] HERSCHEL/SPIRE DRCU Interface Control Document	SAP-SPIRE-CCa-075-02
[AD2] HERSCHEL/SPIRE DRCU/DPU Interface Control Document	SAP-SPIRE-CCa-076-02
[AD3] Herschel/SPIRE DRCU AIV PLAN	SAp-SPIRE-HT-0082-02
[AD4] HERSCHEL/SPIRE DRCU Subsystem specification	Sap-SPIRE-CCa-0025-00
[AD5] Herschel/Planck Instrument Interface Document IID Part A ”	SCI-PT-IIDA/SPIRE-04624
[AD6] Herschel/Planck Instrument Interface Document Part B Instrument “SPIRE”	SCI-PT-IIDB/SPIRE-02124
[AD7] Herschel SPIRE Detector Subsystem Specification Document	SPIRE –JPL-PRJ-000456
[AD8] SPIRE FCU FM Functional test procedure	SAp-SPIRE-HT-0388-06
[AD9] Herschel/SPIRE HSFCU FM Procédure de vibrations	SAp-SPIRE-TT-0401-06

3 Reference documents

[RD1] HERSCHEL/SPIRE DCU EM/QM1 Test Report	Sap-SPIRE-CCa-0129-03 Issue 1.0
[RD2] DS-SPIRE development tree	Sap-SPIRE-DS - Version 07/03/2002
[RD3] FIRST/SPIRE DRCU and WIH Development Plan	SAP-SPIRE-JLA-0047-01
[RD4] Mechanical test report	Référence Intespace E5831.HSFFMMECA
[RD5] HS-FCU QM2 TRR Report	SAp-SPIRE- QA-0419-05

4 Introduction

This technical report applies to the Vibration tests performed on the FCU FM equipment for the HERSCHEL SPIRE Project.

These tests have been performed at Intespace between June 14th 2006 and June 16th 2006.

5 Test Configuration

We use the LTU in its latest software configuration, the fully assembled DCU and FCU, the FPU and the PSU Flight Model (PSU FM).

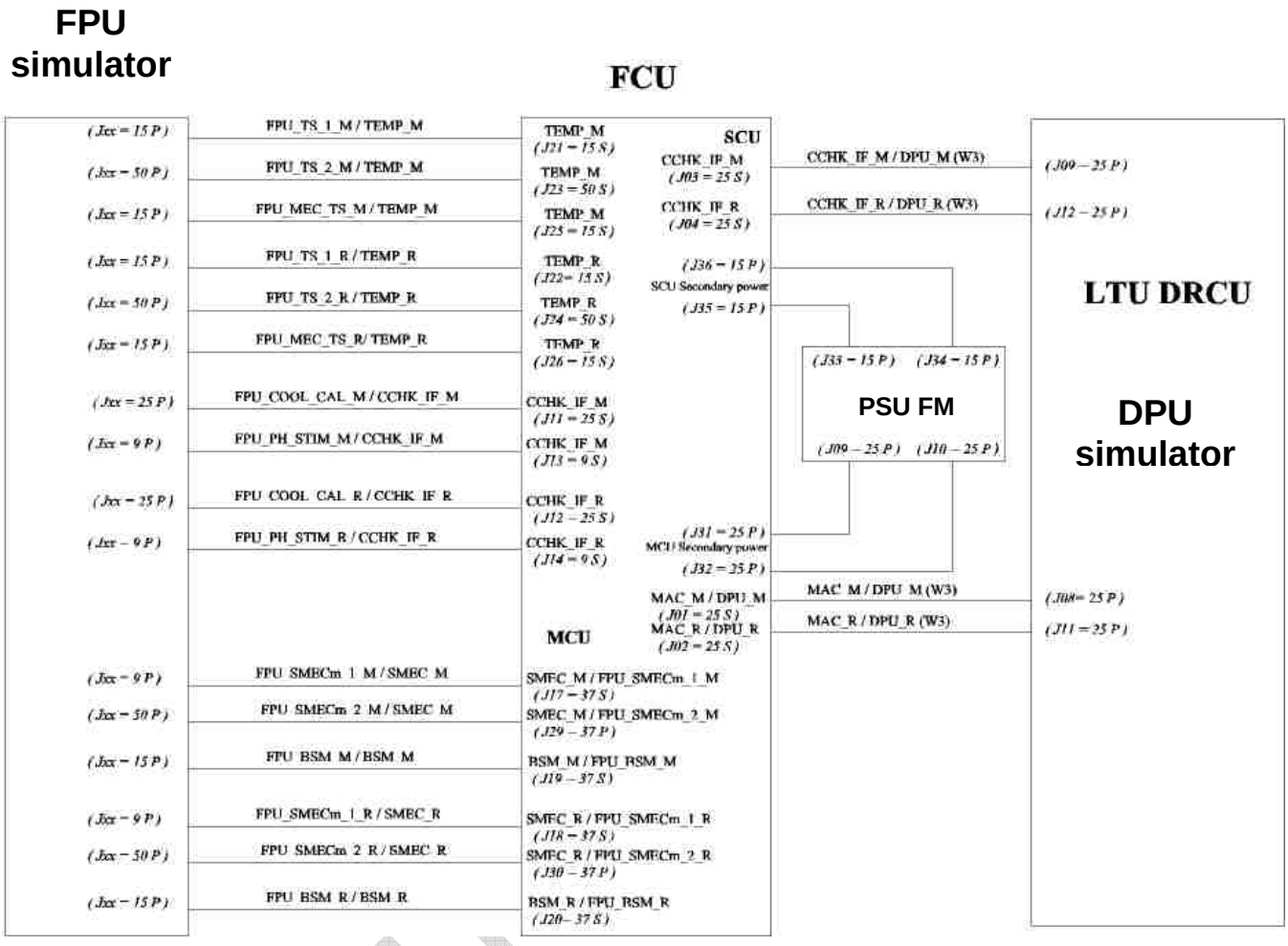
Before to connect any harness, we place savers on all connectors

Connect all harnesses as described below :

- Between SCU and LTU
- Between DCU and PSU FM
- Between SCU and PSU FM

We place savers on all connectors

We connect all harnesses as described below



FCU FLIGHT MODEL TEST CONFIGURATION

FCU FM acceptance tests configuration

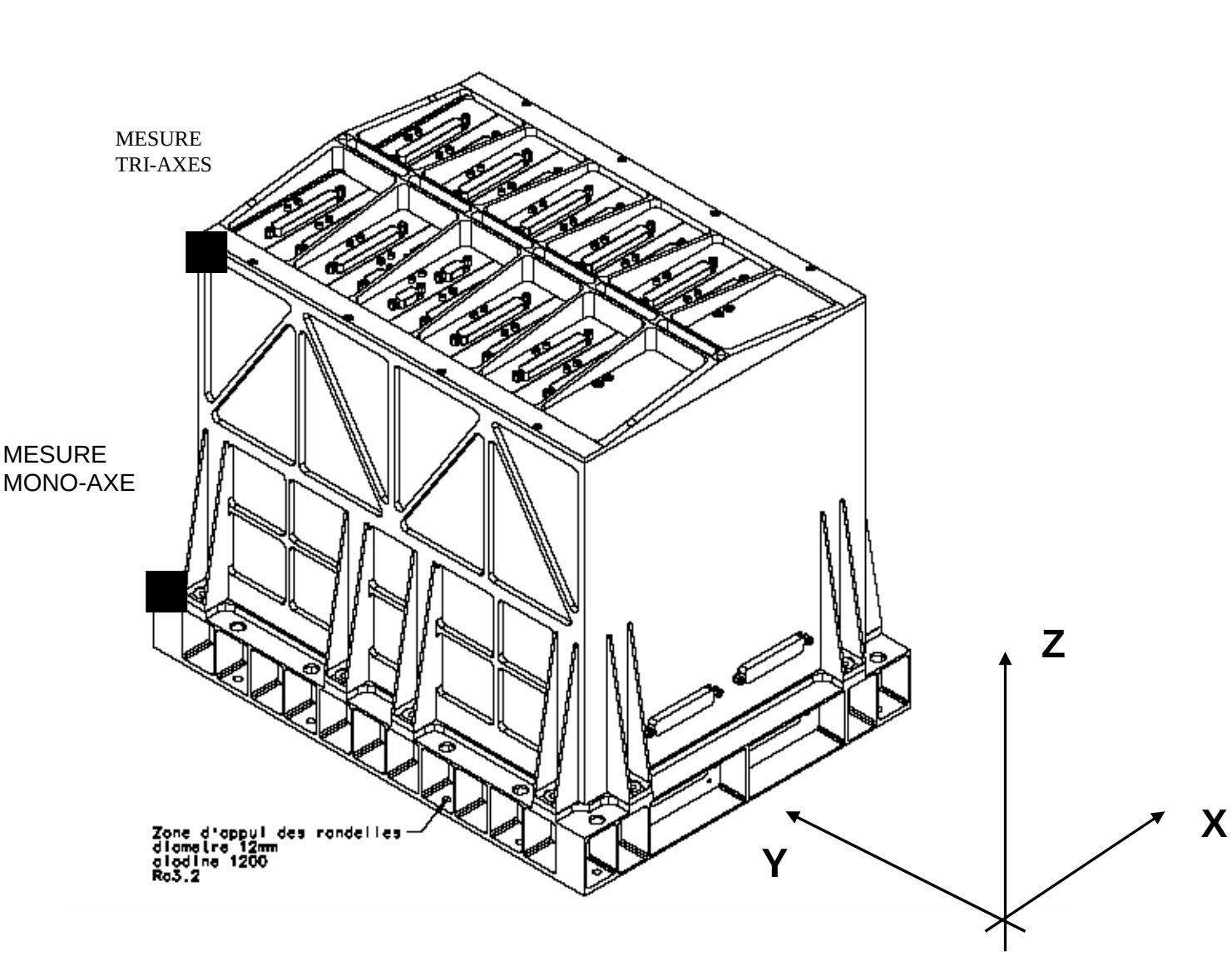
6 Test Program

The description of the vibration test is given in the vibration tests procedure [AD9].

