MIRO
FM Thermal Vacuum Test Plan

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DOCUMENT CHANGE LOG

CHANGE NUMBER	CHANGE DATE	PAGES AFFECTED	CHANGES/ NOTES	GENERAL COMMENTS
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CONTENTS

List of Figures

List of Tables

Acronyms

AMP	Amplifier
Ana	Analog
Bd	Board
C	Centigrade
Cal	Calibration
Curr	Current
Deg	degrees
DET	Detector
ECal	Electronics Unit Calibration
EID-B	Experiment Interface Document, Part B
EQM	Electrical Qualification Model
ERR	Error
EU	Electronics Unit
FS1	Frequency Synthesizer 1 (2182 MHz)
FS2	Frequency Synthesizer 2 (7147 MHz)
FS3	Frequency Synthesizer 3 (7728 MHz)
IF	Intermediate Frequency
IFP	Intermediate Frequency Processor
LFT	Limited Functional Test
LO	Local Oscillator
MIRO	Microwave Instrument for the Rosetta Orbiter
MM	Millimeter
Mult	Multiplier
OB	Optical Bench
PLL	Phase Lock Loop
Pwr	Power
RF	Radio Frequency
SBEU	Sensor Backend Electronics Unit
Sen_El	Sensor Electronics
SMM	Submillimeter
Spect	Spectrometer
Temp	Temperature
TLM	Telemetry
TRP	Temperature Reference Point
V	Voltage

1 Objectives

The objectives of the MIRO FM thermal vacuum tests are to:

- Test the instrument at the extremes of the temperature limits for non-operating and operating conditions in representative instrument modes
- Verify the functional operation of the instrument under temperature and vacuum conditions
- Measure the power (steady state and peak) at the spacecraft interface
- Calibrate the flight instrument

2 Conditions

2.1 Applicable Documents

The following documents of the latest issue in effect on the date of testing shall form a part of this plan to the extent specified herein. In the event that this document is found to be in conflict with any of the reference documents, then the Test Director shall be consulted.

10174190	FM Sensor Unit Main Assembly JPL Dwg.
10174400	FM Sensor Backend Electronics Unit Main Assembly JPL Dwg.
10174700	FM Electronics Unit Assembly JPL Dwg.
10174201	MICD, Sensor Unit
10174210	MICD, Sensor Backend Electronics Unit
10174701	MICD, Electronics Unit
10175001	MICD, Ultrastable Oscillator
RO-EST-RS-30001/EID A	Rosetta Experiment Interface Document, Part A
MIL-STD-45662	Calibration System requirements

2.2 Hazards and Precautions

All personnel shall be alerted for conditions, which may endanger the staff conducting the test or the equipment being tested. Any conditions, which appear hazardous, shall be brought to the attention of the test conductor.

2.3 Personnel and Responsibilities

The following personnel, or appropriate alternates, shall be present to conduct, or observe, or be on call during the tests as required.

MIRO Integration and Test Project Element Manager (PEM): Cynthia Kahn
PEM is to provide the necessary procedures and staff for assembling and handling of the FM hardware during the test and is responsible for the safety of the hardware at all times. PEM and the Test Director shall certify that all test objectives have been met prior to tear down.

Test Director (TD): Cynthia Kahn/Ali Pourangi
TD shall assure compliance with the Test Plan and certify that all the test objectives have been met. TD is responsible for all thermal and functional assessment and shall prepare the Test Plan in conformity with the project environmental requirements. S/He is also responsible for preparing a final Test Report documenting the results of the Tests.

Science Calibration Lead (SCL): Dr. Samuel Gulkis
SCL shall be responsible for the preparation of the detailed Calibration Procedure, real-time calibration test data acquisition, processing, recording and data reduction and preparation of a test report.

Quality Assurance Representative (QAR): Jim Aragon
Quality Assurance will be present at all times to monitor compliance with test procedures and to witness successful completion of the tests.

2.4 Handling of Flight Hardware

Only currently certified personnel shall handle MIRO Flight Hardware. Procedures for ESD avoidance shall be followed. For hardware safety, the temperature while handling shall be room temperature ± 5 degrees with a minumum of 30% humidity.

The MIRO hardware has been baked out prior to thermal vacuum testing so personnel shall wear appropriate clothing (including smocks, hats, face masks, and gloves) while near the hardware. Contamination control for MIRO shall be class 100,000.

3 Limited Functional Test Definition for Thermal Vacuum

A Limited Functional Test (LFT) will be performed before, during and after the thermal vacuum test, as appropriate, in order to demonstrate that functional capability has not been degraded by the environmental test. The Limited Functional Test will demonstrate that the performance of selected hardware and software functions is within acceptable limits.

