

SPD 10005 – FM KHUSAT-03

Thermal Vacuum Testing

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Revision History

Revision	Description	Author	Date
0.0	Draft Document	Seongwhan Lee	10/22/15
1.6	FM Procedure Updated	Seongwhan Lee	10/13/15
1.7	FM Test Result Updated	Jehyuck Shin	11/05/15
3.0	FM Test Result Updated	Seongwhan Lee	11/20/15
3.1	FM Test Result Updated, Voltage, Temperature	Seongwhan Lee	11/26/15

List of Abbreviations and Acronyms

SIGMA – Scientific cubesat with Instruments for Global Magnetic field and rAdiation

KHUSAT – Kyung Hee University SATellite

KHU – Kyung Hee Univeristy

SSR – School of Space Research

YU – York University, Canada

UNH – University of New Hampshire, USA

VT – Virginia Tech, USA

TestPOD - Test Picosatellite Orbital Deployer

UUT – Unit Under Test

HSK – HouSeKeeping

TEPC – Tissue Equivalent Proportional Counter

MAG – miniaturized fluxgate MAGnetometer

IIB – Instrument Interface Board

OBC – On Board Computer

RBF – Remove Before Flight

P/N – Part Number

TVAC – Thermal Vacuum

QM – Qualifying Model

FM – Flight Model

PFM – Proto-Flight Model

BRF – Body Reference Frame

LRF – Launcher Reference Frame

TC – ThermoCouples

KAIST – Korea Advanced Institute of Science and Technology

SaTReC – Satellite Technology Research Center

Special Notes

CAUTION

Note: CAUTION notes identify situations where flight hardware may be damaged without proper attention.

DANGER

Note: DANGER notes identify situations where bodily harm may occur without proper attention.



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1.0 Objective

This document describes TVAC test procedure of the KHUSAT-03 for FM. TVAC test consists of thermal cycling test and thermal balance test. The objective of thermal cycling test is to verify the system performance under the thermal vacuum condition which the spacecraft will encounter in space. The objective of thermal cycling test is subject the KHUSAT-03 satellites to the temperature extremes that have been derived from the combination of thermal analysis results and component-level operational temperature ranges. Functional TVAC tests will be performed in a thermal vacuum chamber at the KHU.

2.0 Personnel

KHUSAT-03	_____	Date: ____/____/____
Mechanical Engineer(s):	_____	Date: ____/____/____
 KHUSAT-03	_____	Date: ____/____/____
Electrical Engineer(s):	_____	Date: ____/____/____
 Test Facility Engineer(s):	_____	Date: ____/____/____
	_____	Date: ____/____/____

3.0 Proper Hardware Handling

All Flight Hardware to be bagged and kept clean. Personnel to handle hardware should only use appropriate gloves. Solar Panels should not be touched on the top surface, except by appropriate plastic covering.

4.0 Reference Documents

GSFC-STD-7000A GENERAL ENVIRONMENTAL VERIFICATION STANDARD (GEVS)
For GSFC Flight Programs and Projects

5.0 Thermal Vacuum Test Specification

5.1 Test Profile

Table 1KHUSSAT-03 Thermal Cycling Test Parameters

Item	Qualification	Acceptance
Number of Cycling	4 times	2 times
Soak Duration(Dwell Time)	2 hrs	2 hrs
Temperature Range	-20 ~ 40 °C	-15 ~ 35°C
Temperature Transition Rate	≤ 2°C/min	≤ 2°C/min
Stabilization Condition	≤ 3°C/hr	≤ 3°C/hr
Pressure	≤ 10 ⁻⁵ Torr	≤ 10 ⁻⁵ Torr

