MIRO Calibration Procedure for FM Thermal Vacuum Test

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DOCUMENT CHANGE LOG

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1	16 Apr 2001	All	Initial Release	
2	24 May 2001		Issue 1, Rev 1	Updated linearity procedure and IF sweep procedure

CONTENTS

List of Figures

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
LNA	Low Noise Amplifier (mm or smm)
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 Objective

The objective of the Thermal Vacuum Calibration is to provide calibration parameters in vacuum and as a function of temperature. Emphasis is on those parameters that cannot be obtained under ambient conditions.

2 Test Approach

2.1 Temperature Profile

For Calibration the temperature will be stepped in 10C increments from –15C to +55C as shown in the FM Thermal Vacuum Test Plan (RO-MIR-PL-0026). The CTS heaters need to be set at each temperature a minimum of 20C above the interface temperature as shown in the Table below.

CTS Warmup and Heater Control Telecommand Table

TV temperature, C	Power (always high) Warmup and Heater	Warmup Heater temperature	Heater Control temperature
-15	0	1(=10 C)	2(=20 C)
-5	0	2(=20 C)	3(=30 C)
5	0	3(=30 C)	4(=40 C)
15	0	4(=40 C)	5(=50 C)
25	0	5(=50 C)	6(=60 C)
35	0	6(=60 C)	7(=70 C)
45	0	7(=70 C)	7(=70 C)
55	0	7(=70 C)	7(=70 C)

2.2 Instrument Modes

The instrument has several science data taking modes.

- Millimetre-wave continuum
- Submillimeter wave continuum
- Dual continuum
- CTS/Submillimeter wave continuum
- CTS-dual continuum

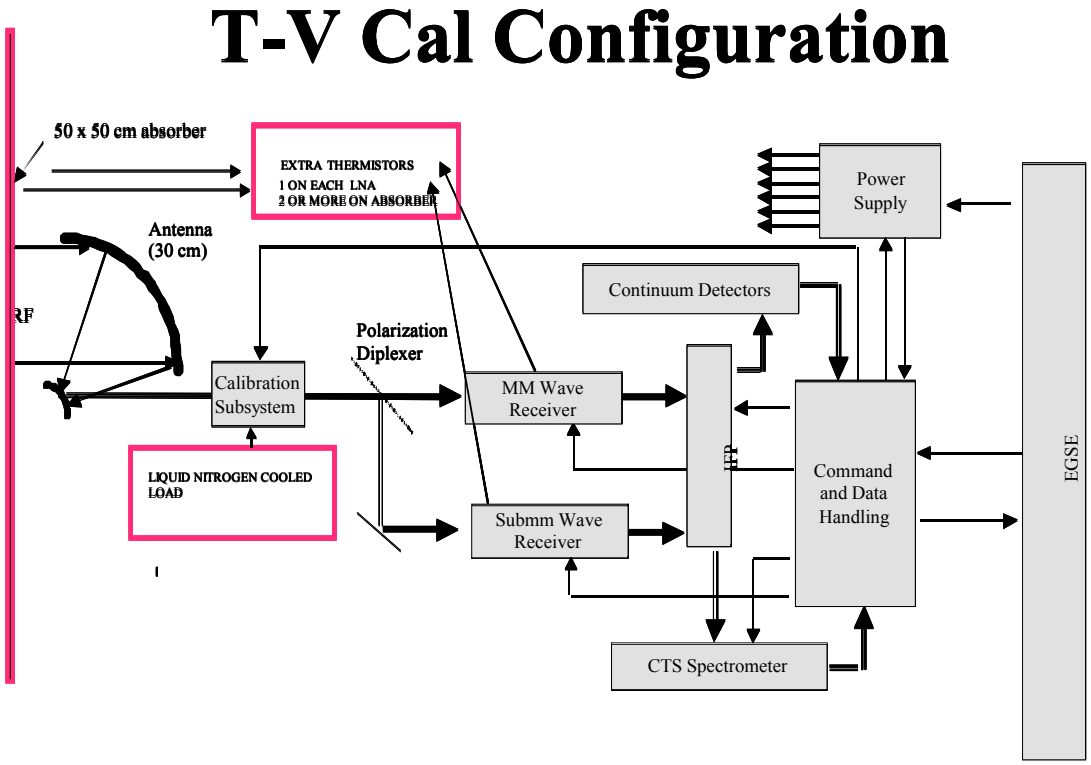
Each mode is characterized by a different power loading and in general operates at different temperatures. Separate function tests will test the functionality of each of these modes. Tests carried out in this procedure have been designed to operate either in the Dual continuum mode or the CTS/Dual continuum mode. The Dual continuum mode tests the continuum channels with frequency switching turned off. The CTS/dual continuum mode tests the spectroscopic capability and the continuum mode with frequency switching turned on. Frequency switching introduces a 5 sec periodicity in the data that is not present when it is off.

