SUNRISE 3

Test Report

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Prepared by	:	M. Eberhardt
Approved by	:	W. Deutsch

APPROVALS

ISLID E-UNIT FM AND F2 FILTER WHEEL FM PART I Issue: Draft

SR3-MPS-RP-LD700-004 Revision: -

	Name	Signature with date
Prepared by:	M. Eberhardt	
Approved by:	W. Deutsch	

DOCUMENT DISTRIBUTION

Institute	Name, First Name
MPS	Deutsch, Werner
MPS	Eberhardt, Michel
MPS	Fernandez Rico, German
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MPS	Ramanath, Sandeep

Institut	Name, First Name
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CHANGE LOG

Iss./Rev.	Date	Pages affected	Reason for changes
Draft/-	27-Apr-2021		

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

CSBF	Columbia Scientific Balloon Facility
NASA	National Aeronautics and Space Administration
TBC	To Be Confirmed
TBD	To Be Discussed
MPS	Max Planck Institute for Solar System Research

1 GENERAL ASPECTS

1.1 SCOPE

This document is listing the full test log of the first ISLiD Controller TV-Test. DUT are the full integrated ISLiD ELE-Unit FM and the F2 filter wheel FM.

Note: The Raspberry Pi PCB of the ISLiD-Controller within the ELE-Unit was modified after this test has been conducted. See part two of the TV Test in AD02.

1.2 APPLICABLE DOCUMENTS

Table 1-1: Applicable documents

No.	Document Title	Document Number	Iss.	Rev.	Date
AD01.	Global list of Acronyms and Synonyms	SR3-MPS-LI-GEN-002			See latest Iss/Rev
AD02.	ISLID E-UNIT FM AND F2 FILTER WHEEL FS PART II	SR3-MPS-RP-LD700-005			See latest Iss/Rev

1.3 REFERENCE DOCUMENTS

Table 1-2: Reference documents

No.	Document Title	Document Number	Iss.	Rev.	Date
RD01.					
RD02.					

2 TEST SETUP

2.1 CHAMBER SETUP

The test setup is located in the “Kleine Just” chamber within the MPS cleanrooms. Only the ISLiD ELE Unit FM and the F2 filter wheel FM are placed inside the chamber. The four ISLiD-heaters are placed next to the chamber. The lab power supply as well as the DUT are connected to the MPS network and can be controlled remotely.