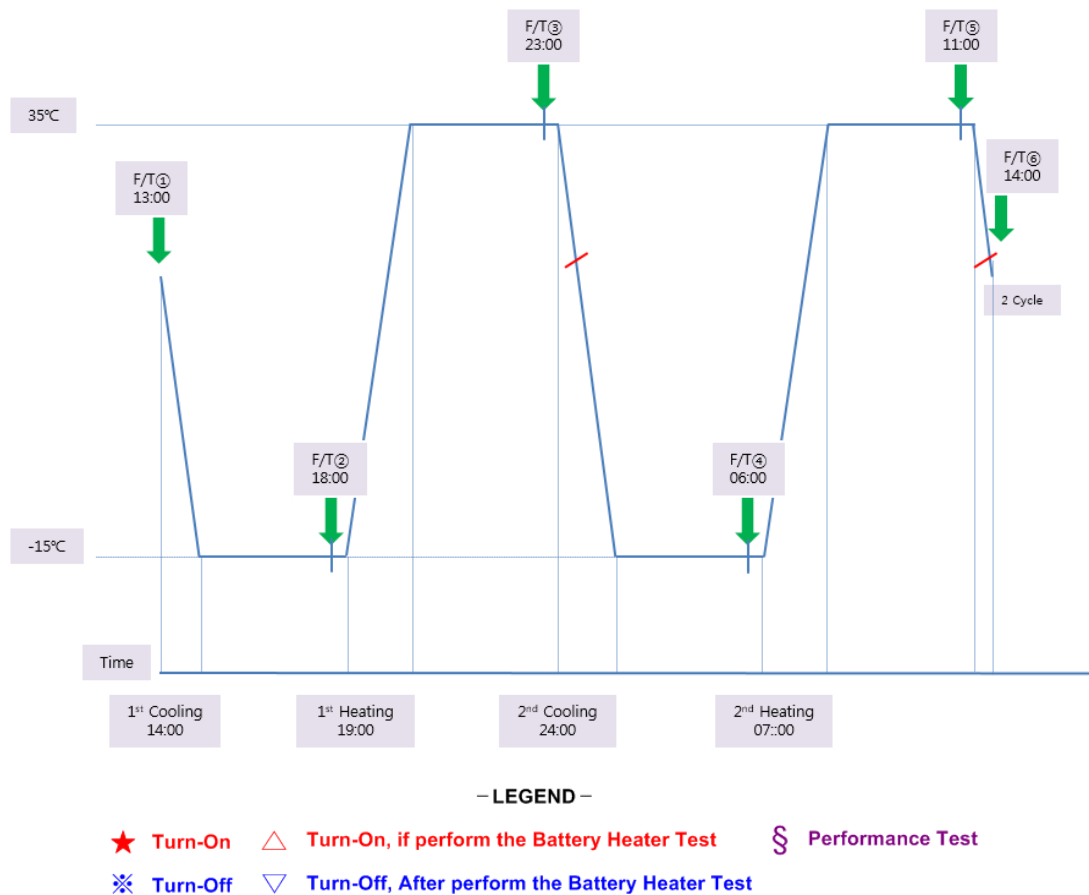


Figure 2 KHUSAT-03 FM Thermal Cycling Test Profile

5.2 Temperature Range

Component	Operating Temperature Limit (°C)
S-band Transmitter	-40 to +85
OBC	-40 to +85
SD card	-40 to +85
RTC coin battery	-30 to +80
EPS	-40 to +85
Battery	-40 to +85
Transceiver	-20 to +50
UHF/VHF Antenna	-20 to +60
IIB	-40 to +85
MAG Board	-40 to +70
ACS Board	-40 to +85
TEPC Board	-40 to +85
TEPC Sensor	-10 to +30
MAG Sensor	-40 to +80
Solar Cell	-100 to +100
Structure	-45 to +65

5.3 Thermo Couples



Omega Engineering 5TC-TT-T-30-36

5.4 Location of Thermo Couples (PFM)

Thermo couple	Location	Thermo couple	Location
T1	+Y +Z Chassis	T2	-Y +Z Chassis
T3 (Optional)	-Z Chassis		



