QRFH Compact Wideband Cryogenic Receiver
Test Plan, Test Procedure & Test Results Matrix

TEST PLAN

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1. INTRODUCTION

1.1 Purpose

This document presents the test procedures for the QRFH Compact receiver.

It details all the tests to be performed to demonstrate the compliance with the Technical Specifications.

The **verification method** indicated in the tables uses the codes defined as follows:

Code	Description
A	by **A**nalysis
AT	by **A**cceptance **T**est
CT	by **C**omponent level **T**est
D	by **D**esign
I	by **I**nspection

Table 1-1: Verification method codes

1.2 Applicable & Reference Documents

This section lists other documents which are referred to in the main body of this document. In cases when the document cited is listed without an issue number, revision number or date, then the reader should refer to the latest available issue.

1.2.1 Applicable Documents

AD 1 Callisto Proposal , Ref. PRP/685/3606 issue 1.0 dated 11th April 2016

1.2.2 Reference Documents

RD 1 User Manual, QRFH Compact Wideband Cryogenic Receiver, DOC/1704/3991

RD 2 Interface Control Document for Patriot 12m Telescope, ICD/1704/4068

RD 3 Interface Control Document for MTM Antenna, ICD/1704/4069

RD 4 Interface Control Document for InterTronic Solutions Telescope, ICD/1704/4070

RD 5 Interface Control Document for Vertex Antenna, ICD/1704/4071

RD 6 Cryo LNA Test Procedure, TST/1900/1453, issue 1

RD 7 Master Check list Compact QRFH, Excel File, v0.4, dated 31.Mar.2017

2. TEST PLAN

2.1 Introduction

Testing of the receiver will take place at various stages throughout the project. The main set of tests will be the final acceptance tests. However, testing during subsystem integration will also be undertaken. At the lowest level, component testing will take place as required in order to prove performance or to verify correction functionality of components prior to integration.

The diagram below shows the main steps of the Integration Validation and Test (IVT) phase.

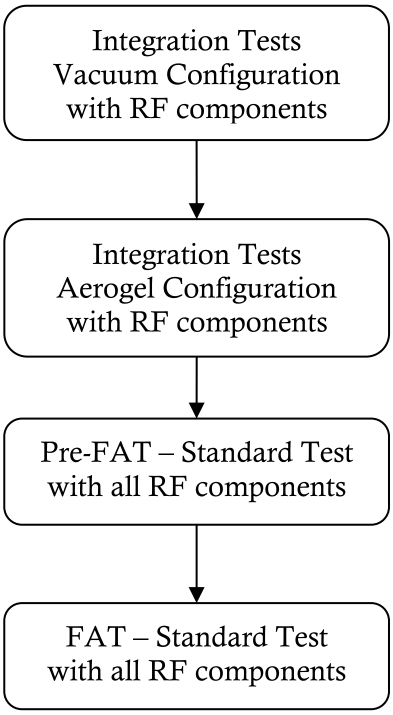

Figure 2-1: QRFH Compact Receiver IVT flow chart

2.2 Integration Tests

Several tests are performed at component level and sub-assemblies level during the integration process of the system. They are all detailed in RD 7.

The integration test session will take place after the assembly of the cryogenic Dewar and will serve to prove the correct function of the cryogenic equipment prior to integration of RF components and during first integration of RF components.

The following list is an outline of the main tests to be carried out on the Dewar assembled **without RF components**.

- Vacuum integrity (leak) test.
- Functional verification of thermometers.
- Time to cool the Dewar from 300 K to 75 K.
- Base temperatures.

The performance of the various RF components will be checked on table according to the manufacturer's specifications prior to integration inside the receiver.

The functionalities of the M&C system (hardware and software) will be tested during their respective integration.

2.3 Acceptance Testing

Acceptance testing will be undertaken in two stages:

- Pre-acceptance testing carried out by Callisto prior to the formal acceptance tests.
- Final acceptance testing carried out by Callisto with or without the witness from the customer.

Both the pre-acceptance and final acceptance tests will be executed in accordance with the generic Callisto test procedures for cryoLNAs (RD 6).

The acceptance testing will broadly follow these categories:

- Visual Inspections
- Functional Tests
- Performance Tests

The performance tests concerning RF measurements will be conducted using the generic LNA test procedure (RD 6) which describes the test methods which will be used for each test case as well as an analysis for test accuracy, were applicable. These RF tests will cover:

- Gain, Frequency Response, Gain Flatness, Pout 1dB
- Noise Temperature
- Output VSWR
- Noise Calibration operation (optional)
- Phase Calibration operation (optional)

2.3.1 M&C tests

The following tests will be carried out on the Receiver fully assembled at the Pre-FAT stage. Only some of these tests may be repeated at the FAT.