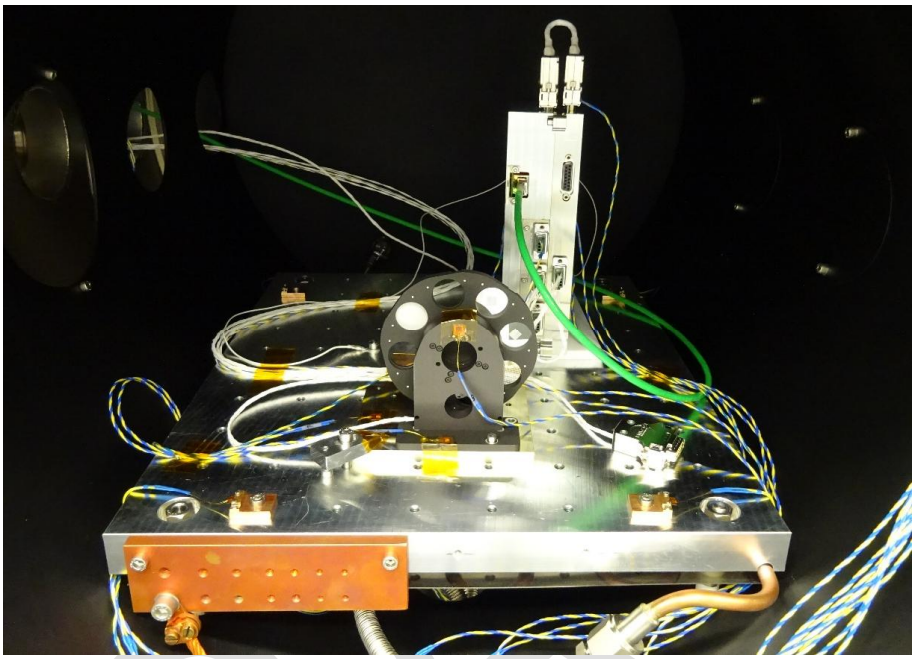


Figure 2-1 Chamber internal setup Filter Wheel FM and ISLiD E-Unit FM

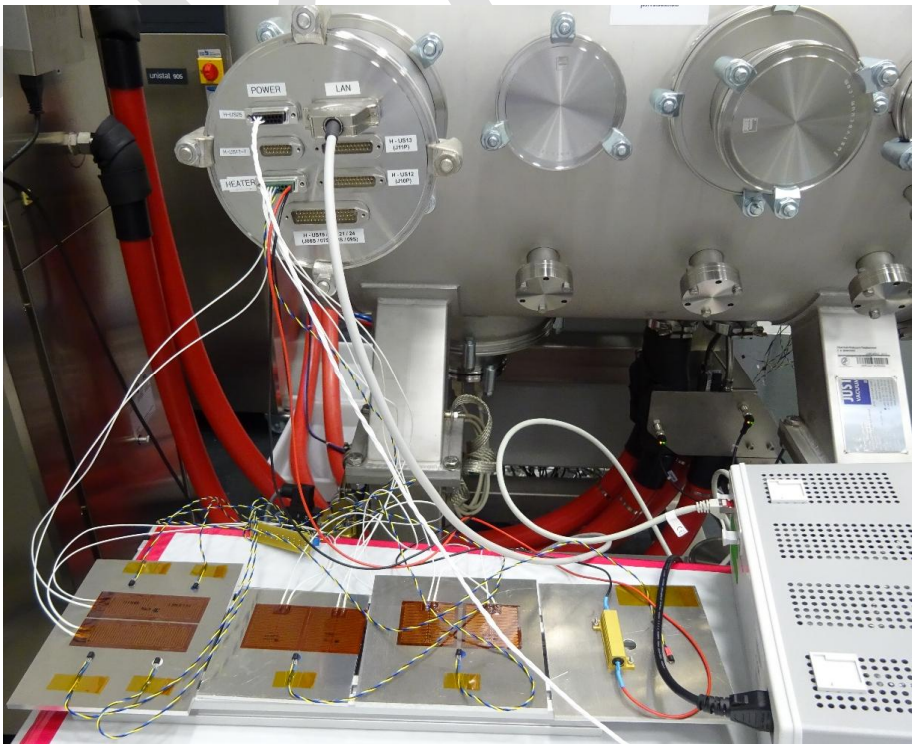


Figure 2-2 External setup, 4 Heater dummies

2.2 TEMPERATURE SENSORS

Table 2-1 is listing the temperature sensors with location, read by the TV test data acquisition system, plus a list of internal and external temperature sensors which are read via the house keeping data from the ISLiD CTRL.

Table 2-1: Temperature sensors

Temp ID.	Unit	Position	Type	Remarks
TS01	ISLiD ELE unit	Housing between piezo cooling body screws	PT100	
TS02	ISLiD ELE unit	Housing opposite 5V power converter	PT100	
TS03	ISLiD ELE unit	Housing opposite 12V power converter	PT100	
TS04	ISLiD ELE unit	Controller housing near cooling body interface	PT100	
TS05	F2 filter wheel	Upper side of the actuator	PT100	
TS06	F2 filter wheel	Mounting plate (foot)	PT100	
TS07	Holding plate for F2	In the middle of the plate	PT100	
TS08	ISLiD ELE unit	Controller housing bottom edge near heater power interface	PT100	
TS09	ISLiD ELE unit	Controller housing top	PT100	
List of temperature sensors read via HK				
Inbuilt	ISLiD ELE unit	MCS piezo controller cooling body	1-wire	
Inbuilt	ISLiD ELE unit	5V power converter	1-wire	
Inbuilt	ISLiD ELE unit	12V power converter	1-wire	
Temp control	Heater H1	H1 plate 1	1-wire	
Temp control	Heater H1*	H1 plate 2	1-wire	
Temp control	Heater H1*	H1 plate 3	1-wire	
Temp control	Heater H1*	H1 plate 4	1-wire	
Temp control	Heater H2	H2 plate	1-wire	
Temp control	Heater H3	H3 plate	1-wire	
Temp control	Heater H4	H4 plate	1-wire	

*may not be logged

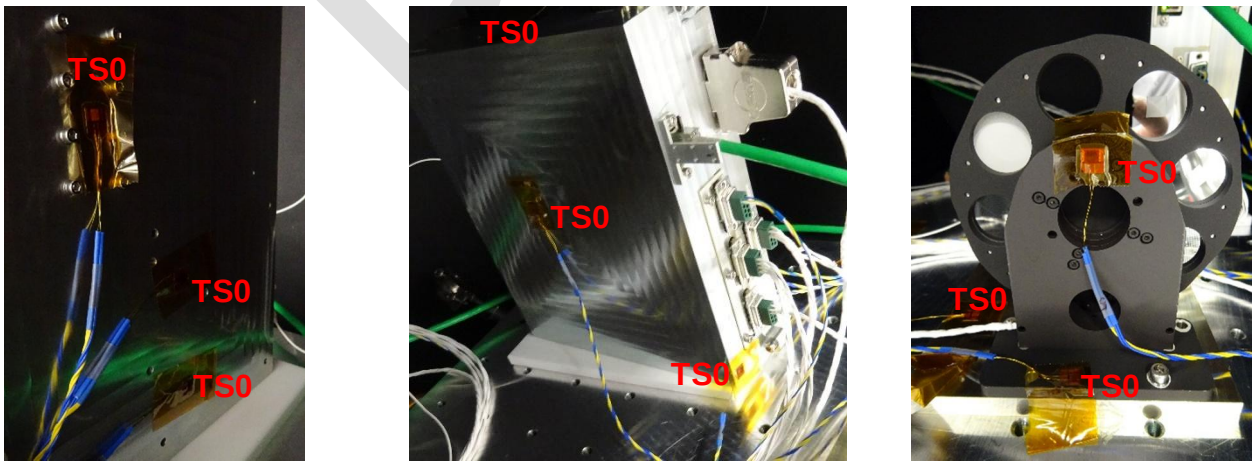
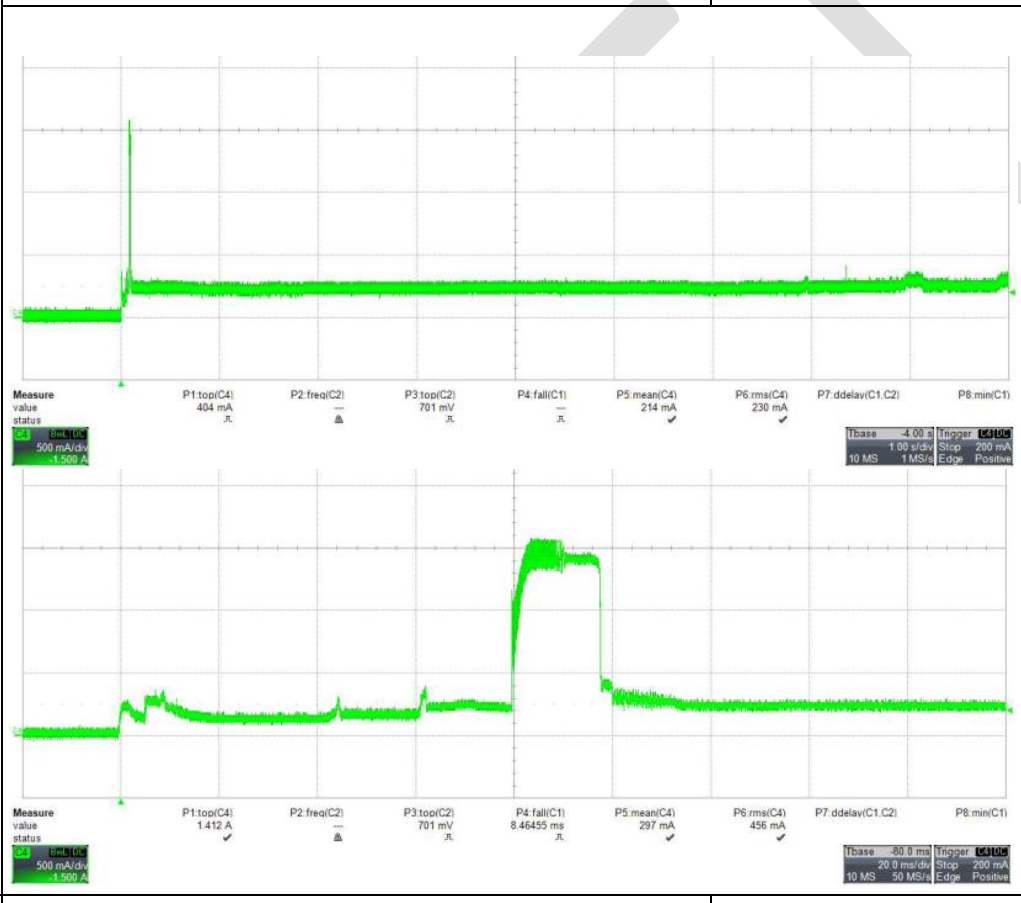