4 Thermal Vacuum Test Requirements

4.1 Thermal Vacuum Test Profile

The thermal vacuum test at instrument level shall be performed as defined Figure 1. The test is split into two major sections. The first section of the test addresses ESA Rosetta Project requirements. The second section of the test provides instrument calibration. Note that the shroud temperature will not be controlled during any part of the test. Further explanation of the temperature limits, cycles, rate of change and durations are given in the following sections as well as a more detailed test sequence.

4.2 Temperature Reference Points, Ranges and Spacecraft Sensor Placement

The temperatures are defined at the spacecraft temperature reference points specified in the EID-B document for MIRO. These points are given in Table 1 and the temperature limits are given in Table 2. The limits specified for the Sensor Unit correspond to those for the optical bench (not the telescope).

Approximate physical sensor placements for the SU and SBEU are shown in Figures 2 and 3. These correspond to the points identified on MIRO's MICDs. For the EU and USO, MIRO will place thermocouples on one of the mounting feet of each unit to monitor the temperature as close to the spacecraft identified monitoring point as possible. Note: Sensors for the EU and USO cannot be placed near the mounting foot because they would be on the heat exchanger plate used to control the each unit's temperature.

Table 1 Temperature Reference Points

Unit	Reference Point
Sensor Unit	Middle of Optical Bench
Sensor Backend Electronics Unit	Mounting Foot
Electronics Unit	Near a Mounting Foot
Ultrastable Oscillator	Near a Mounting Foot

All flight internal temperature sensors are identified in Appendix A along with their yellow and red alarm limits. They are read out through the instrument telemetry. Additional sense points, including the spacecraft temperature sensor points, that are monitored by a separate MIRO GSE computer are identified in Appendix B. Temperatures monitored independently by the Environmental Test Facility are listed in Appendix C. Figures 4, 5, and 6 showing all temperature sensor locations are also in the appendices.

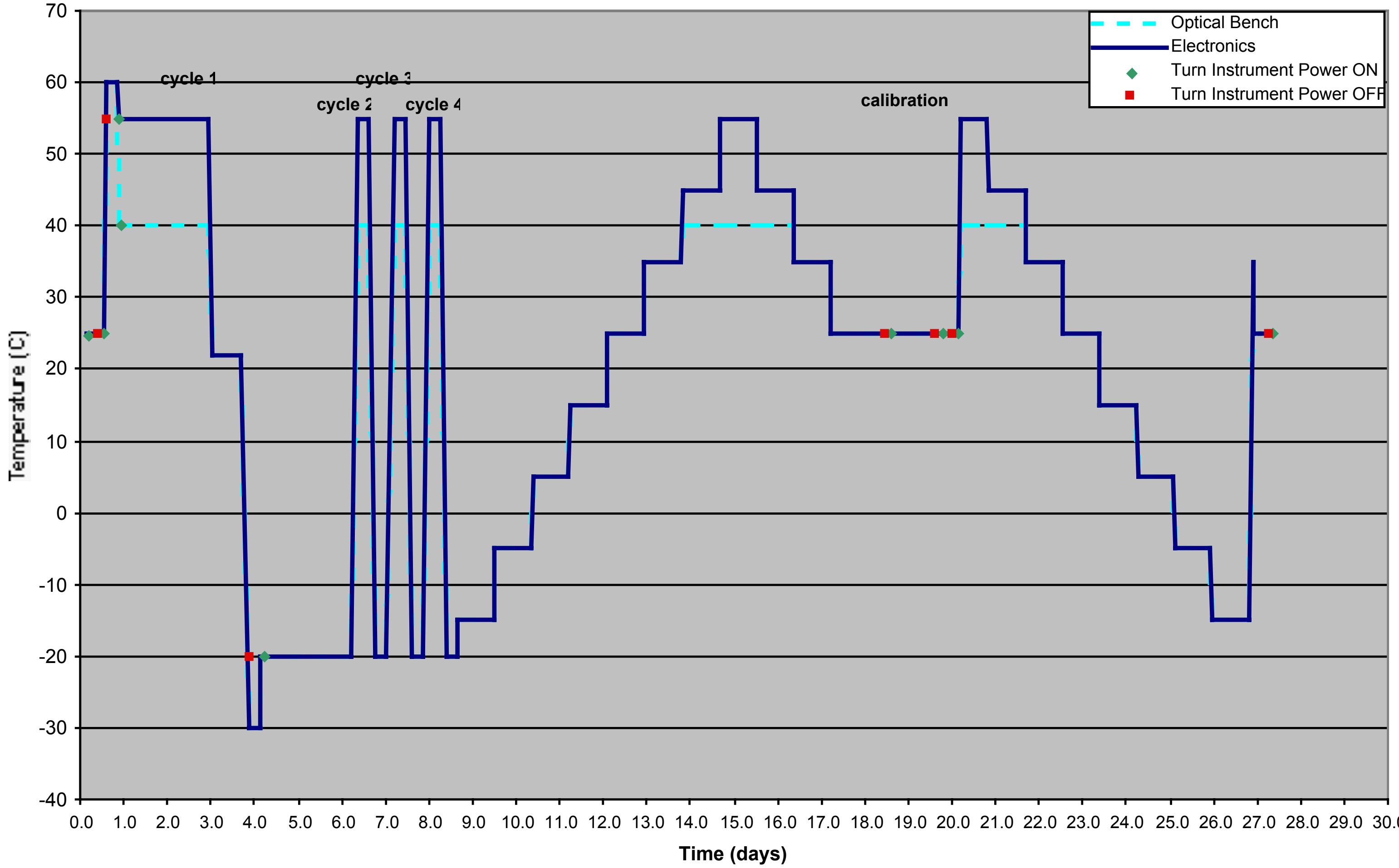
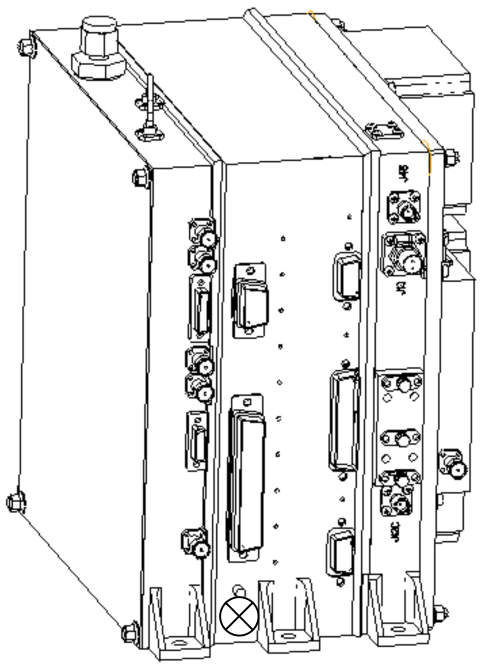