- Visual Inspections:
  - Hardware: Correct labelling of the receiver, drawers, connectors and cables
  - Hardware: Correct length of cables
  - Hardware: Measure of maximum power consumption (when all M&C units are switched on and the cooler is at maximum power, typically during initial cooldown)
  - Software: Correct display and update of status and parameters such as base temperature, remote/local mode, cooler status and summary of alarms on main tab
- Functional Tests
  - Software: Correct switching from remote to local control modes, from operating to maintenance mode as described in the user manual
  - Software: Correct logging of status and parameters in the log files as described in the user manual
  - Hardware and Software: Correct recovery from a mains power loss
  - Hardware and Software: Correct response to remote communication requests as described in the user manual

2.3.2 Vacuum & Thermal Tests

The following tests will be carried out on the Receiver assembled **with all the RF components and thermal insulations**, at the Pre-FAT stage. Only some of these tests may be repeated at the FAT.

- Pressure increase rate calculated over at least one hour: once the receiver is vacuum sealed, measure the pressure and record the time of the measure; wait at least one hour, pressure will increase inside the receiver; measure the pressure and record the time of the measure; apply the following calculation:

  $$Q = \frac{\Delta P \times V}{\Delta t}$$

  Where Q is the pressure increase rate in [mbar.l/s], V in [l] is the vacuum volume of the receiver estimated at 17 litres, ΔP is the pressure difference measured in [mbar] and Δt is the time difference between the two measures in [s]

- Cooldown time on cold head, LNA and feed base plate down to <100K and down to base temperature (i.e. when temperature is stable within ±1K over 1h in a temperature-stable environment)

- Base temperatures of the cold head, LNA, base of the feed and top of the feed
- Cooler electrical input power consumed at cryogenic base temperature on feed
- Cooler Compressor temperature at cryogenic base temperature on feed
- Ambient (Room) Temperature at cryogenic base temperature on feed
- Warmup time (no heaters) calculated from 100K up to 295K on lowest temperature

2.3.3 RF Performance Tests

2.3.3.1 Noise Temperature

The method used is also known as the hot/cold load method or Y factor method.

2.3.3.1.1 Measurement Theory

The receiver under test has a matched and calibrated "hot" noise load connected to its input and the receiver output noise power (P_h) is measured. The amplifier is then connected to a calibrated "cold" load and the output noise power (P_c) is measured. The ratio P_h /P_c is called the Y factor.
The effective noise temperature of the amplifier is calculated using the formula:

$$T_e = \frac{T_H - Y.T_C}{(Y-1)}$$

Where T_h is the hot load noise temperature in K
T_c is the cold load noise temperature in K
Y is the power ratio

2.3.3.1.2 Method

This method requires the use of a pair of special RF loads, which can be held in front of the cryogenic receiver input. One of these RF loads will be a room temperature and will act as a "hot" load. The other RF load will be cooled to liquid nitrogen temperature and will act as the "cold" load.

The NT test setup is shown below.