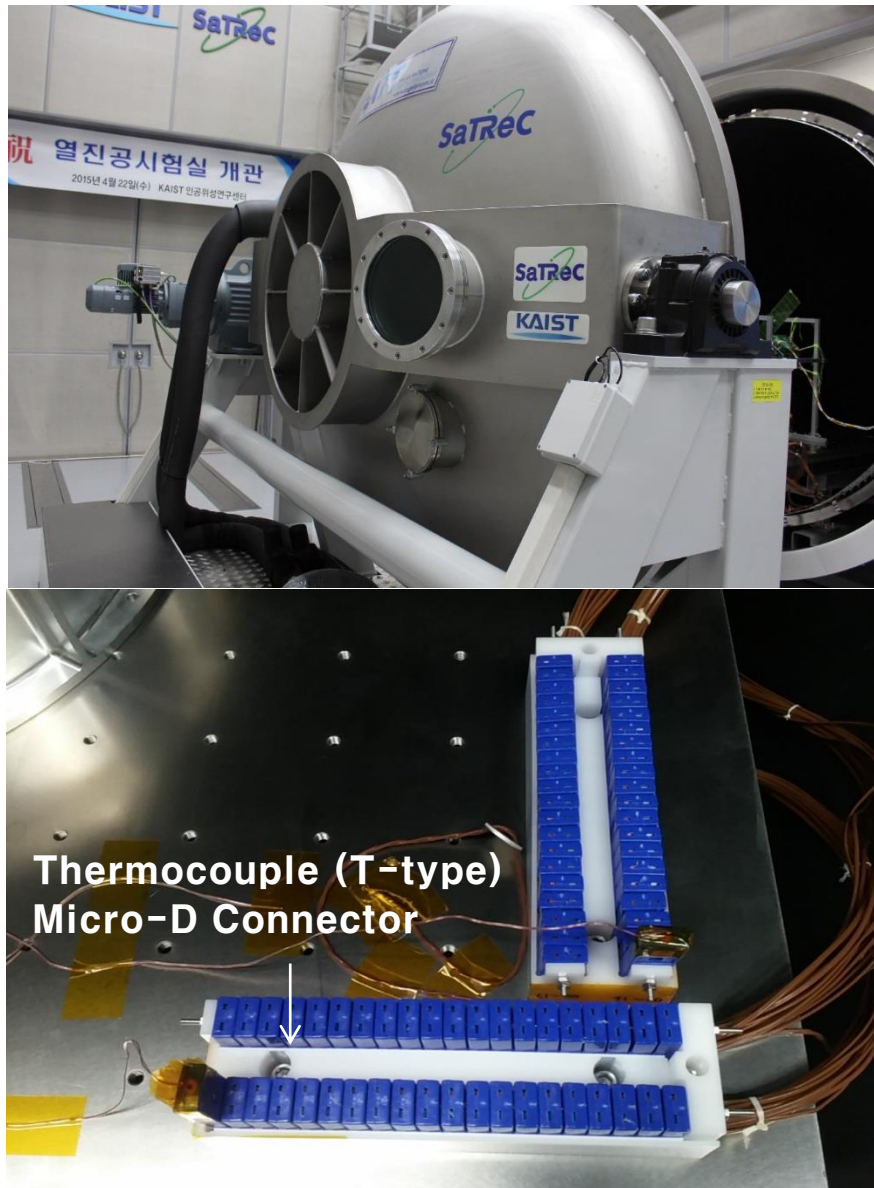
5.5 Check List of Functional Test

Component	Criterion
TEPC	No broken components or connections on electronics boards
	No loss of functionality
MAG	No loss of functionality in MAG boom deploy
	No loss of functionality in miniaturized fluxgate sensor
Torque coils/rod	No mechanical damage
	Retain full functionality
Avionics Bus	Deployment Switch – Plunger travels smoothly
	RBF Switch – remain closed
	OBC – Retains full functionality, no mechanical damage
	EPS – Retains full functionality, no mechanical damage
	Battery – Retains full functionality, no mechanical damage
	Transceiver – Retains full functionality, no mechanical damage
	IIB – Retains full functionality, no mechanical damage
	MAG board – Retains full functionality, no mechanical damage
	ACS board– Retains full functionality, no mechanical damage
Solar Panels	No structural damage that causes loss of functionality
	Electrical Functionality
Chassis	No galling on chassis rails
MAG Boom	No loss of deployment functionality
UHF/VHF Antenna	No loss of deployment functionality
S-band Antenna	No physical damage
	Electrical Functionality
DC-DC converter	Pins still intact and physically undamaged
Harnessing	Electrical Functionality

5.7 FM Test Environment

- Location

SaTReC(Satellite Technology Research Center), Deajeon, Korea



Thermocouple (T-type) micro connector

6.0 FM T-VAC Procedure

6.1 Set-Up

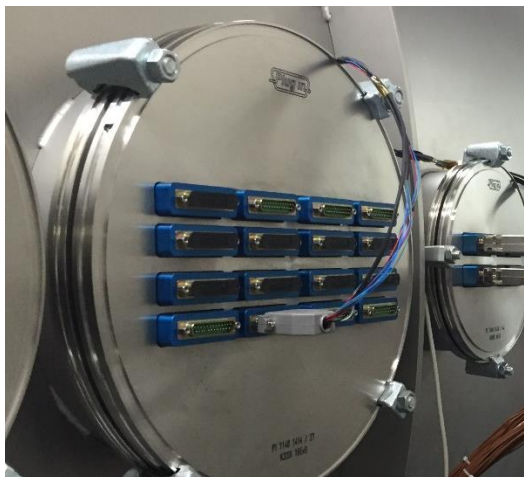
- Chamber Port Assign

챔버외벽 View - Male

01	02	03	04	05	06	07	08	09	10	11	12	13
14	15	16	17	18	19	20	21	22	23	24	25	

챔버내벽 View – Female

13	12	11	10	09	08	07	06	05	04	03	02	01
25	24	23	22	21	20	19	18	17	16	15	14	



1. Shell(GND)	2. X	3. X
4. X	5. - X	6. X
7. X	8. X	9. GND_DRAIN
10. X	11. X	12. X
13. X	14. TEPC V (Red)	15. TEPC GND (Blue)
16. TEPC GND (Green)	17.	18. USB D -
19.	20. USB D +	21. TEPC_GND (Black)
22. USB GND	23. TEPC RX (Blue)	24. USB VBUS
25. TEPC TX (Red)		

7.0 FM Thermal Vacuum Test

7.1 FM T-VAC Test Log and Issues

Date	Time	Cycle	Temperature [°C]		Vac [torr]	Note
			Shroud	Satellite		
2015.10.22	11:15					TEPC and SIGMA Power ON
2015.10.22	11:16	F/T_1	21.9		7.60E+02	F/T and TEPC check - clear!
2015.10.22	11:22		19.3	21.43		HSK Monitoring start
2015.10.22	11:26	Chamber close	20.1		7.60E+02	T-VAC test start
2015.10.22	11:30					HSK check
2015.10.22	11:40					"
2015.10.22	11:50					"
2015.10.22	12:00					"
2015.10.22	12:10					"
2015.10.22	12:20					"
2015.10.22	12:30	RT	20.3	23.90	6.40E-03	HSK, TEPC ACK check
2015.10.22	12:40	RT	20.4	24.30	5.70E-03	HSK check
2015.10.22	12:50	RT				"
2015.10.22	13:00	RT	20.6	25.10	4.80E-03	"
2015.10.22	13:10	RT	20.7	25.52	4.40E-03	"
2015.10.22	13:20	RT		25.82	4.10E-03	HSK check, ACS communication time out
2015.10.22	13:24	RT		25.90	1.70E-06	High vacuum state reaching, F/T, MAG data read fail
2015.10.22	~13:46	RT		26.60	7.80E-07	MAG 동작 하지 않기로 결정 (교수님과 논의함)
2015.10.22	13:50	RT		26.67	7.40E-07	TEPC setting and start, HSK check
2015.10.22	14:01	RT		26.90	2.00E-07	HSK check
2015.10.22	14:02	Cooling	11.7	26.50		Cooling start
2015.10.22	14:10	Cooling	3.1	25.00		HSK check
2015.10.22	14:20	Cooling	-12.5	21.47		"
2015.10.22	14:30	Cooling	-27.4	17.62		"
2015.10.22	14:40	Cooling	-40.1	13.50		"
2015.10.22	14:50	Cooling	-43.6	9.61		"
2015.10.22	15:00	Cooling	-40.2	7.01		"
2015.10.22	15:10	Cooling	-40.0	4.89	3.20E-08	"
2015.10.22	15:20	Cooling	-40.2	2.91	6.80E-07	"
2015.10.22	15:30	Cooling	-40.0	0.80	6.50E-05	"