In addition to the normal data taking modes, it is possible to command the millimeter- and submillimeter-wave Low Noise Amplifiers (LNAs) to the Off mode. In the Off mode, the zero input level backend electronics noise can be determined. We also plan to test various warm up rates and modes such as the CTS Warm up mode.

2.3 Instrument Configuration

For the first part of the calibration, the instrument will be configured as for flight. At least one additional thermistor will be placed on each LNA (mm and smm). The LNA can be powered off and on under software control. The calibration mirror can be stepped incrementally in the forward and backward directions under computer control as well as moving to directly to the space, hot load, and cold load positions. The instrument cold load will be cooled with a liquid nitrogen cooled cold plate. A large (approximately 50 x 50 cm) absorbing load (Space qualified Tessalating TeraHertz RAM) for the 100 to 1000 GHz region will be placed in front of the MIRO telescope. Five thermistors will be imbedded in the load to provide the temperature of the absorber. The instrument configuration is shown in Figure 1.

Figure 1: Thermal Vacuum Configuration



After the first series of calibration tests are completed, the vacuum chamber will be opened and test cables attached to instrument test ports as shown in Figure 1. The nominal configuration is shown in Figure 2. Each special test will instrument the test ports in different ways.

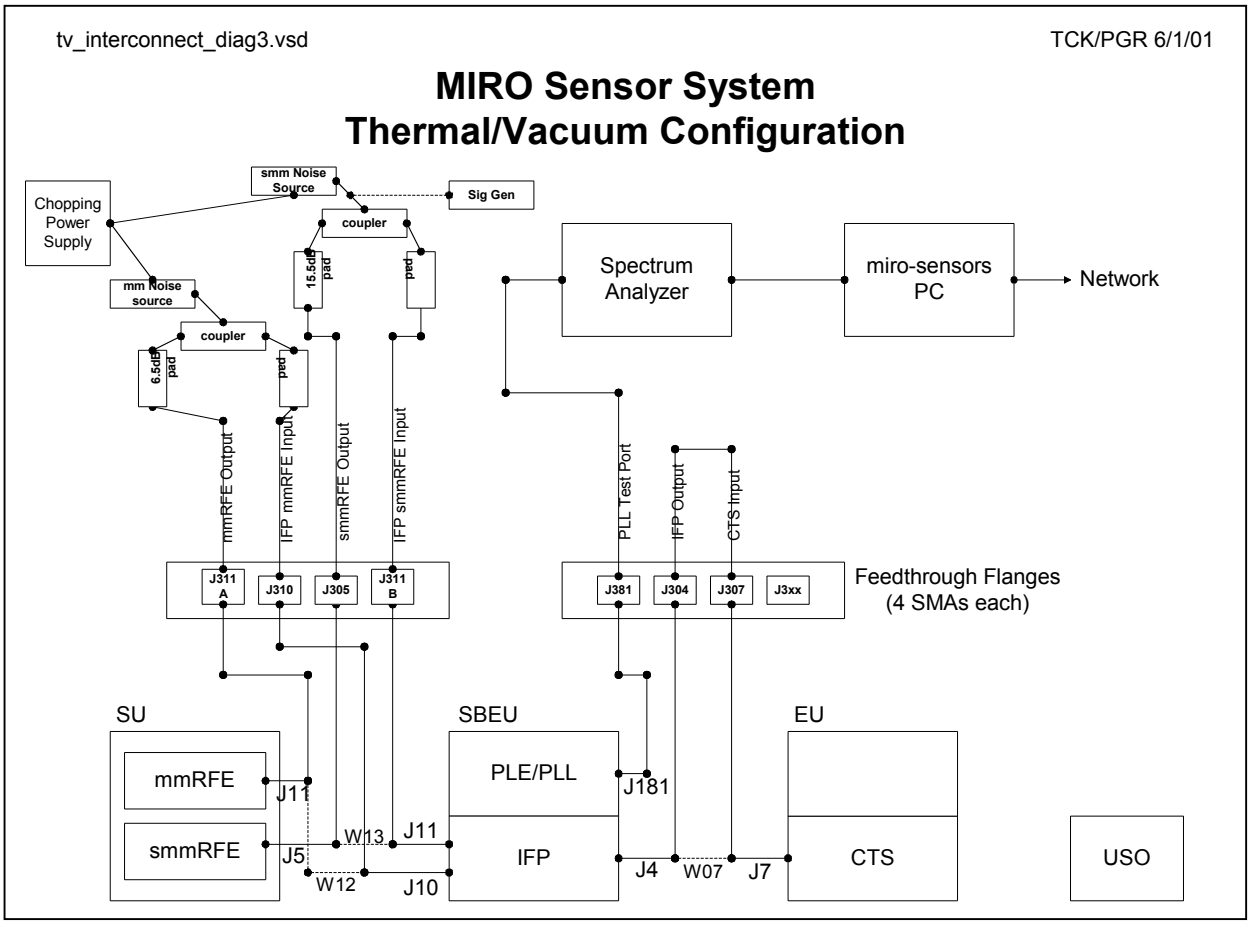


Figure 2: Nominal Recabling of instrument for special tests.

3 Tests with Instrument in Flight Configuration

The following tests will be carried out with the instrument in the flight configuration using instrument commands.

1. USO Warmup Time and Stability
2. CTS Warmup Time
3. CTS/dual Mode System Stabilization Time