The FCU is mounted on the shaker through a rigid interface (f >2 kHz). We apply on this interface the specified vibration levels.

Before and after applying these levels, we apply acceptance sinus and random levels that show the FCU eigen frequencies of the structure. By comparison of the dynamic signatures (low level sinus) of the FCU before and after the tests, we check its structural integrity.

The tests are performed on **Y,X,Z axes** successively in the reference frame given in [AD9] .



Preliminary tests have been performed on the interface plate of the shaker before mounting the FCU on it.

Before to start the vibration procedure and after the vibrations applied on each axis, we perform a full functional test following the functional test procedures [AD8].

The sequence, which is the same on each axis, is as follows :

Test	
Functional test	Refer to [AD8]
Low level Sinus	Described in § 6.1 of [AD9]
Qualification level Sinus	Described in § 6.2.1 of [AD9]
Random low level	Described in § 6.3 of [AD9]
Random qualification level	Described in § 6.4.1 of [AD9]
Low level Sinus	Described in § 6.1 of [AD9]
Functional test	Refer to [AD8]

The results of the mechanical tests are given in the next chapter.

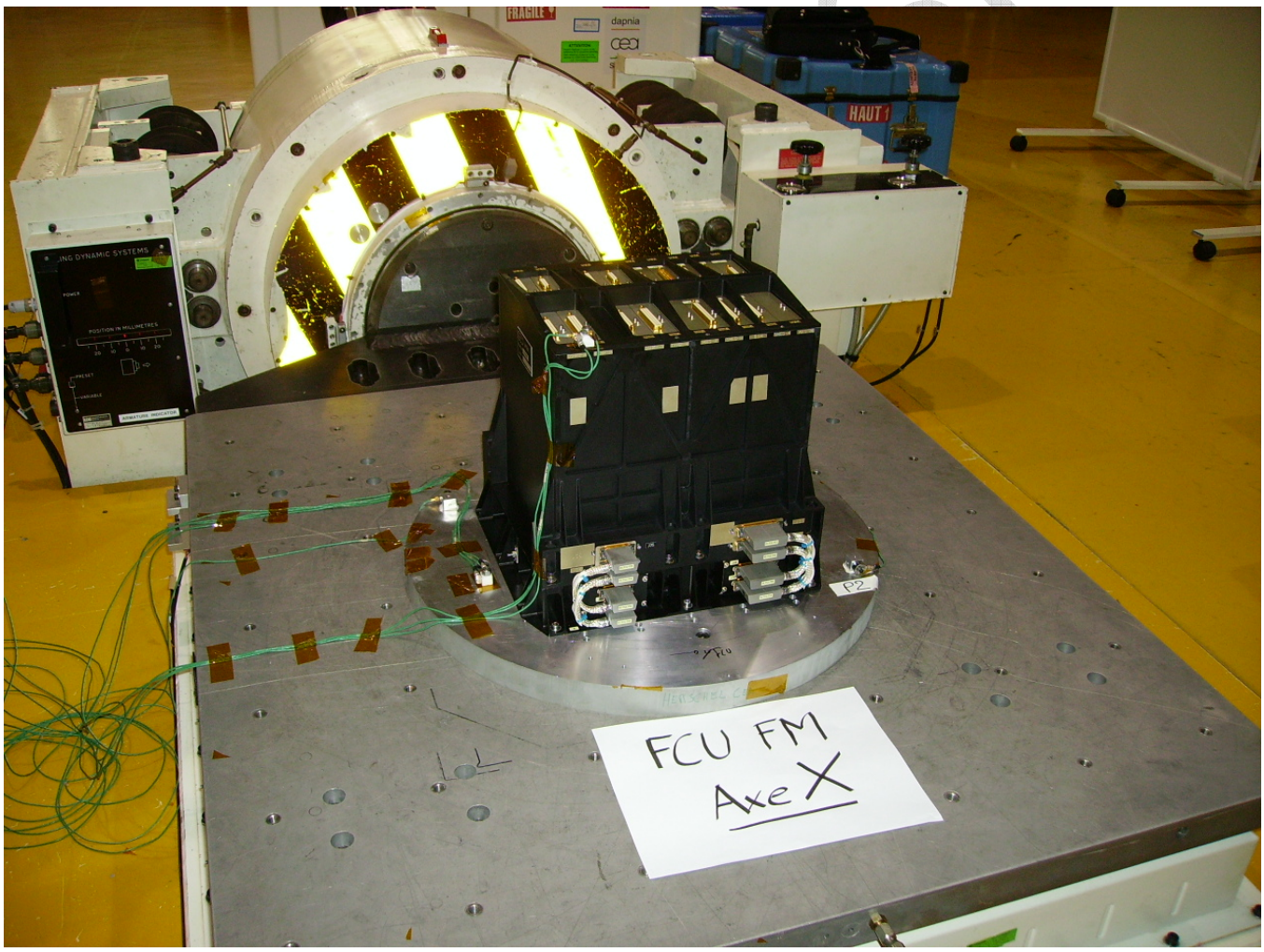
The results of the functional tests are given in the chapter 8.

7 Report of the mechanical tests

It consists in the analysis of the response of the structure to the applied vibration levels. All the data relative to these tests are given in the test report from Intespace referenced as [RD4].

The comparison of the low level sinus response before and after the vibration applied on each axis is being analyzed thereafter.

We look for eigen frequencies and associated magnitudes and check their shift following the test (frequency shift should be lower than 5%). We also test that all eigen frequencies are above 150 Hz.



Vibration on X axis

The graphics representing the low level sinus, the qualification level sinus and the random qualification levels on each axis are given in [RD4].

Their analysis shows that the signatures remain the same (with respect to before vibrations) with no significant frequency shift.

The acceleration levels (g_{rms}), as observed during acceptance ensure the following security margins with respect to qualification levels :

- On X axis : Margin of safety = 1,15
- On Y axis, margin of safety = 1,25
- On Z axis, margin of safety = 1,50

8 Report of the functional tests

The list of the performed test, with reference to [AD8] is :

FCU QM2 tests	Preliminary : after FCU integration at INRTESPACE	After X and Y axis	Final (after Z axis)
Consumption SCU redundant	x	x	x
SCU HouseKeepings	x	x	x
SCU Frames			
SCU Temp/SubK channels	x	x	x
SCU Temp/SubK ON/OFF			
SCU Heater/Calibrators channels	x	x	x
Heater/Calibrators ON/OFF			
SCU currents measured by FPU simulator			
SCU Currents in Stand alone			
Consumption MCU redundant	x	x	x
Consumption MCU main	x	x	x
HouseKeepings	x	x	x
Configuration 1 Main	x	x	x
Configuration 2 Main	x	x	x
Configuration 3 Main	x	x	x
Configuration 4 Main	x	x	x
Configuration 5 Main	x	x	x
Configuration 1 Redundant	x	x	x
Configuration 2 Redundant	x	x	x
Configuration 3 Redundant	x	x	x
Configuration 4 Redundant	x	x	x
Configuration 5 Redundant	x	x	x

In this document, only the main results are given.

8.1 Visual inspection

A visual inspection was performed after each axis. It revealed no specific problem.

8.2 Consumption tests

We thereafter report the consumptions as measured during each functional tests after vibrations.

The MCU configurations testes are the following :

- Configuration 1 : MCU ON, all currents applied to the mechanisms set at 0 level
- Configuration 2 : MCU ON, all currents applied to the mechanisms set at 0 level; latch engaged
- Configuration 3 :MCU ON, all currents applied to the mechanisms set at 10% level;
- Configuration 4 :MCU ON, all currents applied to the mechanisms set at 50% level;
- Configuration 3 :MCU ON, all currents applied to the mechanisms set at 100% level;

Before vibrations

Report of the primary current consumption (mA) at PSU FM level (28V)

MCU Status	Main	Redundant
OFF	400	400
MCU ON	810	810
MCU after boot	870	870
Configuration 1	880	870
Configuration 2	880	870
Configuration 3	940	930
Configuration 4	1060	1060
Configuration 5	1220	1210

After Y axis

Report of the primary current consumption at PSU FM level (28V)

MCU Status	Main	Redundant
OFF	400	400
MCU ON	810	810
MCU after boot	870	870
Configuration 1	880	870
Configuration 2	880	870
Configuration 3	940	930
Configuration 4	1060	1050
Configuration 5	1210	1210

After X axis

Report of the primary current consumption at PSU FM level (28V)

MCU Status	Main	Redundant
OFF	400	400
MCU ON	810	810
MCU after boot	870	870
Configuration 1	880	870
Configuration 2	880	870
Configuration 3	940	940
Configuration 4	1060	1060
Configuration 5	1220	1210

After Z axis

Report of the primary current consumption at PSU FM level (28V)

MCU Status	Main	Redundant
OFF	400	400
MCU ON	810	810
MCU after boot	870	870
Configuration 1	880	870
Configuration 2	880	870
Configuration 3	940	940
Configuration 4	1060	1060
Configuration 5	1220	1210

The consumptions of SCU and MCU did not move following the vibrations.