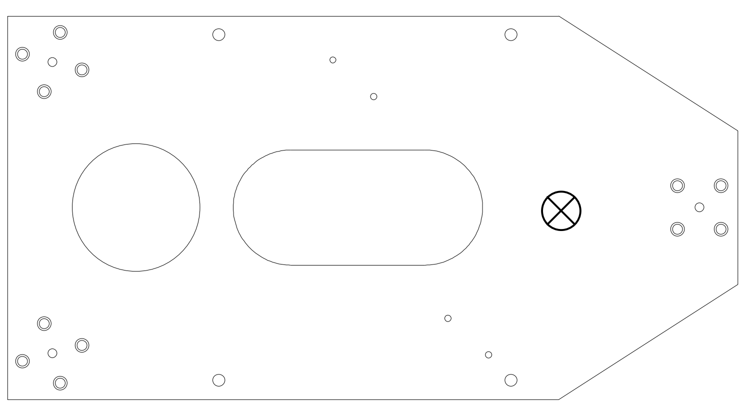
Figure 1 Thermal/Vacuum Test Profile

Figure 2 Sensor Backend Electronics Unit Temperature Reference Point



⊗ = Temperature Reference Point

Figure 3 Sensor Unit Temperature Reference Point



⊗ = Temperature Reference Point

Table 2 Temperature Ranges

Unit	Non-Operating Range		Operating Range	
	Min	Max	Min	Max
Sensor Unit	- 30 °C	+ 60 °C	- 20 °C	+ 40 °C
Sensor Backend Electronics Unit	- 30 °C	+ 60 °C	- 20 °C	+ 55 °C
Electronics Unit	- 30 °C	+ 60 °C	- 20 °C	+ 55 °C
Ultrastable Oscillator	- 30 °C	+ 60 °C	- 20 °C	+ 55 °C

The temperature tolerances are:

For the maximum Temperature: +3/-0 deg C
For the minimum Temperature: +0/-3 deg C

4.3 Temperature Rate of Change

The rate of change will be ≤ 20 degrees C / hour.

4.4 Thermal Cycles

The total number of thermal cycles (non-calibration) will be 4. The instrument shall be operating during the temperature cycles.

4.5 Temperature Stabilization and Duration for Thermal Cycles

Temperature stabilization is based on the temperature at the temperature reference point. Time at test temperature is counted from the end of the stabilization period.