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2015.10.22	15:40	Cooling	-40.0	-0.56	2.10E-08	"
2015.10.22	15:50	Cooling				"
2015.10.22	16:00	Cooling	-40.0	-3.47	2.10E-08	"
2015.10.22	16:10	Cooling	-47.6	-5.26	2.20E-08	"
2015.10.22	16:20	Cooling	-53.6	-7.45	4.90E-07	"
2015.10.22	16:30	Cooling	-50.6	-9.00	5.00E-07	"
2015.10.22	16:40	Cooling	-50.0	-10.30	1.80E-08	HSK 66
2015.10.22	16:50	Cooling	-50.0	-11.52	4.70E-07	HSK 67
2015.10.22	17:00	Cooling	-50.2	-12.75	2.30E-08	HSK 68, ACS 통신 연결 확인
2015.10.22	17:10	Cooling	-50.0	-13.80	1.30E-08	HSK 69
2015.10.22	17:20	Cooling	-43.4	-14.70	1.80E-08	HSK 70
2015.10.22	17:30	Cooling	-37.0	-13.83	2.10E-08	HSK 71
2015.10.22	17:40	Cooling	-43.6	-14.87	1.30E-08	HSK 72
2015.10.22	17:50	Cooling	-42.3	-15.30	1.10E-08	HSK 73
2015.10.22	18:00	Cooling	-39.0	-15.41	1.30E-08	HSK 74, 3.3 V 전류량 증가 (Batt Heater on)
2015.10.22	18:10	Cooling	-39.7	-15.57	1.80E-08	HSK 75
2015.10.22	18:20	Cooling	-40.1	-15.87	2.10E-08	HSK 76
2015.10.22	18:30	Cooling	-40.1	-16.18	1.40E-08	HSK 77
2015.10.22	18:40	Cooling	-39.9	-16.34	9.40E-09	HSK 78
2015.10.22	18:50	Cooling	-39.2	-16.54	1.60E-08	HSK 79
2015.10.22	19:00	Cooling	-38.0	-16.45	4.60E-09	HSK 80
2015.10.22	19:10	Cooling	-36.6	-16.38	2.30E-08	HSK 81
2015.10.22	19:20	Cooling	-34.2	-16.01	3.50E-07	HSK 82 Batt 7.86 V
2015.10.22	19:30	Colling Soak	-34.9	-15.92	3.20E-07	HSK 83
2015.10.22	19:40	Colling Soak	-35.2	-15.85	2.90E-07	HSK 84
2015.10.22	19:50	Colling Soak	-35.1	-15.79	1.80E-07	HSK 85
2015.10.22	20:00	Colling Soak	-35.0	-15.79	3.20E-07	HSK 86
2015.10.22	20:10	Colling Soak	-35.0	-15.68	3.50E-07	HSK 87
2015.10.22	20:20	Colling Soak	-35.1	-15.62	3.00E-07	HSK 88
2015.10.22	20:30	Colling Soak	-35.1	-15.58	2.30E-08	HSK 89
2015.10.22	20:40	Colling Soak	-35.1	-15.56	5.50E-09	HSK 90
2015.10.22	20:50	Colling Soak	-35.0	-15.54	3.70E-08	HSK 91
2015.10.22	21:00	Colling Soak	-35.1	-15.54	3.00E-07	HSK 92
2015.10.22	21:10	Colling Soak	-35.1	-15.53	2.50E-07	HSK 93
2015.10.22	21:20	Colling Soak	-35.0	-15.49	2.80E-07	HSK 94
2015.10.22	21:30	Colling Soak	-21.1	-14.65	1.80E-08	HSK 95