Figure 2-3 Thermal sensor positions

3 AS RUN PROCEDURE

3.1 AMBIENT BEFORE VAC

Simple function check before closing the chamber

Step no.	Action	Check/comments	Date /time	Operator
2.01	Connect all test Harnesses inside and outside the chamber (except F2 filter wheel)		25/11/2020 11:30	ME
2.02	Power lab supply 25,6V (10A with two CH)		25/11/2020 11:30	SG,ME
2.03	Enable supply output to power up DUT		25/11/2020 11:30	SG
2.04	Measure inrush current on the main 25.6V supply 		23/11/2020	ME SG
2.05	Current after booting the ISLiD controller and the MCS piezo controller	Current: 0.309A Power: 7.91W	25/11/2020 15:55	SG
2.06	Move F2 with 15°/sec	Current: 0.544A Power: 13.93W	25/11/2020 15:57	
2.07	Enable heater #4 100%	Current: 1.0776A Power: 27.59W Senor @ H4 rising	25/11/2020 15:58	SG,ME
2.08	Enable heaters #1-4 100%	Current: 3.222A Power: 82.48W	25/11/2020 15:59	SG,ME

Step no.	Action	Check/comments	Date /time	Operator
2.09	Power down DUT and turn off the lab supply			SG,ME

Issue: Heater control was not properly working, heater were powered off for a short duration even when set to 100%. A potential cause may be a higher processor load when the filter wheel is disconnected. Software issue fixed when connecting the filter wheel.

3.2 NON OP CYCLE

Step no.	Action	Check/comments	Date /time	Operator
2.10	Close chamber and pump down		25/11/2020	WD
2.11	Set temperature to +50°C T_non_op_max		26/11/2020 7:00	WD
2.12	Set temperature to -10°C T_non_op_min		26/11/2020 12:00	WD

3.3 COLD CASE1

3.3.1 POWER CONSUMPTION

Step no.	Action	Check/comments	Date /time	Operator
2.13	Set temperature to -5°C		26/11/2020 16:00	WD
2.14	Power lab supply		27/11/2020 10:00	SG,ME
2.15	Enable supply output to power up DUT			SG
2.16	Current after booting the ISLiD controller and the MCS piezo controller	Current: 0.26A Power: 6.85W		SG
2.17	Enable heater #1 100%	Current: 1.2A Power: 28.84W Senor @ H1 rising		SG
2.18	Disable heater #1			SG
2.19	Enable heater #2 100%	Current: 0.92A Power: 23.57W Senor @ H2 rising		SG
2.20	Disable heater #2			SG
2.21	Enable heater #3 100%	Current: 0.9A Power: 22.76W Senor @ H3 rising		SG
2.22	Disable heater #3			SG

Step no.	Action	Check/comments	Date /time	Operator
2.23	Enable heater #4 100%	Current: 1.09A Power: 27.82W Senor @ H4 rising		SG
2.24	Disable heater #4			SG
2.25	Enable all four heaters 100% for ~5min	Current: 3.32A Power: 82.5W		SG
2.26	Disable all heaters			SG

3.3.2 OPERATE F2 MECHANISM

Step no.	Action	Check/comments	Date /time	Operator
2.27	Move F2 positive 360° @ 15°/sec	Current: 0.56A Power: 14.38W CCW movement observed		SG,ME,AG
2.28	Move F2 negative 360° @ 3°/sec	Current: 0.31A Power: 8.1W CW movement observed		SG,ME,AG
2.29	Move F2 positive in steps of 45° @ 15°/sec	45° 90° 135° 180° 225° 270° 315° 360°		SG,ME,AG
2.30	Power down OS	Current: 0.19A Power: 4.97W		SG
2.31	Disable Supply output		01/12/2020 14:48	SG

3.4 HOT CASE1

3.4.1 POWER CONSUMPTION

Step no.	Action	Check/comments	Date /time	Operator
2.32	Set temperature to 30°C		27/11/2020 16:00	WD
2.33	Power lab supply		30/11/2020 09:00	SG,ME
2.34	Enable supply output to power up DUT		30.11.2020 09:34	SG
2.35	Current after booting the ISLiD controller and the MCS piezo controller	Current: 0.25A Power: 6.5W	30.11.2020 09:363:56 PM	SG