Temperature stabilization is reached when the temperature rate of change at the temperature reference point is less than 5 degrees C during a time period of 1 hour. After temperature stabilization, the instrument will remain at each extreme of temperature for a minimum of 4 hours.

4.6 Vacuum Level

The vacuum during test performance will be ≤ 7.5×10^{-6} Torr (10^{-3} Pa).

4.7 Test Set Up

The MIRO FM shall be mounted on or connected to heat exchanger plates simulating the spacecraft mounting surface and layout. The SU shall be bolted to a vertical section of an aluminum adapter plate and thermally strapped to a heat exchanger via thermal braids attached to the radiator struts. The SBEU, EU and USO shall be bolted directly to the horizontal surface of a heat exchanger. All units shall be mounted in conformance with the MICDs identified in Section 2.1 of this document. (See Figure 6 in Appendix C).

To provide appropriate calibration conditions, the following setup will also be in place:

Thermal braids will be attached to the MIRO cold load and attached to a separate thermal plate (provided by the Environmental Test Laboratory (ETL, Section 351) for cooling the load to < -50 ^{o}C. An absorber plate for microwave radiation will be placed in the field of view of the telescope.

Temperature monitoring in addition to that discussed in Section 4.2 of this document shall be provided by the ETL facility. Monitoring points are defined in Appendix C of this document.

4.8 Test Facility

Environmental Test Laboratory (Section 351) personnel shall be responsible for the thermal vacuum chamber in Building 144, Room 119.

5 Data Handling

5.1 Data Acquisition

All instrumentation data shall be permanently recorded on disk during the test.

Digital photographs of test set up shall be taken before and after each test.

All pertinent test data shall be retained until their disposition is determined by the MIRO Project Office.

5.2 Data reduction

Two types of data reduction shall take place.

The first type of data reduction shall demonstrate compliance with the EID-A requirements.

The Limited Functional Test data shall be analyzed and all the temperature sensor and pressure data shall be plotted.

The written Test Report shall present the photographs and plotted test data to summarize the tests conducted, the results of all performance obtained, the analysis of test data, observations and conclusions of test phase.

The second type of reduction shall cover the science calibration analysis. Details of this analysis are given the Calibration Plan.

5.3 Data archiving

Data shall be archived on CD-Rs from the EGSE. [Note: It is recommended that gold-on gold or gold/silver-on gold CD-Rs be used.] Calibration data shall be archived as described in the Calibration Plan.

6 Test Sequence

6.1 Detailed Test Sequence

The following is the detailed test sequence for the thermal vacuum test.

Day 1	Install in chamber and perform ambient (in air) Limited Functional Test
	Close chamber door and pumpdown
	Perform Limited Functional Test in vacuum at ambient temperature
	Transition to hot non-operational temperature
	Hot soak after temperature stabilization
	Transition to hot operational temperature
Day 2	Test at hot operational temperature
Day 3	Continue to test at hot operational temperature
Day 4	Transition to room temperature
	Test at room temperature
	Transition to cold non-operational temperature
Day 5	Cold soak after temperature stabilization
	Transition to cold operational temperature
	Test at cold operational temperature
Day 6	Continue test at cold operational temperature
Day 7	Continue test at cold operational temperature
	Start remaining thermal cycles

Day 8	Continue thermal cycles
Day 9	Finish thermal cycles Begin calibration
Day 10 - 19	Calibration Pause calibration at ambient temperature (downward temperature) Perform Limited Functional Test in vacuum at ambient temperature
Day 20	Break vacuum. Perform ambient (in air) Limited Functional Test Reconfigure instrument and chamber for additional calibration
Day 21	Perform ambient (in air) Limited Functional Test Close chamber door and pumpdown Perform Limited Functional Test in vacuum at ambient temperature Transition to hot calibration temperature
Day 21 – 26	Calibration
Day 27	Finish Calibration Heat to above ambient temperature and drift to ambient
Day 28	Perform Limited Functional Test in vacuum at ambient temperature Break vacuum. Perform ambient (in air) Limited Functional Test Remove instrument from chamber
Day 29 - 30	Contingency days

6.2 Description of Functional and Calibration Tests

Both functional and calibration tests will be performed while MIRO is going through its thermal vacuum test profile. Brief description of each are contained below. Detailed procedures for accomplishing these tests are contained in the MIRO FM Thermal Vacuum Test Procedures document.

6.2.1 Functional Tests

The MIRO FM Thermal Vacuum Procedure (RO-MIR-PR-0054) will be used for the thermal vacuum tests. Some post test processing may be required for verification. Examples of the test types are listed below.