4. CTS/dual Mode Receiver Noise Temperature and Gain
5. Phase Lock Performance Verification
6. IF Noise Temperature
7. CTS/dual Mode System Stability
8. Dual Continuum Mode System Stabilization Time

9. Dual Mode Receiver Noise Temperature and Gain
10. Dual Mode System Stability
11. Cold Load Characterization

4 Special tests

4.1 Noise Figure of the IFP

The objective of this test is to measure the contribution to the system noise temperature of the IFP.

This test is operated in CTS/Dual continuum mode.

Record Trace A/B on spectrum analyser as below.

The test ports are configured as follows:

Connector No.	Signal Name	Trace A, “LNA on”	Trace B, “LNA off”
J311A	mm RFE IF out:	nominal	nominal
J310	IFP mm IF in:	nominal	nominal
J305	smm RFE IF out:	nominal	nominal
J311B	IFP smm IF in:	nominal	nominal
J381	PLL Test Port:	nominal	nominal
J304	IFP out:	spectrum analyser	spectrum analyser
J307	CTS in:	termination	termination
J3xx	Spare:	nominal	nominal

Use the following settings for spectrum analyzer (stored in Recall, State 2):

Press “Recall” button
Press “Recall State” menu button
Press “State 2” menu button

Use these steps to capture trace A/B on spectrum analyzer

Turn LNA Off
Press “Trace” button
Press “Trace A/B” menu button to toggle to “B”
Press “Write Clear B” menu button
Press “View B” menu button
Press “Trace A/B” menu button to toggle to “A”
Turn LNA On
Record spectrum on computer

Use these steps to record spectra on computer

Doubler Click on BenchLink icon to start program if not started
Click on “Trace Data”
Click on “New…”
Click on “Select All” (Traces A + B)
File
Save
Path: My Computer\D:\MIRO\Flight\TV_testing\TVxxxx.tdx
Write filename in logbook

4.2 Noise Figure of the CTS

The objective of this test is to measure the contribution to the system noise temperature of the CTS.