8.3 SCU and MCU HouseKeepings

We have started the DCU Monitoring Mode from LTU (1 Hz frequency) after each vibration test (each axis) and the results were consistent with the expected values.

Note that we observe the results over a sufficient time (1 minute).

The housekeepings remained nominal during the whole test, id est after each vibration test.

We thereafter show the results relative the H/K acquisitions performed after the vibrations :

SCU main side

SCU

Status

Nom Parametre	Description	Valeur Lue H...	Valeur Nomin...
ScuStatus	SCU Status	0000	

Temperatures

Nom Parametre	Description	Valeur Conver...	Unite
Csu Temp	CCHK_IF Booard temperature	21.00	°C
Tsu Temp	Temp Board temperature	21.00	°C
Psu Temp1	PSU temperature 1	24.00	°C
Psu Temp2	PSU temperature 2	23.00	°C

Reference/Voltage

Nom Parametre	Description	Valeur Conver...	Valeur Lue H...	Min	Max
ScuCHTp05	+5V DC powe...	5.25	697B	4.77	5.28
ScuCHTp09	+9V DC powe...	9.09	68B2	8.89	9.07
ScuCHTn09	-9V DC power...	-9.09	9757	-9.07	-8.88
ScuCHT25	+2.5V DC inte...	2.52	408F	2.47	2.55
ScuCHTref	Internal voltag...	1.23	3F14	1.21	1.25
ScuCHTgnd	Internal Groun...	0.00	0006	-0.04	0.04
ScuTHTref	Internal voltag...	1.23	3F39	1.21	1.25
ScuTHTgnd	Internal Groun...	-0.00	FFFD	-0.04	0.04

SCU redundant side

SCU

Status

Nom Parametre	Description	Valeur Lue H...	Valeur Nomin...
ScuStatus	SCU Status	0000	

Temperatures

Nom Parametre	Description	Valeur Conver...	Unite
Csu Temp	CCHK_IF Booard temperature	22.00	°C
Tsu Temp	Temp Board temperature	22.00	°C
Psu Temp1	PSU temperature 1	23.00	°C
Psu Temp2	PSU temperature 2	24.00	°C

Reference/Voltage

Nom Parametre	Description	Valeur Conver...	Valeur Lue H...	Min	Max
ScuCHTp05	+5V DC powe...	5.24	6946	4.77	5.28
ScuCHTp09	+9V DC powe...	9.09	68BA	8.89	9.07
ScuCHTn09	-9V DC power...	-9.11	9719	-9.07	-8.88
ScuCHT25	+2.5V DC inte...	2.52	408E	2.47	2.55
ScuCHTref	Internal voltag...	1.23	3F1A	1.21	1.25
ScuCHTgnd	Internal Groun...	0.00	000B	-0.04	0.04
ScuTHTref	Internal voltag...	1.24	3F4B	1.21	1.25
ScuTHTgnd	Internal Groun...	0.00	0001	-0.04	0.04

MCU main side

MCU

Nom Par...	Description	Valeur Decimale	Valeur Convertie	Min	Max	Unite
5V	+5V power supply volt...	39682	5.06	4.85	5.25	V
P14V	+14V power supply vo...	38920	14.01	14.20	14.60	V
M14V	-14V power supply vol...	26474	-14.33	-14.60	-14.20	V
P15V	+15V power supply vo...	39524	15.39	15.20	15.60	V
M15V	-15V power supply vol...	25972	-15.48	-15.60	-15.20	V
MACTemp	MAC temperature probe	38552	13.04	-5.75	30.00	°C
SMECTemp	SMEC temperature pr...	38654	18.08	-5.75	30.00	°C
BSMTemp	BSM temperature probe	38645	17.64	-5.75	30.00	°C
ErrorCode	errors, warnings occur...	0	0.00	0.00	0.00	

MCU Redundant side

MCU

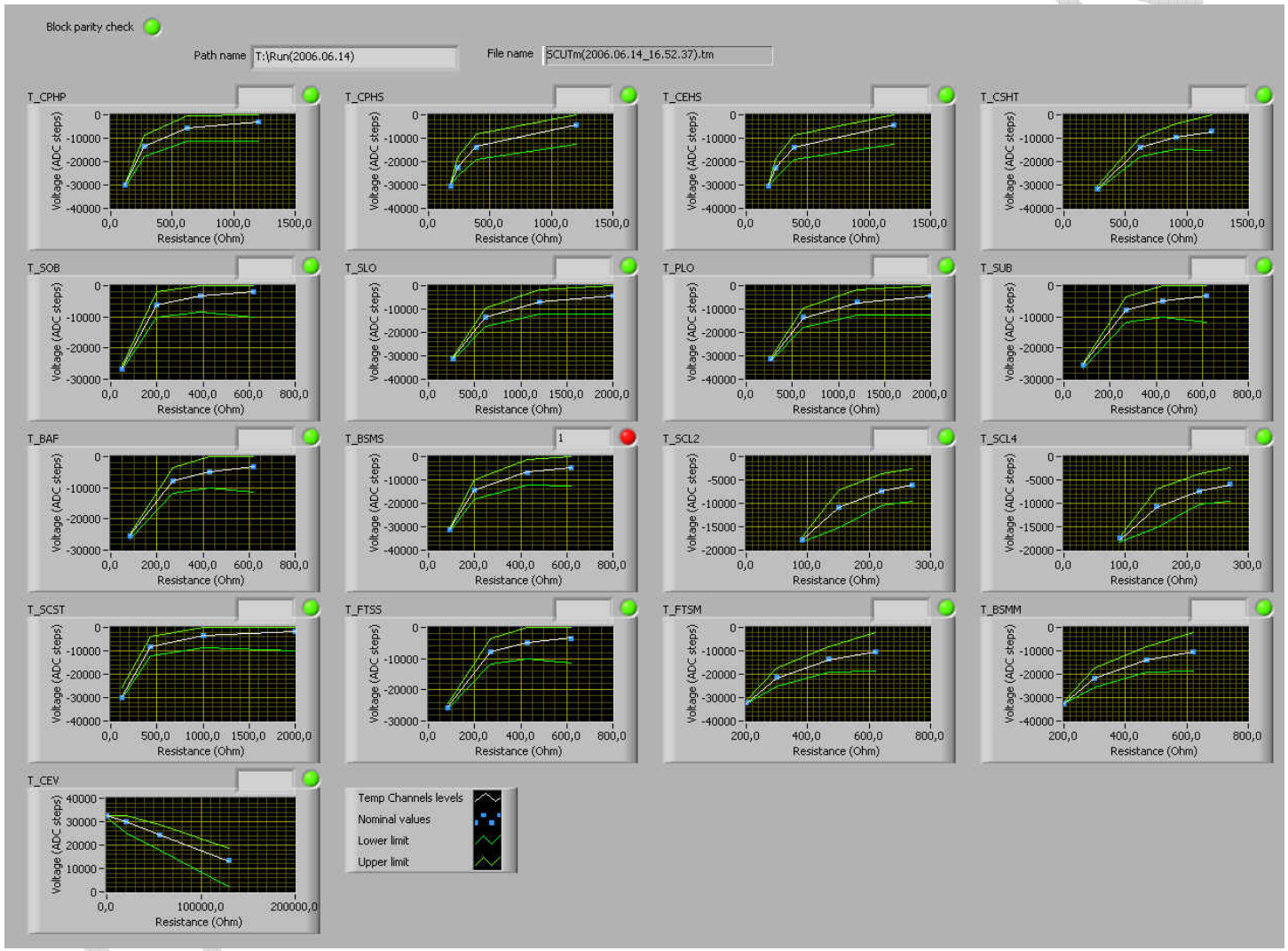
Nom Par...	Description	Valeur Decimale	Valeur Convertie	Min	Max	Unite
5V	+5V power supply volt...	39663	5.05			V
P14V	+14V power supply vo...	38909	13.99			V
M14V	-14V power supply vol...	26469	-14.35			V
P15V	+15V power supply vo...	39507	15.35			V
M15V	-15V power supply vol...	25983	-15.45			V
MACTemp	MAC temperature probe	38568	13.83			°C
SMECTemp	SMEC temperature pr...	38647	17.74			°C
BSMTemp	BSM temperature probe	38649	17.83			°C
ErrorCode	errors, warnings occur...	0	0.00			