Step no.	Action	Check/comments	Date /time	Operator
2.36	Enable heater #1 100%	Current: 1.11A Power: 28.56W Senor @ H1 rising		SG
2.37	Disable heater #1			SG
2.38	Enable heater #2 100%	Current: 0.93A Power: 23.6W Senor @ H2 rising		SG
2.39	Disable heater #2			SG
2.40	Enable heater #3 100%	Current: 0.92A Power: 23.4W Senor @ H3 rising		SG
2.41	Disable heater #3			SG
2.42	Enable heater #4 100%	Current: 1.1A Power: 28.08W Senor @ H4 rising		SG
2.43	Disable heater #4			SG
2.44	Enable all four heaters 100% for ~5min	Current: 3.21A Power: 82.02W		SG
2.45	Disable all heaters			SG

3.4.2 OPERATE F2 MECHANISM

Step no.	Action	Check/comments	Date /time	Operator
2.46	Move F2 positive 360° @ 15°/sec	Current: 0.572A Power: 14.823W CCW movement observed in HK readings		SG
2.47	Move F2 negative 360° @ 3°/sec	Current: 0.31A Power: 7.86W CW movement observed in HK readings		SG
2.48	Move F2 positive in steps of 45° @ 15°/sec	45° Done 90° Done 135° Done 180° Done 225° Done 270° Done 315° Done 360° Done		SG
2.49	Power down OS	Current: 0.21A Power: 5.19W		SG

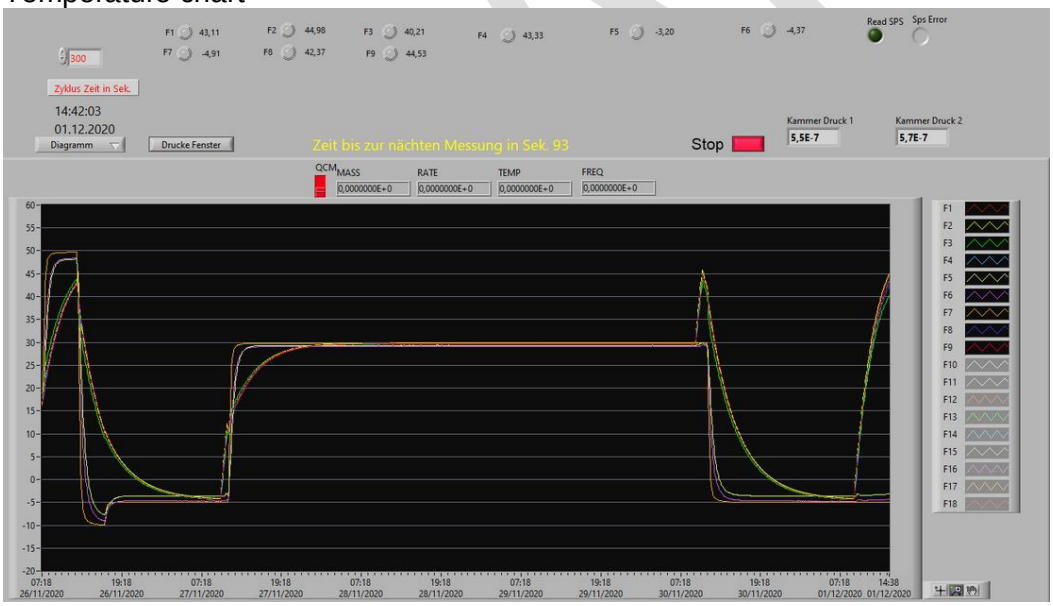
Step no.	Action	Check/comments	Date /time	Operator
2.50	Disable Supply output		01/12/2020 14:48	SG

3.5 COLD CASE2

3.5.1 POWER CONSUMPTION

Step no.	Action	Check/comments	Date /time	Operator
2.51	Set temperature to -5°C		30/11/2020 11:00	WD
2.52	Power lab supply		01/12/2020 9:15	MMü
2.53	Enable supply output to power up DUT		01/12/2020 9:20	
2.54	Current after booting the ISLiD controller and the MCS piezo controller	Current: 0.28A Power: 6.74W	01/12/2020 9:25	
2.55	Enable heater #1 100%	Current: 1.14A Power: 29.07W Senor @ H1 rising	01/12/2020 9:30	
2.56	Disable heater #1			
2.57	Enable heater #2 100%	Current: 0.93A Power: 23.73W Senor @ H2 rising	01/12/2020 9:32	
2.58	Disable heater #2			
2.59	Enable heater #3 100%	Current: 0.9A Power: 22.92W Senor @ H3 rising	01/12/2020 9:34	
2.60	Disable heater #3			
2.61	Enable heater #4 100%	Current: 1.09A Power: 27.94W Senor @ H4 rising	01/12/2020 9:35	
2.62	Disable heater #4			
2.63	Enable all four heaters 100% for ~5min	Current: 3.23A Power: 82.63W	01/12/2020 9:35	
2.64	Disable all heaters			

3.5.2 OPERATE F2 MECHANISM

Step no.	Action	Check/comments	Date /time	Operator
2.65	Move F2 positive 360° @ 15°/sec	Current: 0.543A Power: 13,89W CCW movement observed	01/12/2020 9:43	
2.66	Move F2 negative 360° @ 3°/sec	Current: 0.32A Power: 8.08W CW movement observed	01/12/2020 9:45	
2.67	Move F2 positive in steps of 45° @ 15°/sec	45° 90° 135° 180° 225° 270° 315° 360°	01/12/2020 9:35	
2.68	Long term settling: Set all heaters to 50%	On for >=5h Current: Power: about 55W		
2.69	Set all heaters OFF	Current: 0.25A Power: 6.34W	01/12/2020 12:52	
2.70	Temperature chart 		01/12/2020 14:42	
2.71	Power down OS	Current: 0.21A Power: 5.37W	01/12/2020 14:47	SG
2.72	Disable Supply output		01/12/2020 14:48	SG