This test is operated in CTS/Dual continuum mode.

Trigger an Instrument calibration in each of the configurations below. Record the IFP output spectrum on the spectrum analyser in the “IFP Off” configuration.

The test ports are configured as follows:

Connector No.	Signal Name	Spectrum, “IFP On”	Spectrum, “IFP Off”
J311A	mm RFE IF out:	nominal	nominal
J310	IFP mm IF in:	nominal	nominal
J305	smm RFE IF out:	nominal	nominal
J311B	IFP smm IF in:	nominal	nominal
J381	PLL Test Port:	nominal	termination
J304	IFP out:	nominal	spectrum analyser (Recall, State 2)
J307	CTS in:	nominal	termination
J3xx	Spare:	nominal	nominal

4.3 IF Frequency Sweep Test

The objective of this test is to measure the frequency response of the instrument with an input at its 1st IF. The input will be a CW of -66 dBm (~1 Mcnt in one CTS channel) at the IFP smmRFE input injected via a coupler at the following “IFP smm input” frequencies and triggering a calibration.

IFP smm input [GHz]	IFP output [GHz]	Output Filter	CTS [chan]

5.753	1.389	FL1	2937
5.877	1.270	FL7	228
9.667	1.425	FL3	3759
9.685	1.407	FL3	3344
10.791	1.301	FL4	932
13.455	1.363	FL2	2342
15.137	1.339	FL6	1808
16.338	1.320	FL5	1365

This test is operated in CTS/Dual continuum mode.

The test ports are configured as follows:

Connector No.	Signal Name	
J311A	mm RFE IF out:	nominal
J310	IFP mm IF in:	nominal
J305	smm RFE IF out:	nominal attenuation
J311B	IFP smm IF in:	Sig Gen on smm coupler
J381	PLL Test Port:	nominal
J304	IFP out:	nominal
J307	CTS in:	nominal
J3xx	Spare:	nominal

4.4 Linearity in CTS/Dual Mode

The objective of this test is to measure the linearity of the mm continuum channel, smm continuum channel, and CTS spectroscopic channels when operated in spectroscopic mode with CTS on and frequency switching on.

This test is operated in CTS/Dual continuum mode.

Chopped Noise Source Setup: Configure Wavetek model 23 function generator for 0.1-0.5 Hz, 0-6V square wave. Turn off function generator. On back panel of HP-E3615A power supply, connect function generator output to “CV” + and – terminals, and slide “CV” switch to remote mode. Connect LNA to supply output. While monitoring power supply output on oscilloscope, turn on function generator and power supply. Output should be 0-12V square wave. This setup will turn the noise source on and off at a 50% duty cycle.

Inject chopped noise sources through couplers on each of the RFE inputs to the IFP and at each of the following settings of attenuation trigger an instrument calibration:

	smm attenuator (dB)	mm attenuator (dB)

high RF power	13.5	4.5
nominal	15.5	6.5
low RF power	17.5	8.5

The test ports are configured as follows:

Connector No.	Signal Name	
J311A	mm RFE IF out:	mm attenuator
J310	IFP mm IF in:	mm noise source on mm coupler
J305	smm RFE IF out:	nominal
J311B	IFP smm IF in:	smm attenuator
J381	PLL Test Port:	smm noise source on smm coupler
J304	IFP out:	nominal
J307	CTS in:	nominal
J3xx	Spare:	nominal

4.5 Linearity in Dual Continuum Mode

The objective of this test is to measure the linearity of the mm continuum channel and smm continuum channel when operated in continuum mode with frequency switching off.