8.4 SCU Temp / SubK Channels

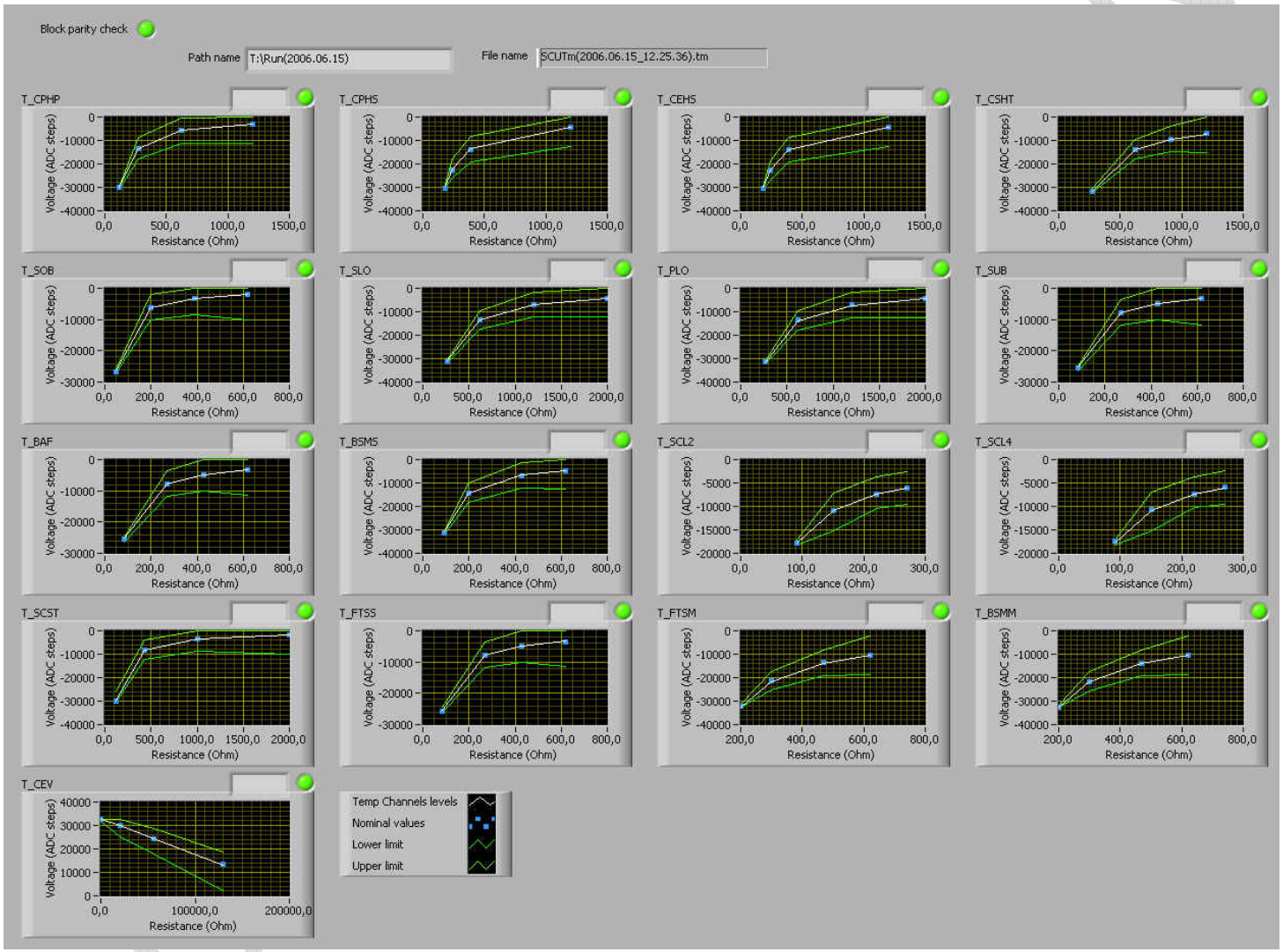
For this test, the FPU simulator is switched ON and runs in slave mode. The TEMP channels are tested with the four set of TEMP resistances that are implemented in the FPU simulator.

The tests have been performed on main and redundant sides. We thereafter show the graphics corresponding to SCU main side :