3.6 HOT CASE2

3.6.1 POWER CONSUMPTION

Step no.	Action	Check/comments	Date /time	Operator
2.73	Set temperature to 30°C		01/12/2020 16:00	WD
2.74	Power lab supply		02/12/2020 10:15	DO
2.75	Enable supply output to power up DUT		02/12/2020 10:35	SG, ME
2.76	Current after booting the ISLiD controller and the MCS piezo controller	Current: 0.25A Power: 6.3W	02/12/2020 09:38	SG, ME
2.77	Enable heater #1 100%	Current: 1.13A Power: 28.1W Senor @ H1 rising	02/12/2020 10:45	SG, ME
2.78	Disable heater #1		02/12/2020 10:45	SG, ME
2.79	Enable heater #2 100%	Current: 0.91A Power: 23.3W Senor @ H2 rising	02/12/2020 10:48	SG, ME
2.80	Disable heater #2		02/12/2020 10:48	SG, ME
2.81	Enable heater #3 100%	Current: 0.89A Power: 22.76W Senor @ H3 rising	02/12/2020 10:53	SG, ME
2.82	Disable heater #3		02/12/2020 10:53	SG, ME
2.83	Enable heater #4 100%	Current: 1.18A Power: 27.74W Senor @ H4 rising	02/12/2020 10:58	SG, ME
~~2.84~~	~~Disable heater #4~~			
2.85	Enable all four heaters 100% for ~~5min~~	Current: 3.22A Power: 82.41W	02/12/2020 11:02	SG, ME
2.86	Disable all heaters	Current: 0.23A Power: 6.09W	02/12/2020 11:03	SG, ME

3.6.2 OPERATE F2 MECHANISM

Step no.	Action	Check/comments	Date /time	Operator
2.87	Move F2 positive 360° @ 15°/sec	Current: 0.587A Power: 16.646W CCW movement observed in HK readings	02/12/2020 11:10	SG, ME
2.88	Move F2 negative 360° @ 3°/sec	Current: 0.31A Power: 7.63W	02/12/2020 11:13	SG, ME

Step no.	Action	Check/comments	Date /time	Operator
		CW movement observed in HK readings		
2.89	Move F2 positive in steps of 45° @ 15°/sec	45° Done 90° Done 135° Done 180° Done 225° Done 270° Done 315° Done 360° Done	02/12/2020 11:10	SG, ME
2.90	Movement stopped	Current: 0.24A Power: 6.03W	02/12/2020 11:10	SG, ME
2.91	Power down OS	Current: 0.19A Power: 4.96W	02/12/2020 11:12	SG, ME

3.7 AMBIENT AFTER VAC

3.7.1 POWER CONSUMPTION

Step no.	Action	Check/comments	Date /time	Operator
2.92	Pressurize chamber		03/12/2020	WD
2.93	Power lab supply		03/12/2020 10:20	MB
2.94	Enable supply output to power up DUT		03/12/2020 10:28	SG, ME
2.95	Use only one lab supply channel (CH2 off)		03/12/2020 10:30	SG, ME
2.96	Current after booting the ISLiD controller and the MCS piezo controller	Current: 0.25A Power: 6.25W	03/12/2020 10:33	SG, ME
2.97	Enable heater #1 100%	Current: 1.12A Power: 28.65W Senor @ H1 rising	03/12/2020 10:36	SG, ME
2.98	Disable heater #1		03/12/2020 10:37	SG, ME
2.99	Enable heater #2 100%	Current: 0.91A Power: 23.37W Senor @ H2 rising	03/12/2020 10:40	SG, ME
2.100	Disable heater #2		03/12/2020 10:40	SG, ME
2.101	Enable heater #3 100%	Current: 0.89A Power: 22.9W Senor @ H3 rising	03/12/2020 10:42	SG, ME
2.102	Disable heater #3		03/12/2020 10:44	SG, ME

Step no.	Action	Check/comments	Date /time	Operator
2.103	Enable heater #4 100%	Current: 1.09A Power: 27.93W Senor @ H4 rising	03/12/2020 10:44	SG, ME
~~2.104~~	~~Disable heater #4~~			
2.105	Enable all four heaters 100% for ~~5min~~	Current: 3.23A Power: 82.74W	03/12/2020 10:49	SG, ME
2.106	Disable all heaters	Current: 0.23A Power: 6.09W	03/12/2020 10:51	SG, ME

3.7.2 OPERATE F2 MECHANISM

Step no.	Action	Check/comments	Date /time	Operator
2.107	Move F2 positive 360° @ 15°/sec	Current: 0.57A Power: 14.51W CCW movement observed in HK readings	03/12/2020 10:52	SG, ME
2.108	Move F2 negative 360° @ 3°/sec	Current: 0.3A Power: 7.77W CW movement observed in HK readings	03/12/2020 10:56	SG, ME
2.109	Move F2 positive in steps of 45° @ 15°/sec	45° Done 90° Done 135° Done 180° Done 225° Done 270° Done 315° Done 360° Done	03/12/2020 10:58	SG, ME
2.110	Movement stopped	Current: 0.24A Power: 6.25W	03/12/2020 11:00	SG, ME
2.111	Power down OS	Current: 0.21A Power: 5.41W	03/12/2020 11:08	SG, ME