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2015.10.22	21:40	Heating	4.4	-10.30	1.20E-06	HSK 96
2015.10.22	21:50	Heating	30.9	-2.46	1.50E-06	HSK 97
2015.10.22	22:00	Heating	43.6	6.96	3.70E-06	HSK 98
2015.10.22	22:10	Heating	40.4	11.92	2.80E-06	HSK 99, Batt heater off
2015.10.22	22:20	Heating	51.9	17.22	4.30E-06	HSK 100
2015.10.22	22:30	Heating	63.4	26.18	4.90E-06	HSK 101
2015.10.22	22:40	Heating	47.7	28.08	2.50E-06	HSK 102
2015.10.22	22:50	Heating	49.8	30.83	2.40E-06	HSK 103
2015.10.22	23:00	Heating	38.2	31.05	3.40E-07	HSK 104
2015.10.22	23:10	Heating	43.2		7.30E-07	HSK 105
2015.10.22	23:20	Heating	39.5	33.76	6.80E-08	HSK 106
2015.10.22	23:30	Heating Soak	39.6	34.60	1.70E-07	HSK 107
2015.10.22	23:40	Heating Soak	36.2	34.90	3.00E-07	HSK 108
2015.10.22	23:50	Heating Soak	34.4	35.00	5.40E-08	HSK 109
2015.10.23	0:00	Heating Soak	33.5	35.40	1.20E-06	HSK 110
2015.10.23	0:10	Heating Soak	32.5	35.50	1.60E-06	HSK 111
2015.10.23	0:20	Heating Soak	31.8	35.60	1.00E-06	HSK 112, ACS time out
2015.10.23	0:30	Heating Soak	28.3	35.17	9.90E-07	HSK 113
2015.10.23	0:40	Heating Soak	28.7	35.03	9.20E-07	HSK 114
2015.10.23	0:50	Heating Soak	29.1	35.10	8.50E-07	HSK 115
2015.10.23	1:00	Heating Soak	29.0	35.20	8.40E-07	HSK 116
2015.10.23	1:10	Heating Soak	29.0	35.30	7.80E-07	HSK 117
2015.10.23	1:20	Heating Soak	29.0	35.30	7.90E-07	HSK 118
2015.10.23	1:30	Heating Soak	29.0	35.50	7.20E-07	HSK 119
2015.10.23	1:40	Cooling	29.0	35.50	7.00E-07	
2015.10.23	1:50	Cooling	3.7	31.50	5.70E-07	HSK 120
2015.10.23	2:00	Cooling	-15.8	26.20	4.70E-07	HSK 121
2015.10.23	2:10	Cooling	-33.1	20.56	3.80E-07	HSK 122
2015.10.23	2:20	Cooling	-45.1	15.60	2.50E-07	HSK 123
2015.10.23	2:30	Cooling	-53.8	10.80	9.10E-09	HSK 124
2015.10.23	2:40	Cooling	-52.3	6.90	1.10E-08	HSK 125
2015.10.23	2:50	Cooling	-49.6	3.73	1.10E-08	HSK 126
2015.10.23	3:00	Cooling	-50.0	0.90	1.30E-08	HSK 127, ACS 통신 확인
2015.10.23	3:10	Cooling	-50.2	-1.80	1.30E-07	HSK 128
2015.10.23	3:20	Cooling	-50.1	-4.27	1.20E-07	HSK 129
2015.10.23	3:30	Cooling	-50.0	-6.55	1.20E-07	HSK 130

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2015.10.23	3:40	Cooling	-50.0	-8.50	1.20E-07	HSK 131
2015.10.23	3:50	Cooling	-50.0	-10.80	1.10E-07	HSK 132
2015.10.23	4:00	Cooling	-50.0	-12.30	1.10E-07	HSK 133
2015.10.23	4:10	Cooling	-49.9	-14.10	1.10E-07	HSK 134
2015.10.23	4:20	Cooling	-41.4	-14.90	1.00E-07	HSK 135
2015.10.23	4:30	Cooling	-36.1	-15.80	2.20E-08	HSK 136
2015.10.23	4:40	Cooling	-33.1	-15.40	3.80E-08	HSK 137
2015.10.23	4:50	Cooling	-32.0	-15.50	1.00E-07	HSK 138
2015.10.23	5:00	Cooling Soak	-31.2	-15.90	1.00E-07	HSK 139
2015.10.23	5:10	Cooling Soak	-29.2	-15.59	1.80E-07	HSK 140, Batt, 3.3 V 232mA (Batt heater on)
2015.10.23	5:20	Cooling Soak	-29.6	-16.10	1.20E-08	HSK 141
2015.10.23	5:30	Cooling Soak	-26.2	-15.70	2.50E-08	HSK 142
2015.10.23	5:40	Cooling Soak	-26.8	-15.80	3.20E-08	HSK 143
2015.10.23	5:50	Cooling Soak	-27.1	-15.80	3.40E-08	HSK 144
2015.10.23	6:00	Cooling Soak	-25.9	-15.70	3.70E-08	HSK 145
2015.10.23	6:10	Cooling Soak	-25.8	-15.60	1.30E-07	HSK 146
2015.10.23	6:20	Cooling Soak	-26.1	-15.60	1.30E-07	HSK 147
2015.10.23	6:30	Cooling Soak	-26.0	-15.60	1.40E-08	HSK 148
2015.10.23	6:40	Cooling Soak	-26.0	-15.60	1.30E-07	HSK 149
2015.10.23	6:50	Cooling Soak	-26.0	-15.60	1.30E-07	HSK 150
2015.10.23	7:00	Cooling Soak	-22.0	-15.50	1.70E-07	HSK 151
2015.10.23	7:10	Heating	10.0	-10.37	1.30E-07	HSK 152
2015.10.23	7:20	Heating	36.7	-1.94	1.00E-06	HSK 153
2015.10.23	7:30	Heating	53.1	7.29	9.90E-07	HSK 154
2015.10.23	7:40	Heating	51.1	14.15	7.90E-07	HSK 155
2015.10.23	7:50	Heating	49.8	16.67	7.40E-07	HSK 156 (Batt heater off)
2015.10.23	8:00	Heating	50.1	22.54	8.20E-08	HSK 157
2015.10.23	8:10	Heating	50.1	26.06	8.50E-07	HSK 158
2015.10.23	8:20	Heating	50.0	26.53	8.60E-07	HSK 159
2015.10.23	8:30	Heating	52.0	31.00	9.20E-07	HSK 160, Trans & Ant I2C time out
2015.10.23	8:40	Heating	50.0	33.10	9.80E-07	HSK 161
2015.10.23	8:50	Heating	39.0	33.31	8.80E-07	HSK 162, beacon 발생
2015.10.23	9:00	Heating	45.7	34.40	1.00E-06	HSK 163
2015.10.23	9:10	Heating	37.7	34.54	8.60E-07	HSK 164
2015.10.23	9:20	Heating	36.6	34.21	8.70E-07	HSK 165
2015.10.23	9:30	Heating	38.1	34.63	8.90E-07	HSK 166