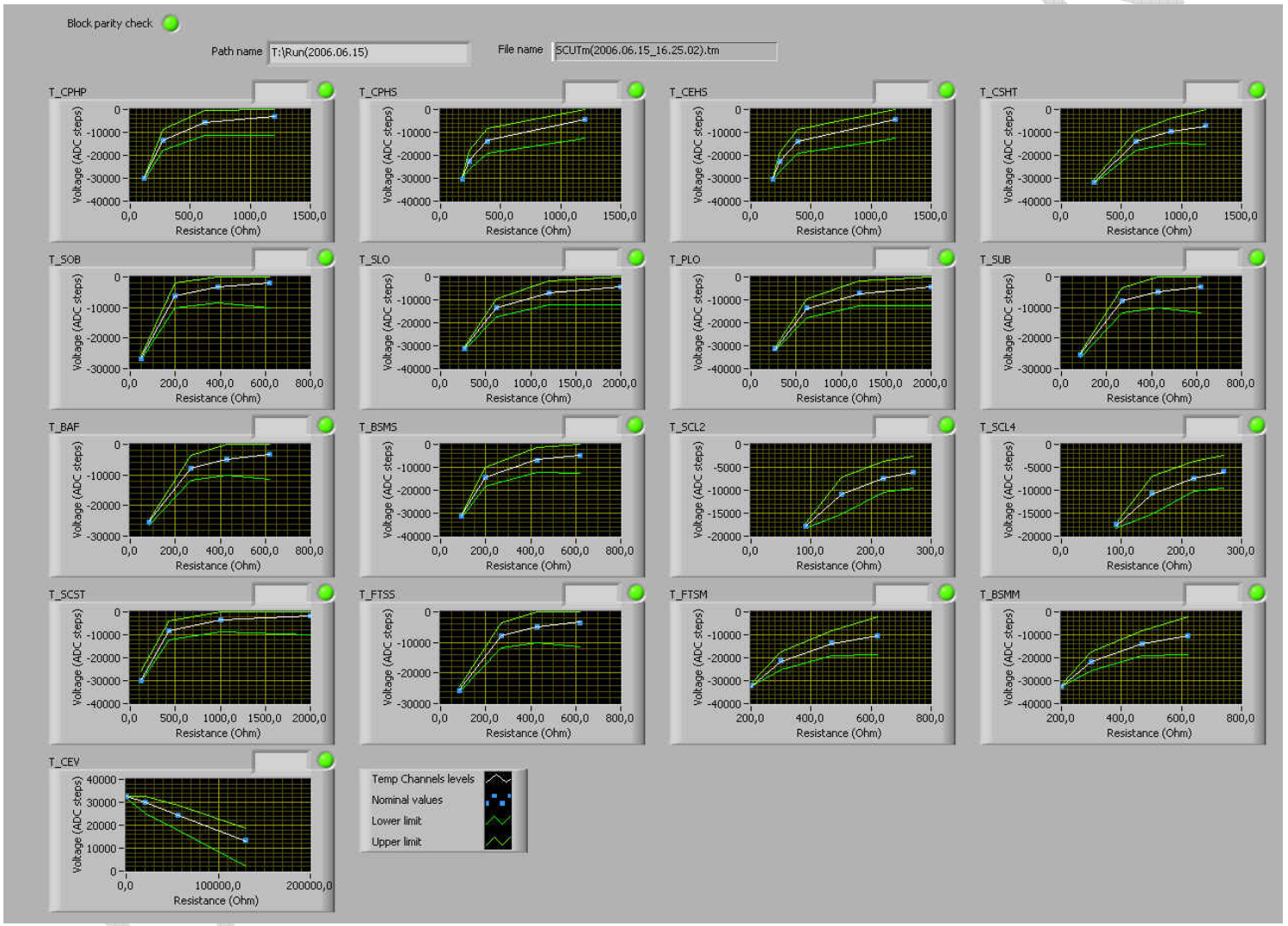
Before vibrations



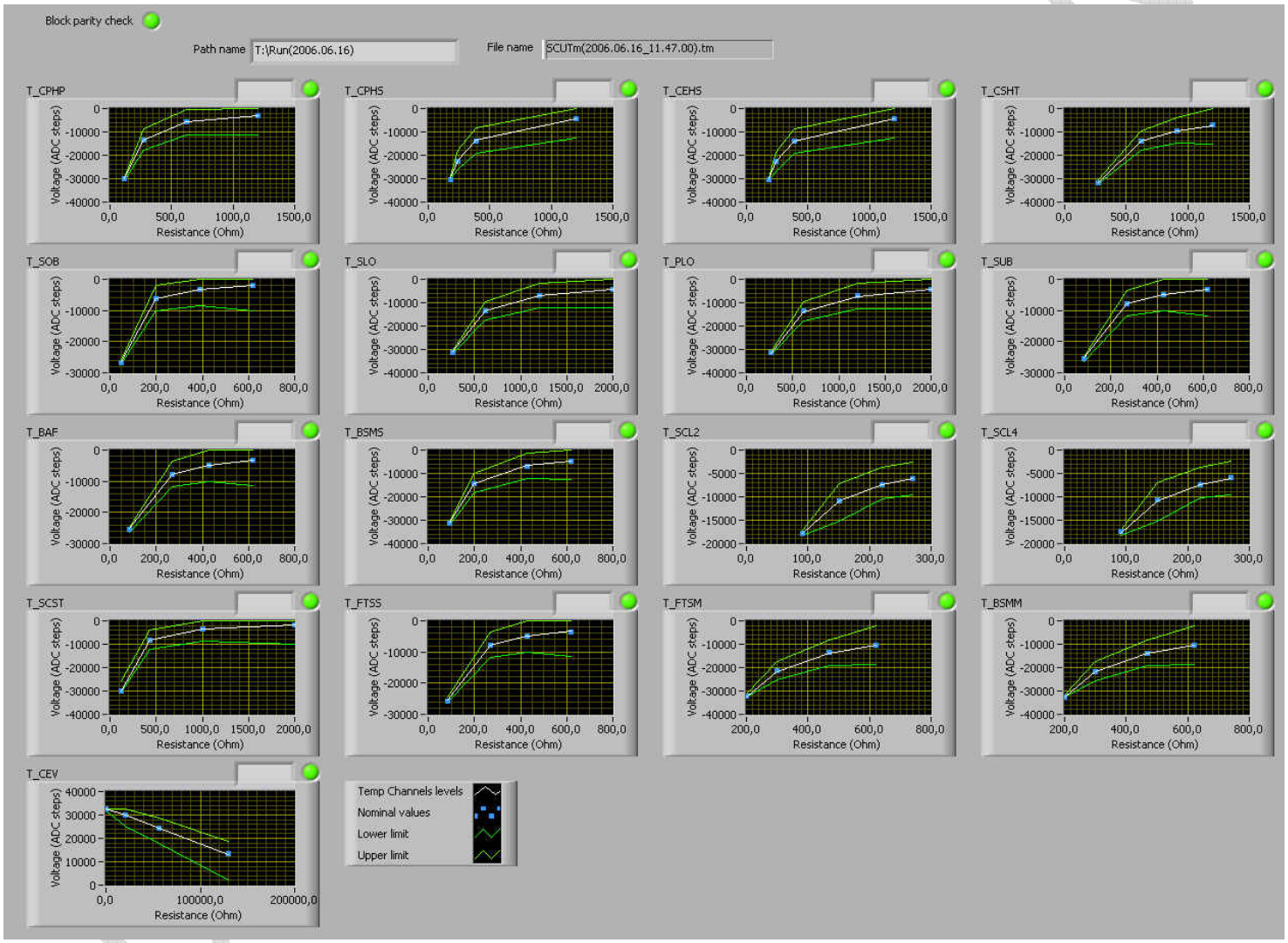
After Y axis vibrations



After X axis vibrations



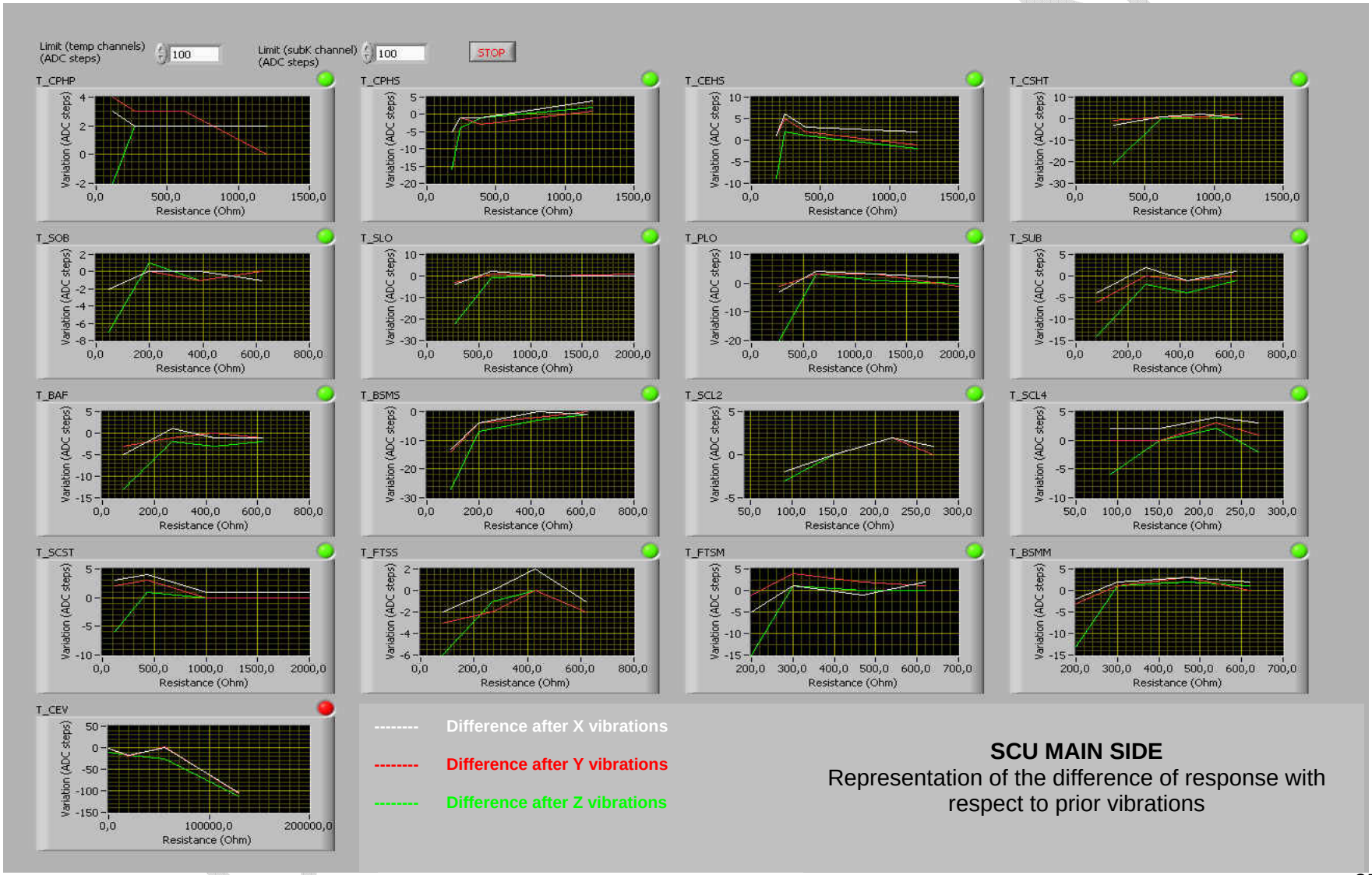
After Z axis vibrations



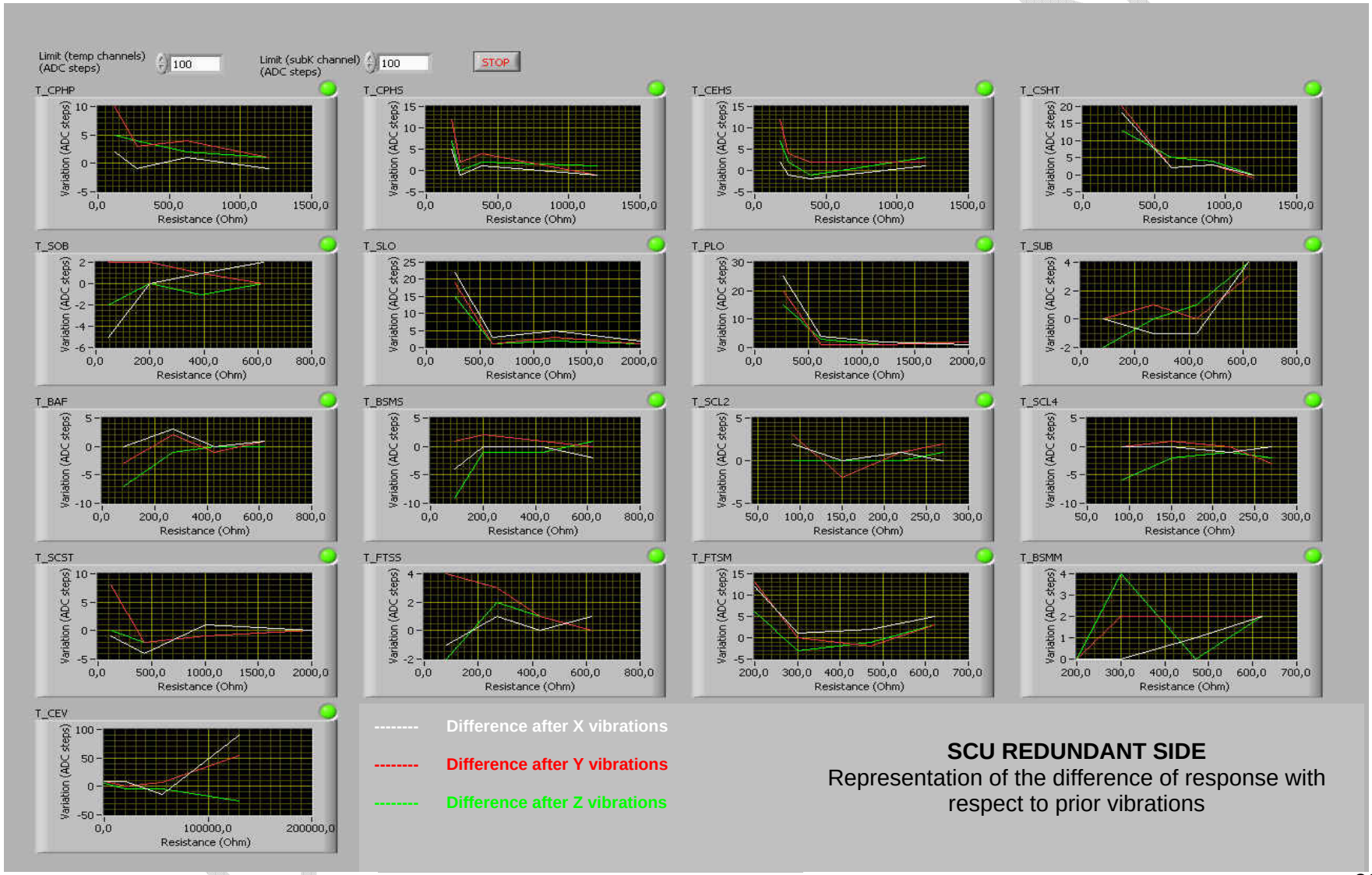
We notice that the results remain within the specified margins before and after the vibrations on each axis.