This test is operated in Dual continuum mode. See Section 4.4 for Chopped Noise Source description.

Inject chopped noise sources through couplers on each of the RFE inputs to the IFP and at each of the following setting of attenuators trigger an instrument calibration:

	smm attenuator (dB)	mm attenuator (dB)
high RF power	13.5	4.5
nominal	15.5	6.5
low RF power	17.5	8.5

The test ports are configured as follows:

Connector No.	Signal Name	
J311A	mm RFE IF out:	mm attenuator
J310	IFP mm IF in:	mm noise source on mm coupler
J305	smm RFE IF out:	nominal
J311B	IFP smm IF in:	smm attenuator
J381	PLL Test Port:	smm noise source on smm coupler
J304	IFP out:	nominal

J307	CTS in:	nominal
J3xx	Spare:	nominal

4.6 LO lock and Frequency Switching Test

The objective of this test is to verify that the LO remains locked and the frequency switching is clean as a function of temperature.

This test is operated in CTS/Dual continuum mode.

Record these spectra from the PLL/PLE Test Port as below capturing both nominal frequencies (1598.0 MHz and 1600.5 MHz) (center/span):

1598/300
1598/30
1598/3

The test ports are configured as follows:

Connector No.	Signal Name	
J311A	mm RFE IF out:	nominal
J310	IFP mm IF in:	nominal
J305	smm RFE IF out:	nominal
J311B	IFP smm IF in:	nominal
J381	PLL Test Port:	Spectrum analyser
J304	IFP out:	nominal
J307	CTS in:	nominal
J3xx	Spare:	nominal

Use the following settings for spectrum analyzer (stored in Recall, State 0):
Press “Recall” button
Press “Recall State” menu button
Press “State 0” menu button
Press “SPAN” button
Enter desired Span on the key pad followed by the units

5 Detailed Test Procedures

5.1 Test Sequence To Be Repeated at Each Temperature with Instrument in Flight Configuration

The test sequence is given in the Table below. Each step, along with the time it occurs shall be recorded in the instrument logbook. The total test sequence takes 16 hours. A calibration is performed at 30 minute intervals, including a calibration with the millimeter-wave and submillimeter-wave LNA off. Commands that need to be entered

are followed by a "/".

Lapsed Time (hr:min)	duratui on (min)	Command / Activity	Applicable Tests and Parameters
0:0	0	/assume instrument starts in Engr. mode	Cold start from engineering mode
0:0	30	USO warmup mode /	USO Warmup Time Test
0:30	30	CTS warmup mode,Heater=0(high),T=1(10C) / At eact temperature level change, change temperature in accordance with following table	CTS Warmup Test:CTS remembers H & T Saw device warmup
1:00	0	CTS-dual mode/	
	15	/calibrate (automatic)	Calibrate and warm up IFP
1:15	1	mm LNA off, submm LNA off/	
1:20	4	CTS-dual mode /(force calibration)	IF Noise Temperature + dc offsets
1:25	1	mm LNA on, submm LNA on/	
	29	/Let CTS-dual Mode system stabilize	CTS-dual Mode Stabilization Time
1:55	35	CTS-dual mode/calibrate (automatic1)	Receiver Noise Temperature, stability and gain
2:30	35	CTS-dual mode/calibrate (automatic2)	Receiver Noise Temperature, stability and gain
3:05	35	CTS-dual mode/calibrate (automatic3)	Receiver Noise Temperature, stability and gain
3:40	35	CTS-dual mode/calibrate (automatic4)	Receiver Noise Temperature, stability and gain
4:15	35	CTS-dual mode/calibrate (automatic5)	Receiver Noise Temperature, stability and gain
5:50	35	CTS-dual mode/calibrate (automatic6)	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
6:25	35	CTS-dual mode/calibrate (automatic7)	CTS-dual Mode Receiver Noise Temperature
7:00	35	CTS-dual mode/calibrate (automatic8)	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
7:35	35	CTS-dual mode/calibrate (automatic9)	CTS-dual Mode Receiver Noise Temperature
8:10	35	CTS-dual mode/calibrate (automatic10)	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
8:45	35	CTS-dual mode/calibrate (automatic11)	
9:20	35	mm LNA off, submm LNA off	
9:55	5	CTS-dual mode (force calibration)	F Noise Temperature + dc offsets
10:00	1	mm LNA on, submm LNA on/	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
	29	/Let CTS-dual Mode system stabilize	
10:30	35	CTS-dual mode/calibrate (automatic12)	CTS-dual Mode Receiver Noise