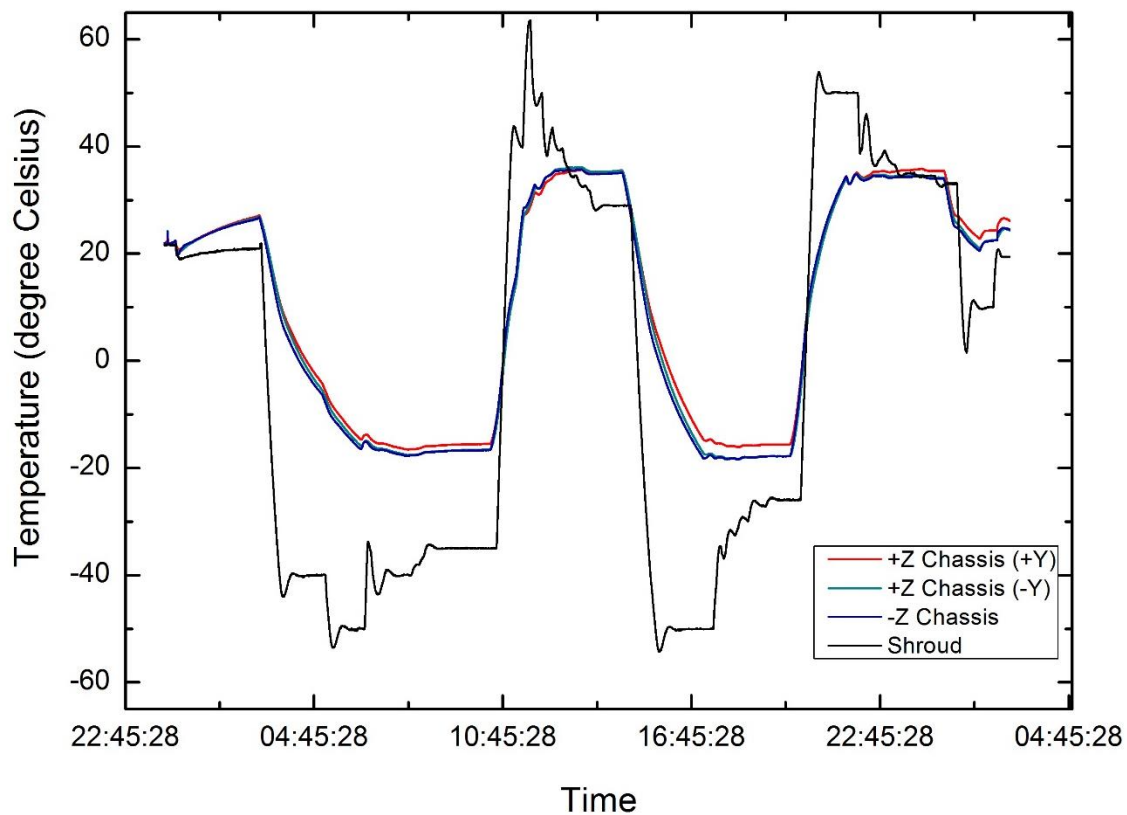
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2015.10.23	9:40	Heating	38.3	35.26	8.50E-07	HSK 167, HSK 168
2015.10.23	9:50	Heating Soak	36.8	35.35	8.00E-07	HSK 169
2015.10.23	10:00	Heating Soak	35.3	35.37	7.70E-07	HSK 170
2015.10.23	10:10	Heating Soak	34.6	35.16	7.30E-07	HSK 171
2015.10.23	10:20	Heating Soak	35.0	35.34	6.80E-07	HSK 172
2015.10.23	10:30	Heating Soak	35.0	35.52	6.70E-07	HSK 173
2015.10.23	10:40	Heating Soak	34.4	35.54	6.20E-07	HSK 174
2015.10.23	10:50	Heating Soak	34.5	35.57	6.30E-07	HSK 175
2015.10.23	11:00	Heating Soak	34.5	35.70	6.60E-07	HSK 176
2015.10.23	11:10	Heating Soak	34.5	35.80	5.90E-07	HSK 177
2015.10.23	11:20	Heating Soak	32.5	35.54	5.70E-07	HSK 178
2015.10.23	11:30	Heating Soak	32.9	35.48	5.60E-07	HSK 179
2015.10.23	11:40	Heating Soak	33.0	35.47	5.60E-07	HSK 180, HSK 181
2015.10.23	11:50	Heating Soak	33.0	35.45	5.40E-07	HSK 182
2015.10.23	12:00		14.0	32.76	5.00E-07	HSK 184
2015.10.23	12:10		1.7	28.03	4.10E-07	HSK 185
2015.10.23	12:20		10.8	26.90	3.90E-07	HSK 186
2015.10.23	12:30		10.3	25.85	3.70E-07	HSK 187
2015.10.23	12:40		9.7	24.68	3.50E-07	HSK 188
2015.10.23	12:50		10.0	23.71	3.30E-07	HSK 189
2015.10.23	13:00		9.9	22.89	3.20E-07	HSK 190
2015.10.23	13:10		20.8	24.11	3.40E-07	HSK 191, HSK 192
2015.10.23	13:20		19.3	24.29	3.40E-07	HSK 193
2015.10.23	13:30	Breaking a vacuum	19.4	24.30	3.30E-07	HSK 194
2015.10.23	13:40				7.60E-02	HSK 195
2015.10.23	13:50					진공해제 완료, HSK 확인 시작
2015.10.23	14:00					
2015.10.23	14:04					진공해제 후 OBC reboot, 모든 통신 정상