- Functional Tests
- Telemetry output verification
- Command input verification
- Calibration mechanism movement
- Continuum and /or Spectral data received, as appropriate for each power mode
- Power application on redundant interface circuit
- Data receipt on redundant interface circuit
- Measurements:

- Total power draw in each power mode
- Total current draw in each power mode
- Temperature of all units in non-operational state at the TRP in each power mode
- Temperature of all units in operational state(s) at the TRP in each power mode

6.2.2 Calibration Tests

The MIRO Calibration Plan (RO-MIR-PL-0025) contains a description of all calibrations to be performed for the MIRO instrument. The MIRO FM Thermal Vacuum Calibration Test Procedure (RO-MIR-PR-xxxx) will be followed.

7 Quality Assurance

Quality Assurance personnel shall be required to witness test preparation, installation in the chamber, changes to cabling during the chamber break, and removal of the instrument from the chamber. All instrumentation data shall be recorded to document the environment the hardware is exposed to. Assembly and Inspection Data sheets shall be used to document the test setup and shall become part of the data package for future reference.

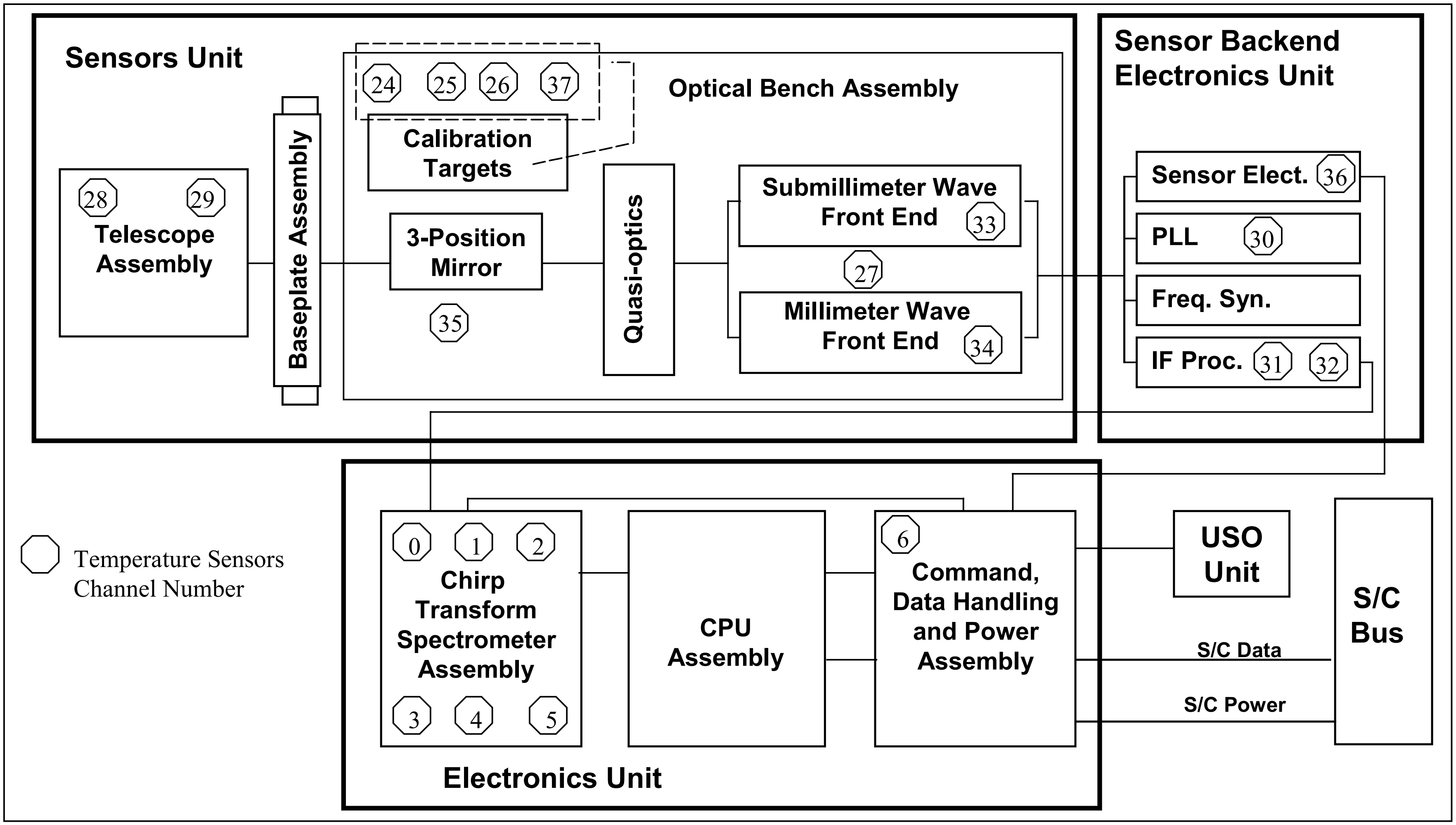
APPENDIX A MIRO Housekeeping Variables

Table 3 Yellow and Red Alarm Limits for Internal MIRO Variables

Channel Number	Variable Name	Description	Units	Yel_lo	Yel_hi	Red_lo	Red_hi
0	Spect_T1	CTS	C	-20	70	-25	75
1	Spect_T2	CTS	C	-20	70	-25	75
2	Spect_T3	CTS	C	-20	70	-25	75
3	Spect_T4	CTS	C	-20	70	-25	75
4	Spect_T5	CTS	C	-20	65	-25	70
5	Spect_T6	CTS	C	-20	65	-25	70
6	EU_Temp	Temp - EU Pwr Bd	C	-20	55	-25	65