4 TEST SUMMARY

4.1 THERMAL

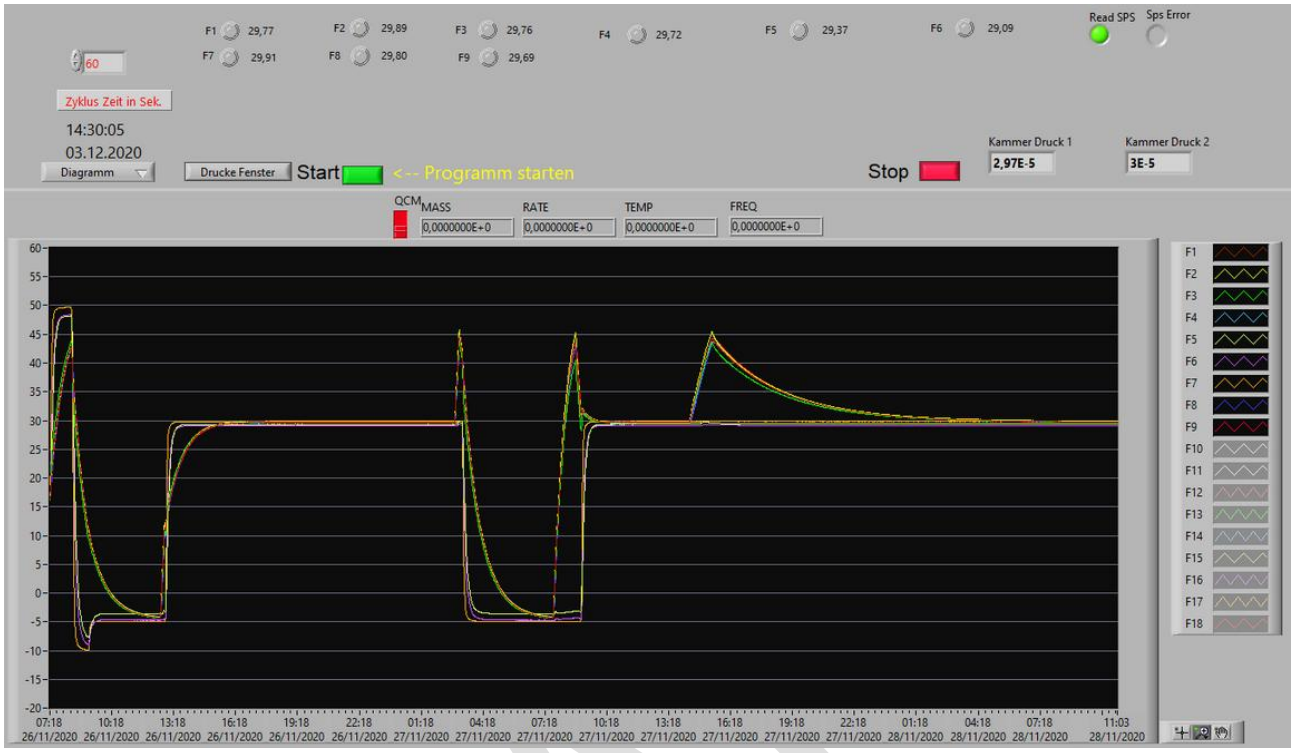


Figure 4-1 Thermal overview of the full test, temperature locking system

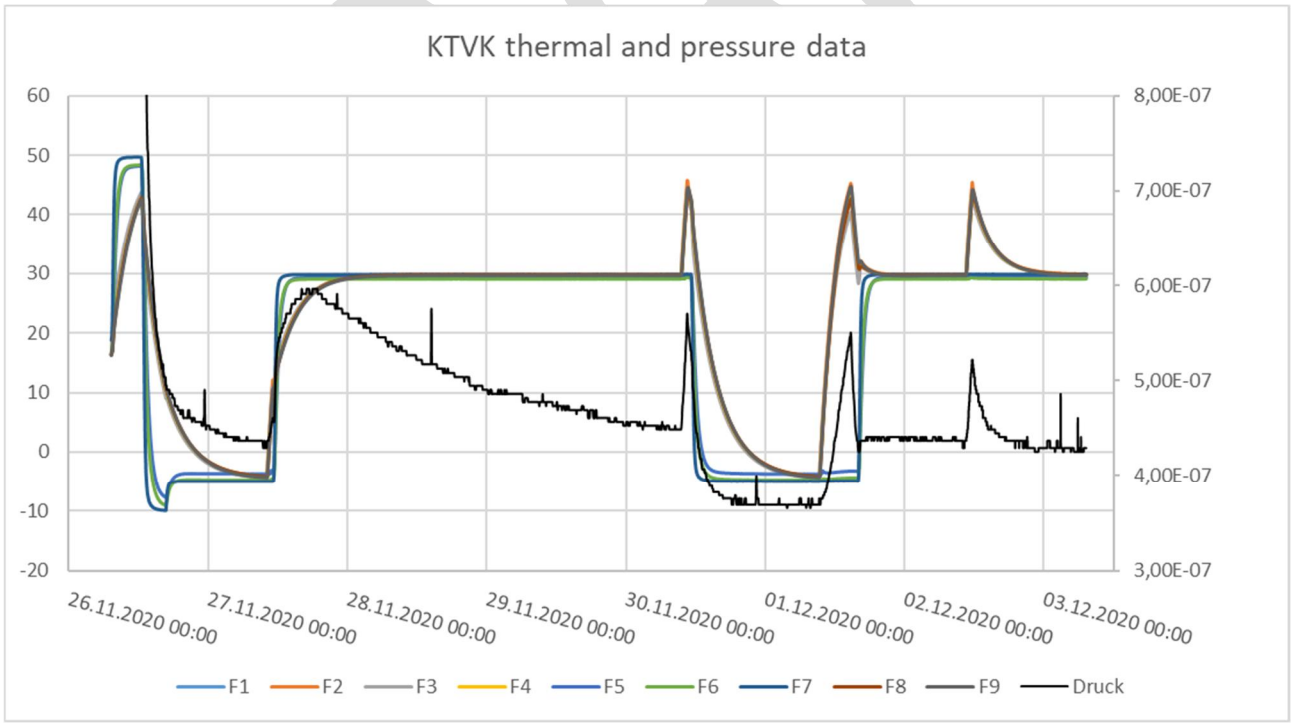


Figure 4-2 Thermal and pressure data

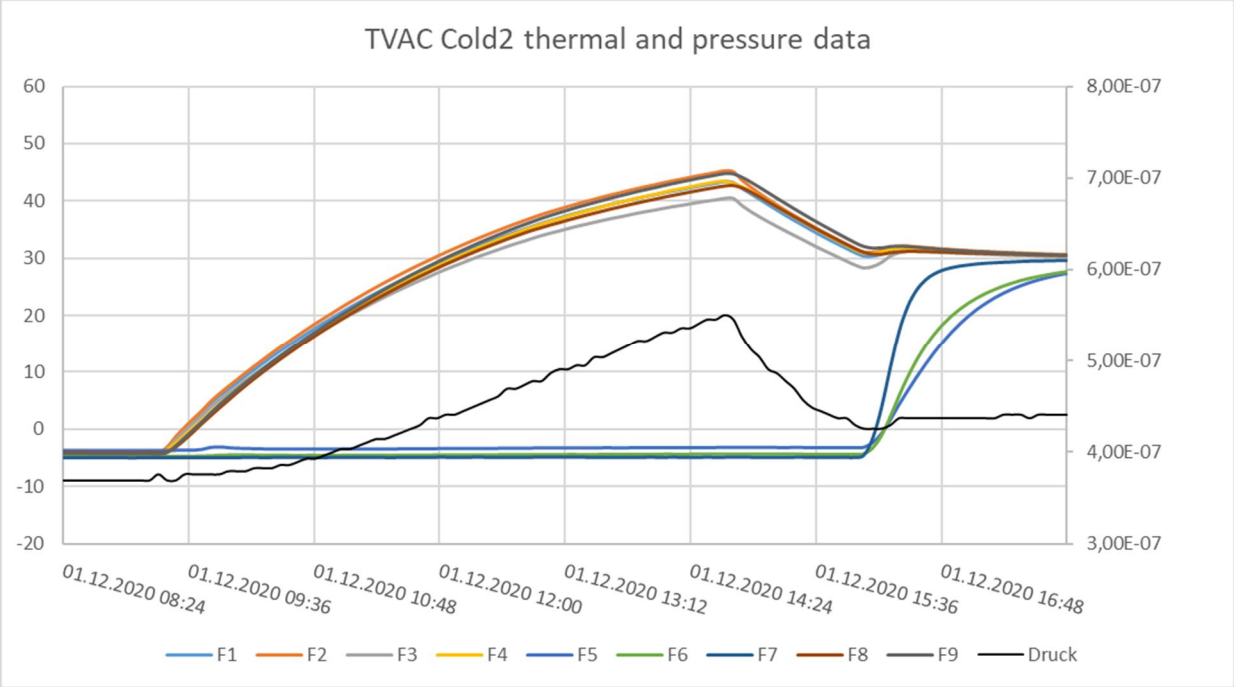


Figure 4-3 Thermal data of cold case2

The aim of the test was to prove the functionality across the operational temperature range of ISLiD. A long operation time was tested in cold case 2, the controller was powered for about 5h. The corresponding sensors are not fully settled in that timeframe and the temperatures increased about 50°C. This suggests to improve the thermal behaviour of the whole E-Unit.

4.2 *Current and Power*

The DUT is supplied with 25.6V for all test cases. The current and power values are sampled every minute and current and power values are acquired separately. The overall accuracy is therefore reduced too about ±1W. The running Linux OS in the RPI can cause significant changes in power which makes it difficult to record accurate values.

Table 4-1 Power summary

Operation	C1			H1			C2			H2			Ambient after		
	A	W	W (calc)	A	W	W (calc)	A	W	W (calc)	A	W	W (calc)	A	W	W (calc)
power up	0,26	6,85	6,656	0,25	6,5	6,4	0,28	**6,74**	7,168	0,25	6,3	6,4	0,25	6,25	6,4
H1	1,2	28,84	30,72	1,11	28,56	28,416	1,14	29,07	29,184	1,13	28,1	28,928	1,12	28,65	28,672