			Temperature
11:05	30	CTS Heater Control,Heater =0(High),T=2(20C)/warm up At eact temperature level change, change temperature in accordance with following table	Test heater control
11:35	35	CTS-dual mode/calibrate (automatic)	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
12:10	35	CTS-dual mode/calibrate (automatic)	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
12:45	35	CTS-dual mode/calibrate (automatic)	CTS-dual Mode Receiver Noise Temperature
13:25	35	Dual continuum mode/	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
14:00	35	Dual continuum mode/	CTS-dual Mode Receiver Noise Temperature
14:35	35	Dual continuum mode/	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
15:10	1	Mm lna off, smm lna off/	CTS-dual Mode Receiver Noise Temperature
15:11	4	Dual continuum mode/ force calibration	Frequency Switching Verification, Phase Lock Loop Performance Verification, CTS-dual Mode System Stability Test
15:15	15	mm LNA on, submm LNA on/warm up	
15:30	30	Run Dual Continuum Mode	
16:00		Change temperature level	
		After new temperature level is achieved	
		Repeat this sequence -	
		Remember to increase the temperature setting For CTS warm up mode and CTS Heat mode	

5.2 Test Sequence To Be repeated at each temperature with the Instrument in the Test Port Configuration

Lapsed Time (hr:min)	duratuion (min)	Command / Activity	Applicable Tests and Parameters
0:00	0:00	/assume instrument starts in Engr. mode	Cold start from engineering mode
0:30	0:30	USO warmup mode /	USO Warmup Time Test

1:00	0:30	CTS warmup mode,Heater=0(high),T=1(10C) /	CTS Warmup Test:CTS remembers H & T
1:00	0:00	CTS-dual mode/	
1:15	0:15	/calibrate (automatic)	Calibrate and warm up IFP
1:16	0:01	mm LNA off, submm LNA off/	
1:20	0:04	CTS-dual mode /(force calibration)	IF Noise Temperature + dc offsets
1:21	0:01	mm LNA on, submm LNA on/	
1:50	0:29	/Let CTS-dual Mode system stabilize	CTS-dual Mode Stabilization Time
2:25	0:35	CTS-dual mode/calibrate (automatic1)	Receiver Noise Temperature, stability
1:00	1:00	carry out Noise Figure of IFP Procedure	Noise Figure of CTS
2:00	1:00	carry out Noise Figure of CTS Procedure	IF Frequency Sweep Test
3:00	1:00	carry out Spectroscopic Linearity Procedure	Linearity of Submm Spectroscopic and Continuum Systems
3:30	0:30	carry out LO Lock and Freq Switch Procedure	Verify LO lock and Frequency Switching
4:00	0:30	mode change /Dual mode	stabilize in Dual Cont. mode
4:01	0:01	mm LNA off, submm LNA off/	dc offsets and IF noise temperature
4:05	0:04	dual mode/(force calibration)	
4:06	0:01	mm LNA on, submm LNA on/	
4:35	0:29	/Let Dual Cont. Mode system stabilize	stabilize and noise temperature
5:35	1:00	carryout Dual Cont. Linearity procedure	Linearity of Continuum Systems w/o CTS
6:05	0:30	cmd to Engineering mode, let all data read out	read out data
		Change temperature level	