7	ECal_Temp	Temp Circuit Monitor	DN	3295	3335	3285	3345
8	+5V_EU	EU +5 Voltage	V	4.7	5.3	4.5	5.5
9	+12V_ EU	EU +12 Voltage	V	11.5	12.5	11	13
10	-12V_ EU	EU -12 Voltage	V	-12.5	-11.5	-13	-11
11	+3.3V_ EU	EU +3.3 Voltage	V	3.1	3.5	2.9	3.7
12	+24V_ EU	EU +24 Voltage	V	23	25	22	27
13	+5VAna_ EU	EU +5 Analog Voltage	V	4.7	5.3	4.5	5.5
14	+5V_Curr_EU	EU +5 Current	A	0.1	3	0	3.3
15	+12V_Curr_EU	EU +12 Current	A	0.1	0.8	0	0.9
16	-12V_Curr_EU	EU -12 Current	A	0.01	0.11	0	0.113
17	+24VAna_Curr_EU	EU +24 Current	A	0.1	0.8	0	0.83
18	+3.3V_Curr_EU	EU +3.3 Current	A	0.1	2	0	3
19	+5VAna_Curr_EU	EU +5 Analog Current	A	0.1	0.8	0	1
20	TLM_Heating	USO Heater Voltage	V	1	2.2	0	4.9
21	TLM_RF	USO RF Voltage	V	1.5	4.5	0	4.9
22	CTS_V_Ana_1	CTS	V	2.45	2.6	2.4	2.65
23	CTS_V_Ana_2	CTS	V	2.45	2.6	2.4	2.65
24	Cold_Load1_Temp	Temp 1 - Cold Load	C	-100	50	-120	60
25	Cold_Load2_Temp	Temp 2 - Cold Load	C	-100	50	-120	60
26	Warm_Load1_Temp	Temp 1 - Warm Load	C	-20	55	-25	60
27	OB_Temp	Temp – Optical Bench	C	-20	35	-25	40
28*	Telescope1	Temp – Primary	C	-100	50	-120	60
29*	Telescope2	Temp - Secondary	C	-100	50	-120	60
30	PLL_Temp	Temp - PLL	C	-20	55	-25	60
31	IFP_DET_Temp	Temp – IFP Detector	C	-20	55	-25	60
32	IFP_AMP_Temp	Temp – IFP Amplifier	C	-20	55	-25	60
33	SMM_LO_GUNN	Temp – SMM Gunn	C	-20	45	-25	65
34	MM_LO_GUNN	Temp – MM Gunn	C	-20	35	-25	45
35	Motor_Temp	Temp – Cal Motor	C	-20	100	-25	120
36	Sen_El	Temp – SU Pwr Bd	C	-20	55	-25	60
37	Warm_Load2_Temp	Temp 2 – Warm Load	C	-20	55	-25	60
38	Cal_Temp_Low	Load Circuit Monitor	DN	440	500	430	560
39	Cal_Temp_High	Load Circuit Monitor	DN	3700	3850	3650	3900
40	+5V_SBEU	SBEU +5 Voltage	V	4.7	5.3	4.5	5.5
41	+12V_1_SBEU	SBEU +12 Voltage	V	11	12.5	10.8	13