H2	0,92	23,57	23,552	0,93	23,6	23,808	0,93	23,73	23,808	0,91	23,3	23,296	0,91	23,37	23,296
H3	0,9	22,76	23,04	0,92	23,4	23,552	0,9	22,92	23,04	0,89	22,76	22,784	0,89	22,9	22,784
H4	1,09	27,82	27,904	1,1	28,08	28,16	1,09	27,94	27,904	1,18	27,74	30,208	1,09	27,93	27,904
H1-4	3,32	82,5	84,992	3,21	82,05	82,176	3,23	82,63	82,688	3,22	82,41	82,432	3,23	**82,74**	82,688
heater off										0,23	6,09				
F2 15°/sec	0,56	14,38	14,336	0,572	14,323	14,64	0,543	13,89	13,90	0,587	**16,646**	15,03	0,57	14,51	14,592
F2 3°/sec	0,31	8,1	7,936	0,31	7,86	7,936	0,32	8,08	8,192	0,31	7,63	7,936	0,3	7,77	7,68
H1-4 50%								~55							
heater off							0,25	6,34	6,4	0,24	6,03	6,144	0,24	6,25	6,144
power down	0,19	4,97	4,864	0,21	5,19	5,376	0,21	5,37	5,376	0,19	4,96	4,864	0,21	5,41	5,376

Peak power consumption:

1. At power up inrush à 36W for <20ms
2. Idle operation, heater OFF F2 in fix position à 6,7W
3. F2 operation, heater OFF à 16,6W
4. All heater 100%, F2 in fix position à 83W
5. Maximum consumption, all heater 100% and F2 moving à 93W (calculated)

The power consumption of the piezo controller for F2 can temporally increase up to >10W when rotating the filter wheel with a higher speed of 15°/sec. This is normally limited to a time below 12sec because all filter can be reached within a rotation of maximum 180°.