To study in detail, we have plotted, for each TEMP channel, the difference of response relatively to prior the vibrations : difference in encoder steps wrt resistance values respectively after the vibrations on X axis (white plot), Y axis (red plot) and Z axis (green plot).

As we notice on the thereafter plots, the results remain within approximately 10 encoder steps (except for the SUBK probe, CEV, that is much more sensitive, especially at high resistance values) which means that the vibrations have no effect on the TEMP channels responses.



SCU MAIN SIDE
Representation of the difference of response with respect to prior vibrations



SCU REDUNDANT SIDE
Representation of the difference of response with respect to prior vibrations

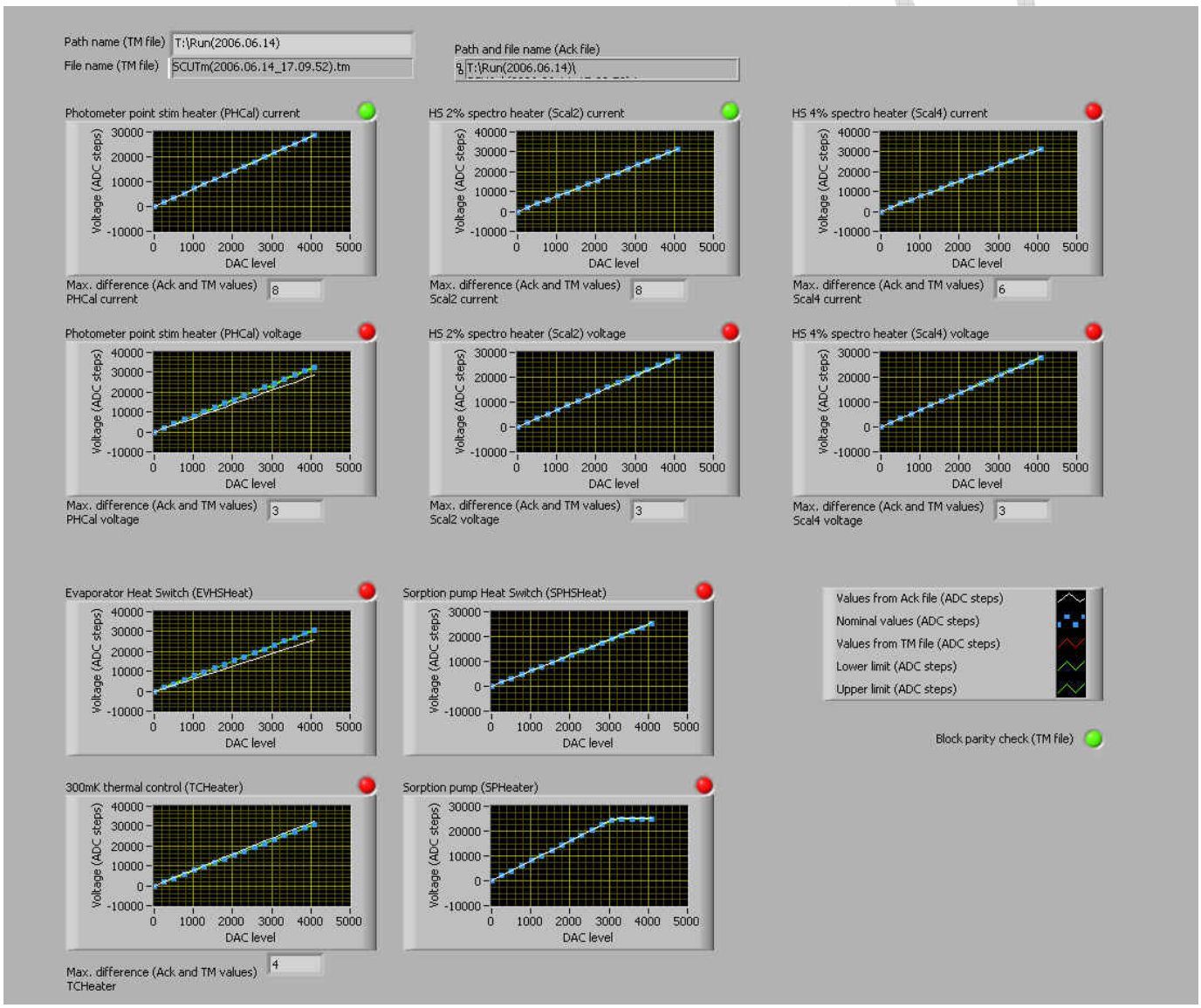
8.5 SCU Heaters Calibrators tests

For this test, the FPU simulator switched ON and runs in stand alone mode. The Heaters/calibrators channels are tested for 17 ADC values over the range [0 – 4095].

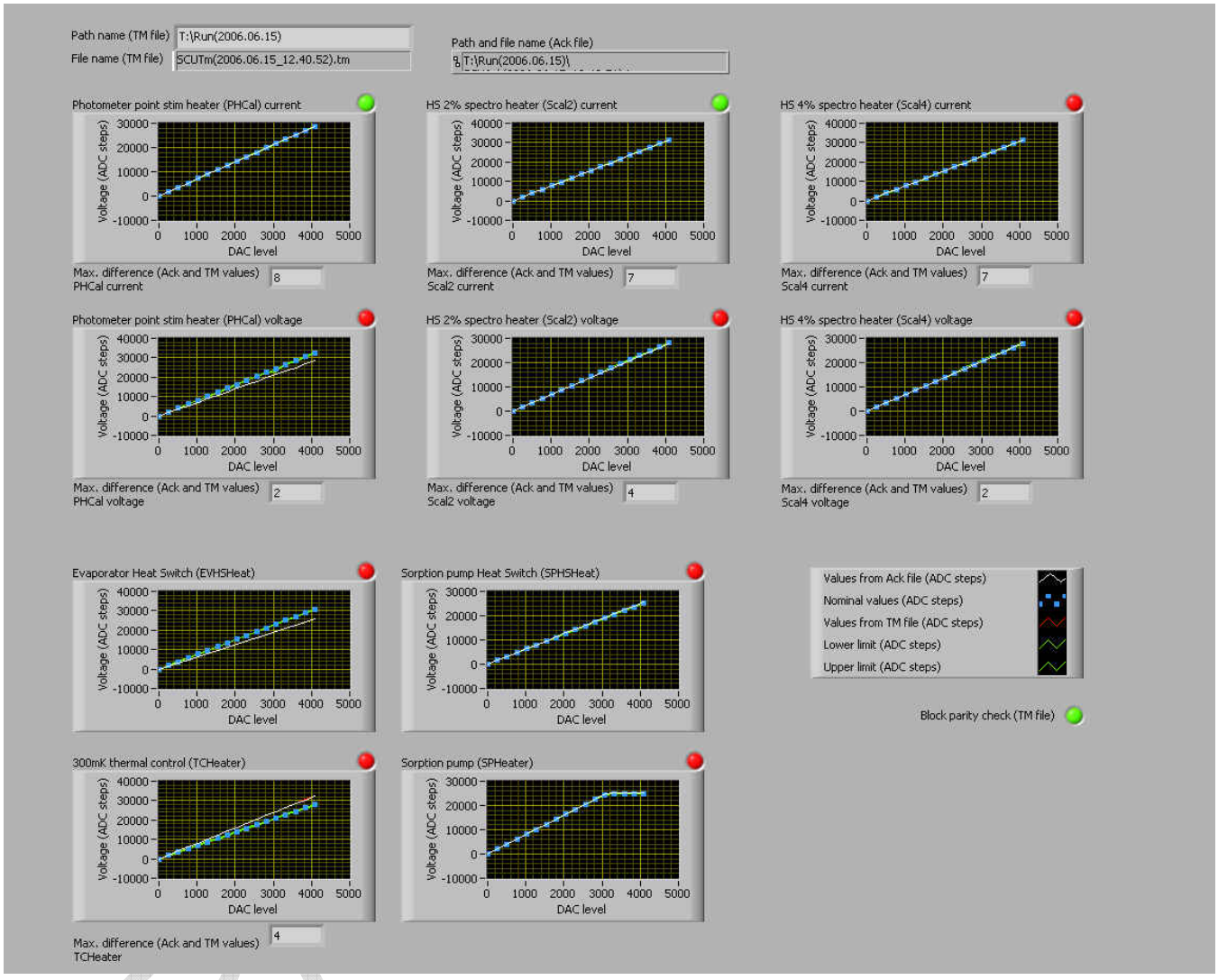
The tests have been performed on main and redundant sides. We thereafter show the graphics corresponding to SCU main side :

:

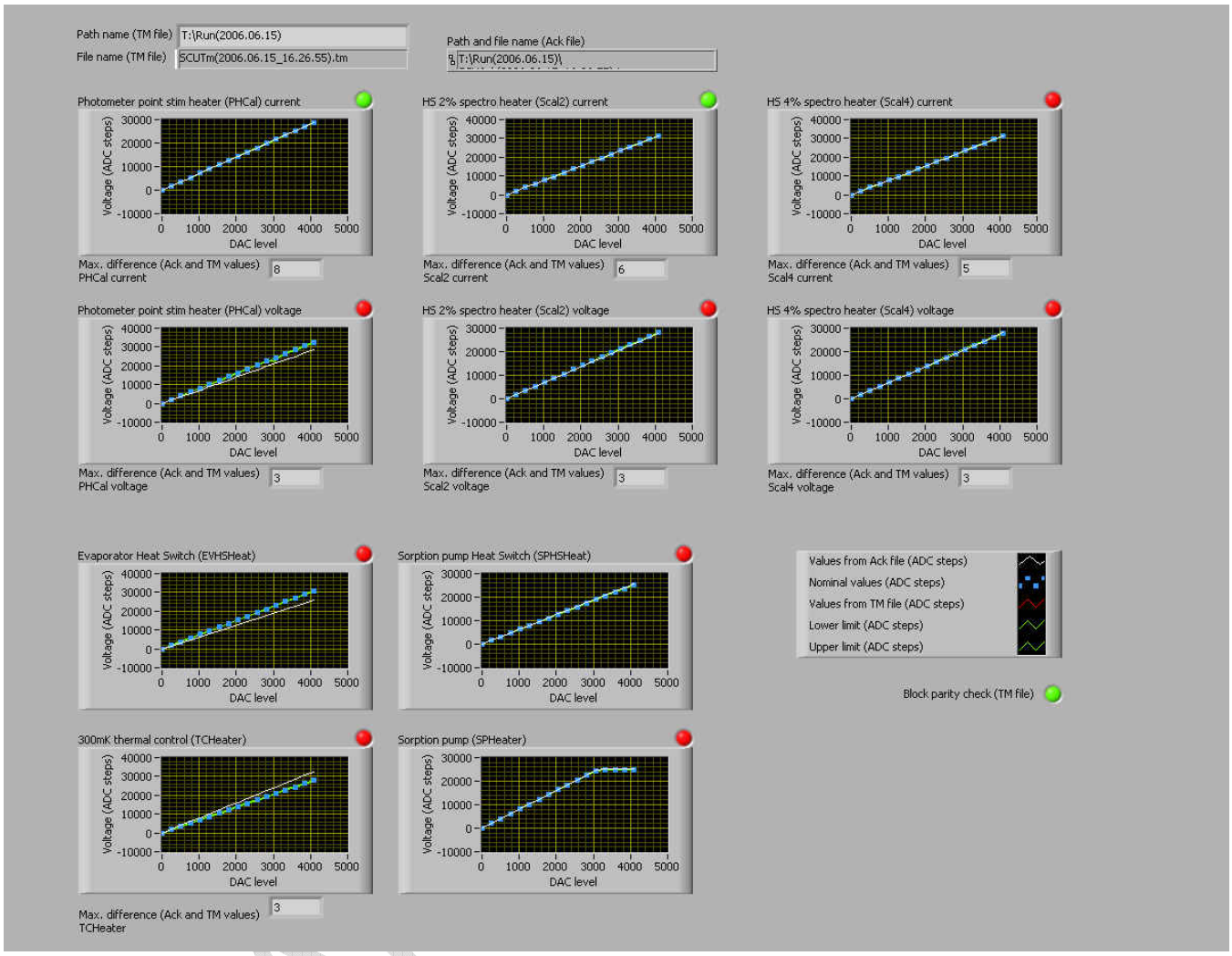
Before vibrations :