Channel Number	Variable Name	Description	Units	Yel_lo	Yel_hi	Red_lo	Red_hi
42	+12V_2_ SBEU	SBEU +12 S Voltage	V	11.5	12.5	11	13
43	-12V_ SBEU	SBEU -12 T Voltage	V	-12.5	-10.8	-13	-10.3
44	+5V_Curr_ SBEU	SBEU +5 Current	A	0.45	0.6	.05	0.7
45	+12V_Curr _1_ SBEU	SBEU +12 T Current	A	0.125	0.5	.05	0.6
46	+12V_Curr _2_ SBEU	SBEU +12 S Current	A	0.7	0.8	0.25	0.85
47	-12V_Curr _ SBEU	SBEU -12 Current	A	0.125	0.2	0.05	.25
48	MM_GUNN_Curr	MM Gunn Current	mA	150	160	145	165
49	SMM_Mult_Curr	SMM Multiplier Current	mA	0	3	0	5
50	SMM_PLL_ERR	Smm PLL Phase Error	V	1.5	2.75	1.25	3.0
51	FS1_ERR	FS1 Phase Error -2182	V	1.0	3.5	0.5	4.0
52	FS2_ERR	FS2 Phase Error -7147	V	1.0	3.5	0.5	4.0
53	FS3_ERR	FS3 Phase Error -7728	V	1.0	3.5	0.5	4.0
54	SMM_PLL_GUNN_Curr	SMM Gunn Current	mA	150	160	145	165
55	SMM_PLL_IF_PWR	PLL IF Power	V	8.2	9.3	8.0	9.5

Figure 4 MIRO Temperature Sensor Locations



APPENDIX B Ancillary Temperature Monitoring

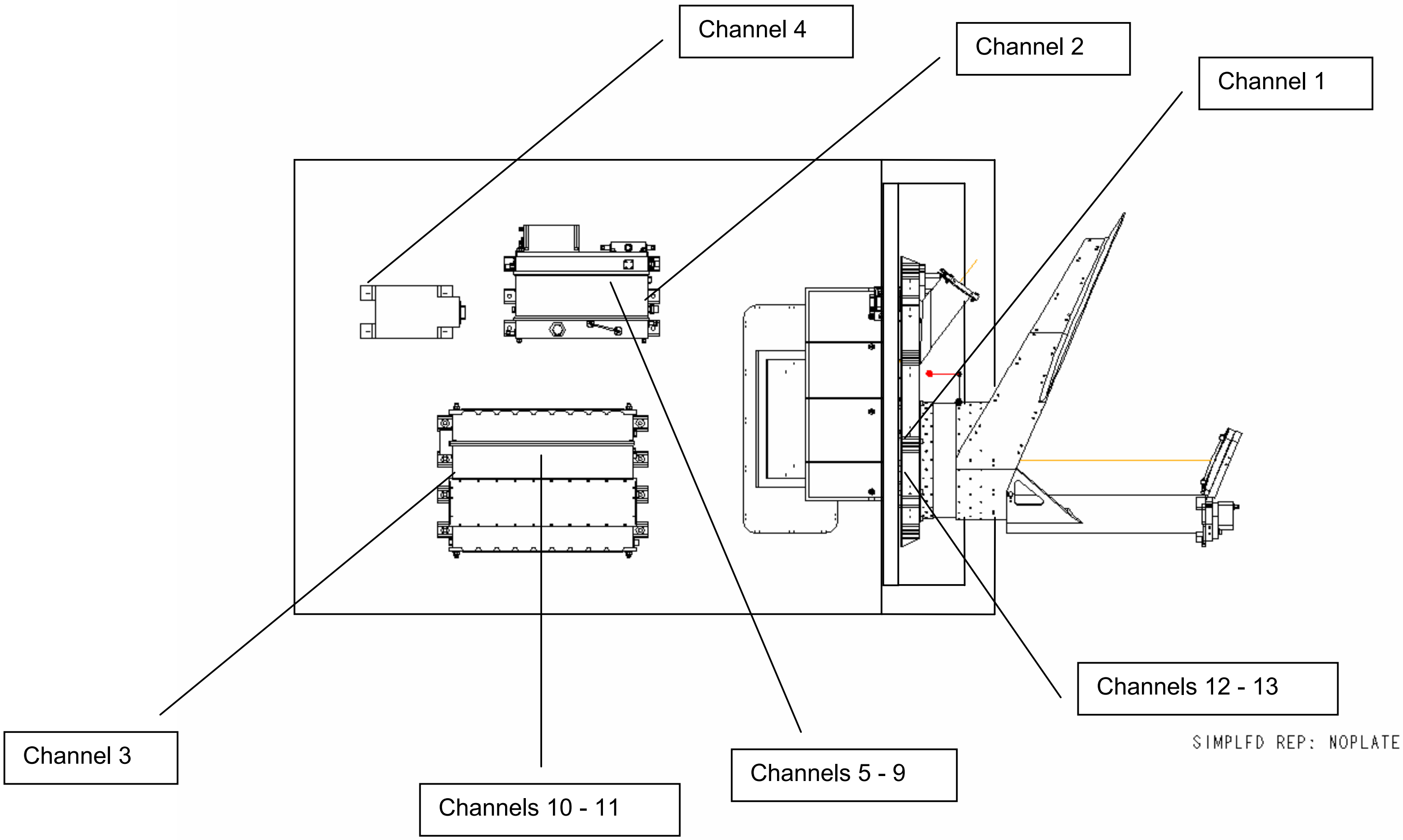
Table 4 Ancillary Temperature Monitoring, Instrument Power OFF