4.3 RASPBERRY PI PERFORMANCE

Table 4-2 RPI summary

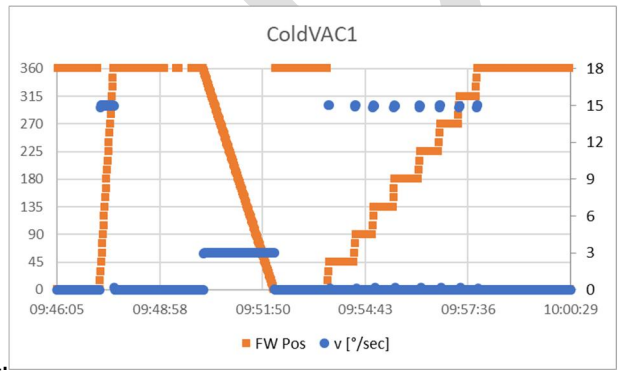
	ColdVAC1	HotVAC1	ColdVAC2	HotVAC2	Ambient
Max Temp	20,336	39,8	56,92	53,154	39,166
AV CPU %	4,777671	4,323314	4,482512	4,501348	4,577981
Max CPU %	35,7	13,25	75*	14,5	13,025
Max RAM (MB)	138,764	132,208	138,764	132,364	132,316
Timeout Count	0	0	0	0	0
Max read time(S)	1,2835	1,0111	1,0034	1,3153	1,0098
AV read time(S)	0,999421	0,999726	0,999631	0,999732	0,999726

*Shortly after RPI Boot(~10 seconds). 100% CPU usage on 2 cores, 50% on the other 2. Timing still nominal.

4.4 F2 OPERATION SPEED AND STABILITY

The speed and position stability were analysed for hot and cold case of cycle one. Figure 4-4 and Figure 4-5 below are showing the angle of F2 on a full rotation 0-360° scale in orange colour. Plot “a.” is also showing the calculated rotation speed and plot “b.” the error from the measured and commanded angle in µ°. Commanded speeds are 3°/sec and 15°/sec for a rotation of 360° or in increments of 45°.

a.



b.

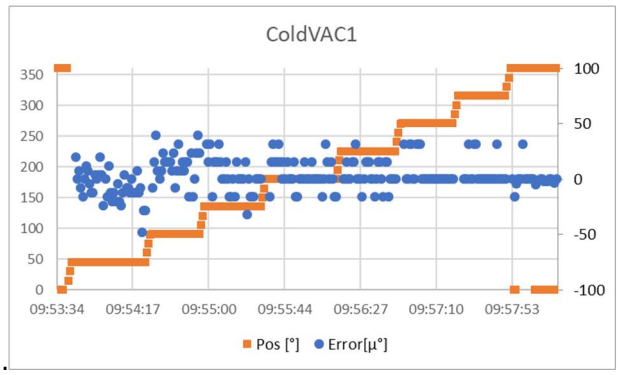
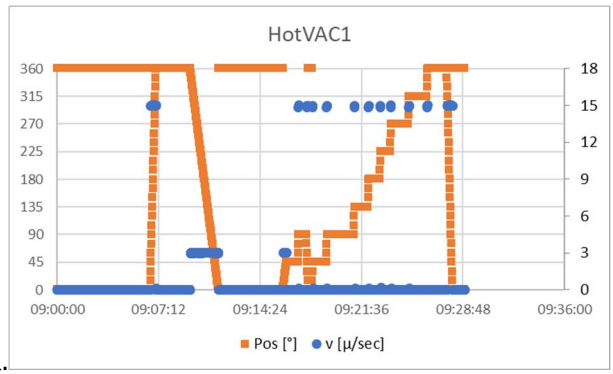


Figure 4-4 Cold case 1

a.) Position angle on the left scale (orange) and the speed when moving on the right scale (blue), b.) Position angle on the left scale (orange) and the position error from the ideal pos on the right (blue)

a. 

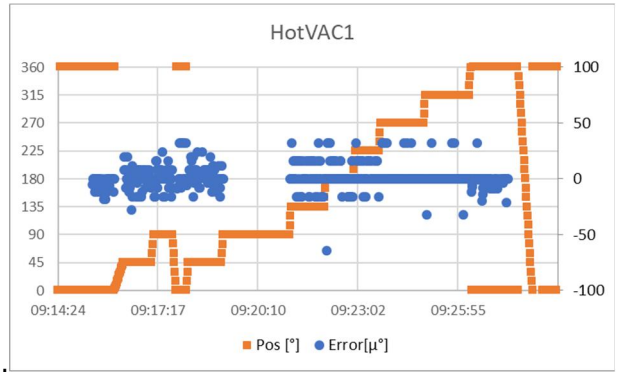
b. 

Figure 4-5 Hot case 1

a.) Position angle on the left scale (orange) and the speed when moving on the right scale (blue), b.) Position angle on the left scale (orange) and the position error from the ideal pos on the right (blue)

4.5 DISCOVERED ISSUES

1. **Software bug:** Heater control was not properly working, heater were powered off for a short duration even when set to 100%. Only occurred when F2 mechanism was disconnected.
   Solution: Software was updated (SG) TBC Sam

2. **Thermal behaviour:** The thermally insulated ELE-Unit has a high increase in temperature. Settling of temperatures was not observed in the duration of a test.
   Solution: Use Silver Coated FEP Tape to improve emissivity of the coated aluminium housing. Verified by test, see second TV-Test SR3-MPS-RP-LD700-005. (GFR)
3. **Software bug:** F2 mechanism angle resolution is reduced with inserting angle.
   Solution: Data type issue, software was updated (SG) Mail 15.3.2021

Note: These test results were measured before modifying the RPI with the USB boot option.