7.2 FM Test Result

7.2.1 Result

7.2.2 Temperature

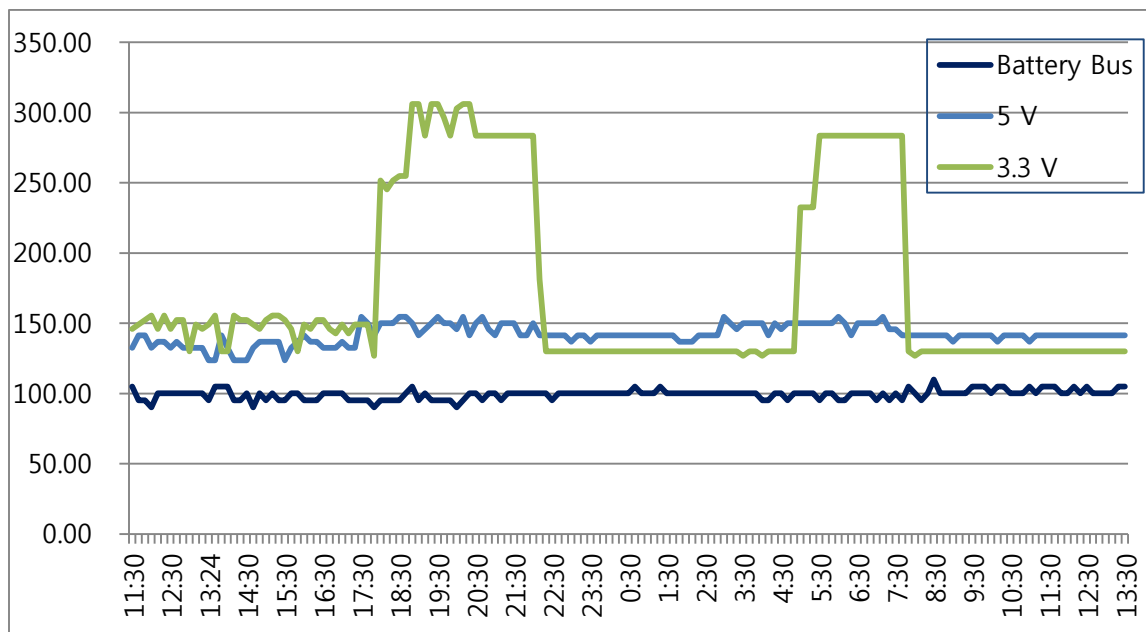


Temperature result of FM KHUSAT-03

Thermal vacuum test was conducted at temperatures -15 to 35 degrees Celsius. Two cycles were completed with a hold at each extreme for 2 hours. The FM KHUSAT-03 was placed in the vacuum chamber and brought down to a hard vacuum (a least 5×10^{-5} Torr).

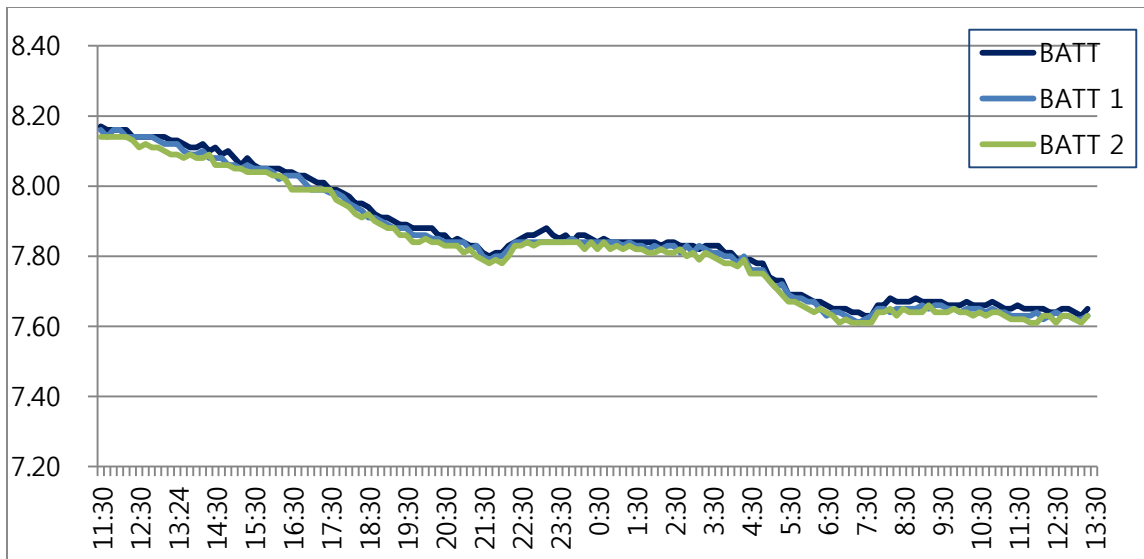
According to results of FM thermal-Vac test, TEPC is fully operated from the external voltage supply for temperature optimization. There was the issue that the temperature of SIGMA had cooled lately due to TEPC boards, TEPC was turned off after 1st heating cycle. So the 2nd cooling cycle was shorter than 1st cooling cycle. There is 5°C difference inside of SIGMA.