Channel	Thermocouple Name	Units	Yel_lo	Yel_hi	Red_lo	Red_hi
1	Optical Bench	C	-25.0	+55.0	-28.0	+58.0
2	SBEU Electronics Interface	C	-25.0	+55.0	-28.0	+58.0
3	EU Electronics Interface	C	-25.0	+55.0	-28.0	+58.0
4	USO Interface	C	-25.0	+55.0	-28.0	+58.0
5	SBEU A1, Triple Supply *	C	-25.0	+55.0	-28.0	+58.0
6	SBEU A2, +12 Power Supply	C	-25.0	+55.0	-28.0	+58.0
7	SBEU U23, -5V Regulator	C	-25.0	+55.0	-28.0	+58.0
8	SBEU U5, Gunn Bias	C	-25.0	+55.0	-28.0	+58.0
9	SBEU U8, LNA Bias	C	-25.0	+55.0	-28.0	+58.0
10	EU-A A1, 24V &5V Regulator	C	-25.0	+55.0	-28.0	+58.0
11	EU-A A2, ±12V & 5V Regulator	C	-25.0	+55.0	-28.0	+58.0
12	mm RFE LNA	C	-25.0	+55.0	-28.0	+58.0
13	submm RFE LNA	C	-25.0	+55.0	-28.0	+58.0

Table 5 Ancillary Temperature Monitoring, Instrument Power ON

Channel	Thermocouple Name	Units	Yel_lo	Yel_hi	Red_lo	Red_hi
1	Optical Bench	C	-15.0	+35.0	-18.0	+38.0
2	SBEU Electronics Interface	C	-15.0	+50.0	-18.0	+53.0
3	EU Electronics Interface	C	-15.0	+50.0	-18.0	+53.0
4	USO Interface	C	-15.0	+50.0	-18.0	+53.0
5	SBEU A1, Triple Supply *	C	-15.0	+90.0	-18.0	+100.0
6	SBEU A2, +12 Power Supply	C	-15.0	+90.0	-18.0	+100.0
7	SBEU U23, -5V Regulator	C	-15.0	+90.0	-18.0	+100.0
8	SBEU U5, Gunn Bias	C	-15.0	+90.0	-18.0	+100.0
9	SBEU U8, LNA Bias	C	-15.0	+90.0	-18.0	+100.0
10	EU-A A1, 24V &5V Regulator	C	-15.0	+90.0	-18.0	+100.0
11	EU-A A2, ±12V & 5V Regulator	C	-15.0	+90.0	-18.0	+100.0
12	mm RFE LNA	C	-15.0	+45.0	-18.0	+55.0
13	submm RFE LNA	C	-15.0	+55.0	-18.0	+60.0

Figure 5 MIRO Ancillary Temperature Monitoring Points



APPENDIX C Environmental Test Facility Temperature Monitoring

Table 6 Temperature Monitoring Points by the ETL Facility

Channel	Thermocouple Name	Units	Yel_lo	Yel_hi	Red_lo	Red_hi
1	Large Thermal Plate	C	-100	80	-110	90
2	Small Thermal Plate	C	-100	80	-110	90
3	Cold Load Thermal Plate	C	-100	-50	-110	-40
4	Target Temp 1 (Center)	C	-25.0	+55.0	-30.0	+60.0
5	Target Temp 2 (UR Corner)	C	-25.0	+55.0	-30.0	+60.0
6	Target Temp 3 (UL Corner)	C	-25.0	+55.0	-30.0	+60.0
7	Target Temp 4 (LR Corner)	C	-25.0	+55.0	-30.0	+60.0
8	Target Temp 5 (LL Corner)	C	-25.0	+55.0	-30.0	+60.0
9	Optical Bench	C	-25.0	+55.0	-28.0	+58.0
10	SBEU Electronics Interface	C	-25.0	+55.0	-28.0	+58.0
11	EU Electronics Interface	C	-25.0	+55.0	-28.0	+58.0
12	USO Interface	C	-25.0	+55.0	-28.0	+58.0

Figure 6 Environmental Test Facility Temperature Monitoring Points