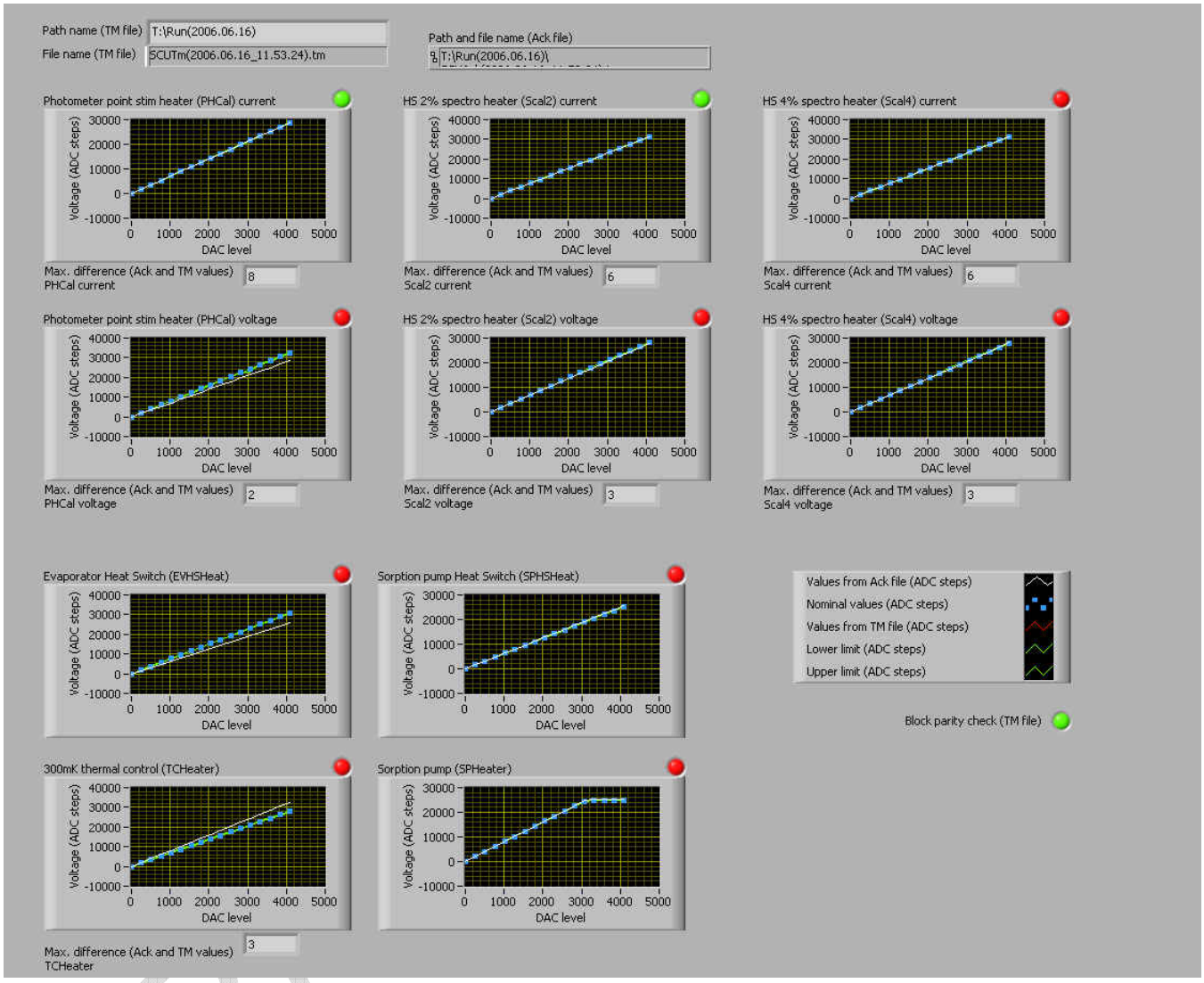
After Y axis vibrations



After X axis vibrations

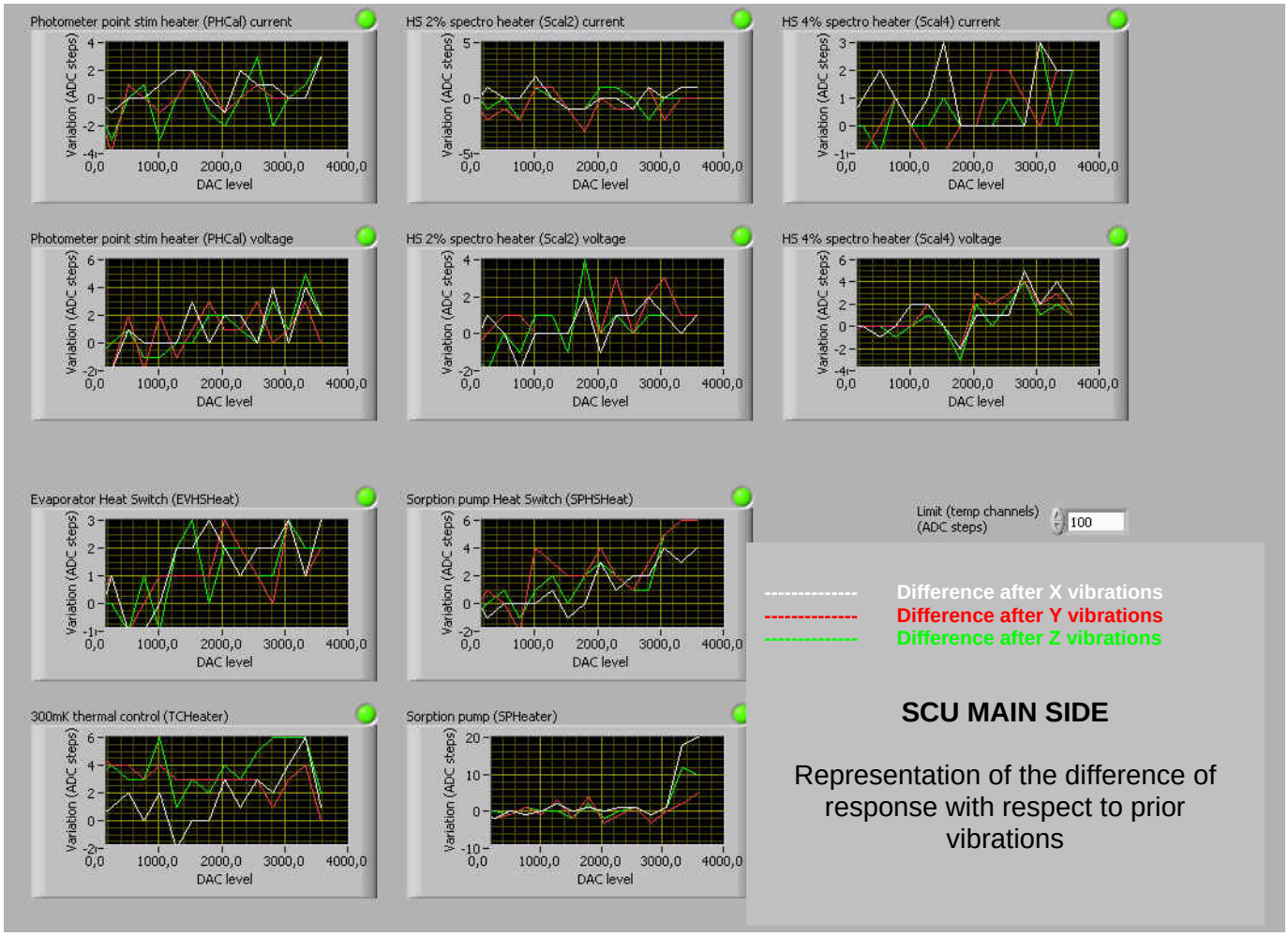


After Z axis vibrations



We notice that the results remain within the specified margins before and after the vibrations on each axis.

To study in detail, we have plotted, for each Heater/Calibrator channel, the difference of response relatively to prior the vibrations : difference in encoder steps wrt resistance values respectively after the vibrations on X axis (white plot), Y axis (red plot) and Z axis (green plot).



We notice that the results remain within approximately 5 encoder steps which means that the vibrations have no effect on the Heater/Calibrator channels responses.

8.6 Currents generated by SCU as measured by FPU simulator

In this test, we set the DAC to their maximum and measure the currents generated on Heaters/Calibrators channels at FPU simulator level.

The results, as obtained after the vibrations, are the following :

After Vibrations, Main side

	Measured	***Expected*(1)**
Sorption pump main :	38.216 E-3 A	38.157E-3 A
Evaporator Switch main :	1.627E-3 A	1.625E-3 A
Sorption pump Switch main :	1.628E-3 A	1.626E-3 A
300mK thermal control main :	4.538E-6 A	4.533E-6 A
HS spect 4% main :	5.610E-3 A	5.597E-3 A
HS spect 2% main :	5.607E-3 A	5.598E-3 A
Photometer point stim main :	7.194E-3 A	7.183E-3 A

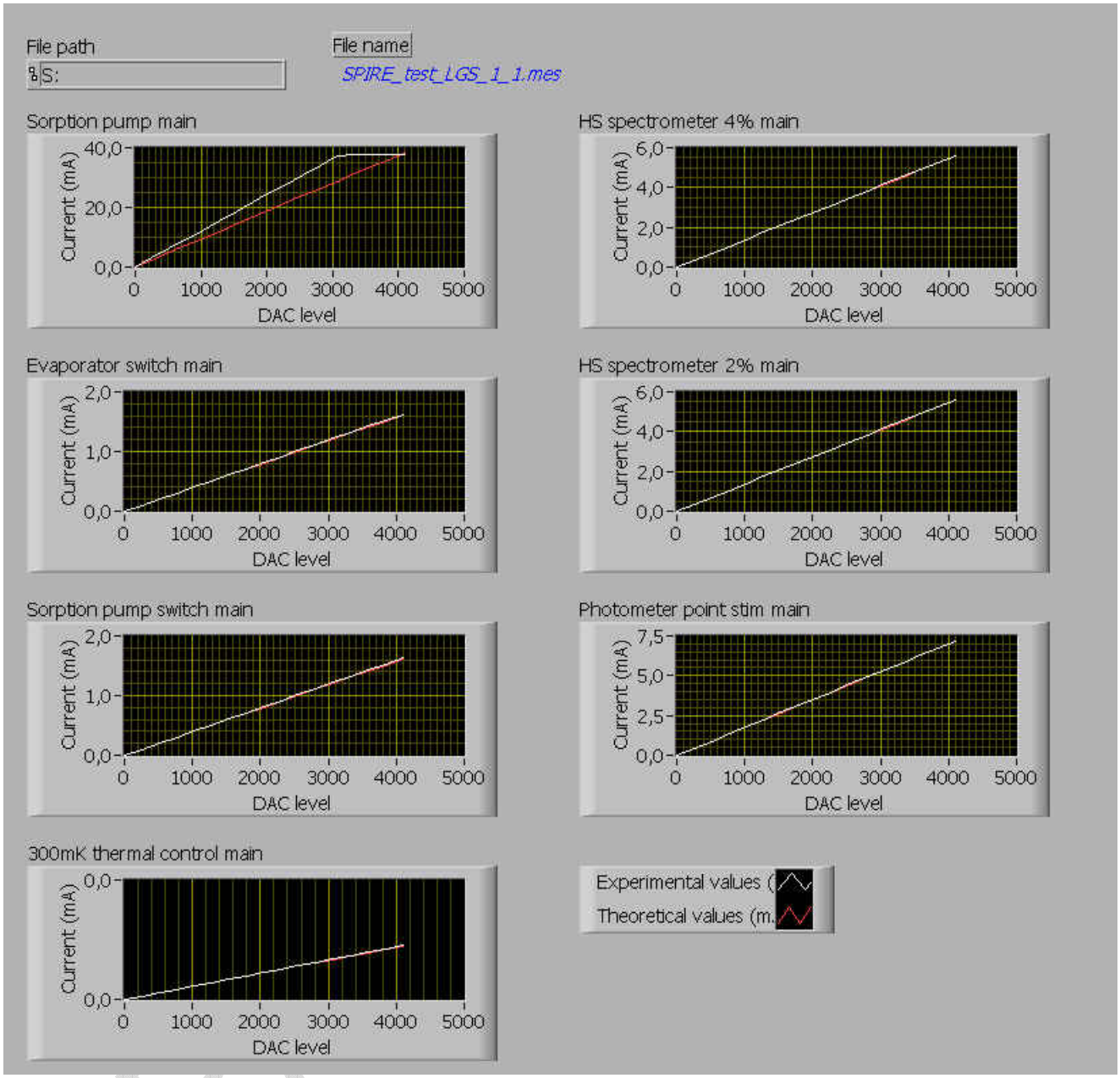
After Vibrations, Redundant side

	Measured	***Expected*(1)**
Sorption pump main :	38.061 E-3 A	38.157E-3 A
Evaporator Switch main :	1.628E-3 A	1.625E-3 A
Sorption pump Switch main :	1.628E-3 A	1.626E-3 A
300mK thermal control main :	4.538E-6 A	4.533E-6 A
HS spect 4% main :	5.610E-3 A	5.597E-3 A
HS spect 2% main :	5.607E-3 A	5.598E-3 A
Photometer point stim main :	7.192E-3 A	7.183E-3 A

*(1)*From tests at saclay

These results are consistent with the specifications. No effect due to the vibrations is observed.

When plotting the evolution wrt DAC level from the FPU simulator data, we get the following representation (where the maximum value correspond to the above “After vibrations” data) :


File path
S:
File name
SPIRE_test_LGS_1_1.mes
Sorption pump main
Current (mA)
40,0
20,0
0,0
0
1000
2000
3000
4000
5000
DAC level
HS spectrometer 4% main
Current (mA)
6,0
4,0
2,0
0,0
DAC level
Evaporator switch main
Current (mA)
2,0
1,0
0,0
DAC level
HS spectrometer 2% main
Current (mA)
6,0
4,0
2,0
0,0
DAC level
Sorption pump switch main
Current (mA)
2,0
1,0
0,0
DAC level
Photometer point stim main
Current (mA)
7,5
5,0
2,5
0,0
DAC level
300mK thermal control main
Current (mA)
0,0
0,0
DAC level
Experimental values (
Theoretical values (m.

8.7 MCU functional parameters

After the vibrations on each axis, the MCU functional parameters, coming from the telemetry messages, have been tested on main and redundant sides and under the following functional configurations :

- Configuration 1 : MCU ON, all currents applied to the mechanisms set at 0 level
- Configuration 2 : MCU ON, all currents applied to the mechanisms set at 0 level; latch engaged
- Configuration 3 :MCU ON, all currents applied to the mechanisms set at 10% level;
- Configuration 4 :MCU ON, all currents applied to the mechanisms set at 50% level;
- Configuration 3 :MCU ON, all currents applied to the mechanisms set at 100% level;

Under each of these configurations, the values of the following parameters :

- Encoder Sinus 0°,
- Encoder Sinus 120°,
- Encoder sinus 240°,
- LVDT AC
- LVDT DC
- SMEC Motor Current,
- SMEC Motor Voltage
- Chopper Sensor
- Chopper current
- Chopper Voltage
- Jiggle sensor
- Jiggle current
- Jiggle voltage

have been compared to expected values. The values of these parameters remained nominal following the vibrations tests.

9 Conclusion

The tests reveal no susceptibility of the FCU FM subsystem (mechanical and functional aspects) to the acceptance vibrations levels.