7.2.3 Battery Voltage



Battery Voltage Usage

Fig.X is shown a current of battery. Normally, ACS and antenna are used 3.3 V. OBC and MAG board are used 5 V. ISIS Transceiver board is used 8 V, unregulated battery bus. From the - 10°C, the current of 3.3V is extremely increased due to heater of battery.

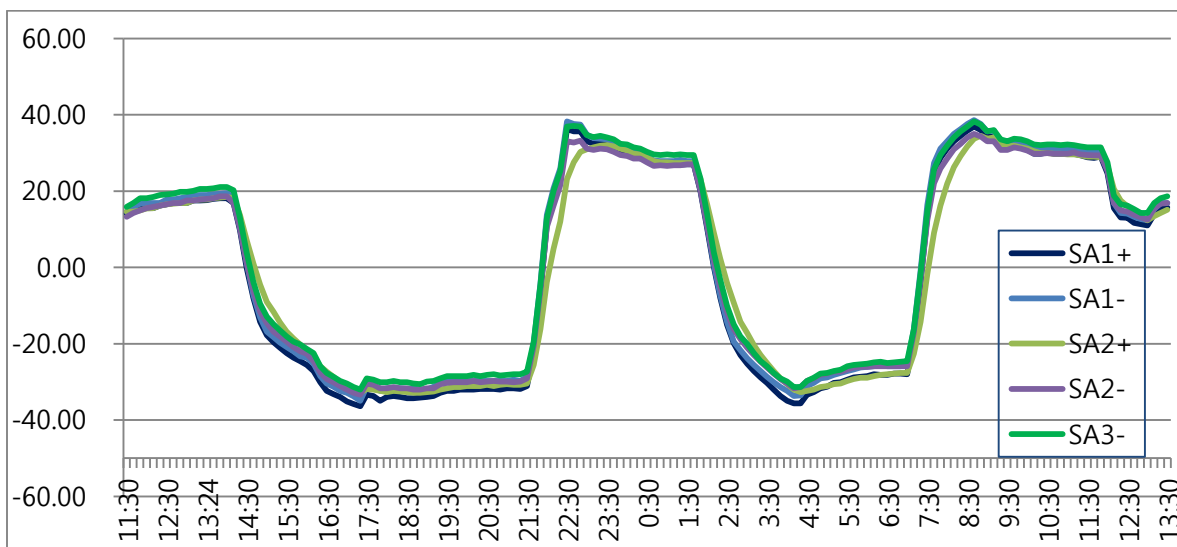


Battery Voltage Output

For using battery heater, battery residual value is extremely decreased on the above graph.

The voltage of battery is about 8.15 V when starting the FM Thermal-Vacuum test and it was about 7.65 V when test ended.

7.2.4 Solar Array Temperature Calibration



Solar Array Temperature

7.3 FM Pass/Fail criteria

Table 21. Check list of pass/fail criteria

NO	Category	Check Item	Home Check	#1 cycle	#2 cycle			Home Check
1. TEPC								
1	TEPC	No mechanical damage	P	N/A	N/A			P
2	TEPC	Electrical functionality	P	P	P			P
2. MAG								
1	MAG	No mechanical damage	P	N/A	N/A			P
2	MAG	Electrical functionality	P	P	P			P
3. Avionics stack								
1	Deployment switch	Plunger travels smoothly	P	N/A	N/A			P
2	RBF switch	Remains closed	N/A	N/A	N/A			N/A
3	Motherboard	Retains full functionality	P	P	P			P
4	Motherboard	No mechanical damage	P	N/A	N/A			P
5	EPS	Retains full functionality	P	P	P			P
6	EPS	No mechanical damage	P	N/A	N/A			P
7	Battery	Retains full functionality	P	P	P			P
8	Battery	No mechanical damage	P	N/A	N/A			P
9	UV Transceiver	No mechanical damage	P	N/A	N/A			P
10	IIB	Retains full functionality	P	P	P			P
11	IIB	No mechanical damage	P	N/A	N/A			P
4. Chassis								
1	Chassis	No galling on chassis rails	P	N/A	N/A			P
5. Torque coils								
1	Torque coils	No mechanical damage	N/A	N/A	N/A			N/A
2	Torque coils	Retain full functionality	N/A	N/A	N/A			N/A
6. Solar panels								

1	Solar panels	No structural damage that causes loss of functionality	P	N/A	N/A			P
2	Solar panels	Electrical functionality	P	P	P			P
7. UHF/VHF antenna assembly								
1	UHF antenna	No loss of deployment functionality	P	N/A	N/A			P
2	UHF antenna	No loss of radio functionality	P	N/A	N/A			P
8. Patch antennas								
1	Patch antennas	No physical damage	N/A	N/A	N/A			N/A
2	Patch antennas	Electrical Functionality	N/A	N/A	N/A			N/A
9. Calex DC-DC Converter								
1	Calex DC-DC converter	Pins still intact and physically undamaged	N/A	N/A	N/A			N/A
2	Calex DC-DC converter	Electrical Functionality	N/A	N/A	N/A			N/A
10. Harnessing								
1	Harnessing	No loss of captivity	P	P	P			P
2	Harnessing	Electrical Functionality	P	P	P			P

* P: Pass, F: Fail, N/A: Not Applicable

8.0 APPENDIX

8.1 APPENDIX A

Test Monitoring Chart