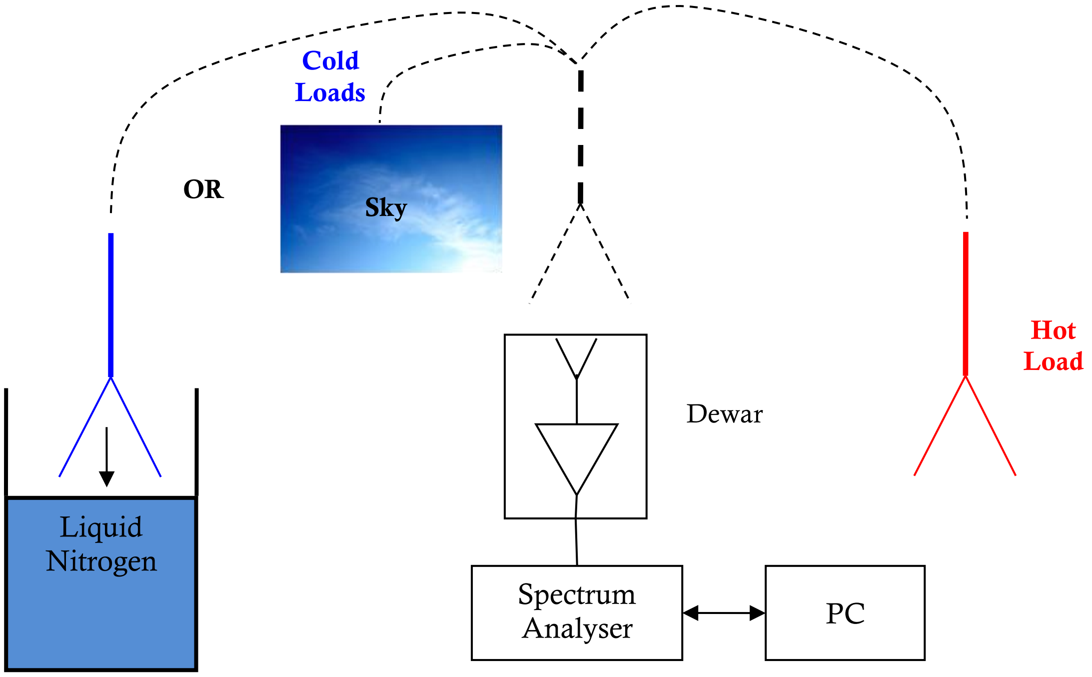

Figure 2-2 Configuration for NT measurement

Nitrogen Method

1. Adjust the spectrum analyzer parameter according to the DUT characteristics:
    a. Number of measurement points, start and stop frequencies are defined.
    b. Resolution bandwidth, Video Bandwidth and Sweep Time are optimized to increase the sensibility of the SA and ensure in the meantime a quick measurement time to keep the cold load at 77.36 K)
    c. Detected power levels should be greater than the noise floor to ensure a reliable and accurate measurement.
    d. Frequency Range= 2-14GHz
2. Configure the System on the Port X
3. Place in front of the DUT the "Hot" load and run a frequency swept to measure the power with the SA in dBm (Phot).
4. Place in front of the DUT the "Cold" load and run a frequency swept to measure the power with the SA in dBm (Pcold)
5. The Labview application will calculate and display the noise temperature automatically.
6. Repeat steps 2 to 4, two more times to have an average value of the NT.
7. Note the results in the Test Results Sheet.
8. Configure the System on Port Y
9. Repeat steps 3 to7

Sky Method

This is the same method as for the nitrogen one but the cold load is replace by a direct view of the Dewar feed horn to the clear sky.

1. With clear sky condition move the Dewar outside to point at zenith
2. Adjust the spectrum analyzer parameter according to the DUT characteristics:
    a. Number of measurement points, start and stop frequencies are defined.
    b. Resolution bandwidth, Video Bandwidth and Sweep Time are optimized to increase the sensibility of the SA
    c. Detected power levels should be greater than the noise floor to ensure a reliable and accurate measurement.
    d. Frequency Range= 2-14GHz
3. Configure the System on the Port X
4. Place in front of the DUT the "Hot" load and run a frequency swept to measure the power with the SA in dBm (Phot).
5. Remove the "Hot" load and run a frequency swept to measure the power with the SA in dBm (Pcold)
6. The Labview application will calculate and display the noise temperature automatically.
7. Repeat steps 2 to 4, two more times to have an average value of the NT.
8. Note the results in the Test Result Sheet.
9. Configure the System on Port Y
10. Repeat steps 3 to7

T Sky calculation

According to sky noise data given between 2GHz and 14GHz the Tcold seen by the receiver can be computed to 6K.

2.3.3.2 Gain and gain flatness

As the receiver has a free space it is not possible to make a direct measurement of the receiver gain.

The gain of the receiver has been extracted from the noise temperature measurement using the following formula:

$$G = \frac{P_{hot}}{(T_e - T_{hot})\times B\times k}$$

With:

- G = Gain of the receiver
- Phot = Power measure at the output of the receiver when the hot load is in front of the receiver

- Te = Noise temperature of the receiver
- Thot = Noise temperature of the hot load
- B = Bandwidth (Resolution Band Width set on the spectrum analyser)
- k = Boltzmann constant

Method

This is the same method as for the noise temperature measurement but only the output power of the receiver when the hot load is in front of the feed horn is necessary.

1. Adjust the spectrum analyzer parameter according to the DUT characteristics:
    a. Number of measurement points, start and stop frequencies are defined.
    b. Resolution bandwidth, Video Bandwidth and Sweep Time are optimized to increase the sensibility of the SA
    c. Detected power levels should be greater than the noise floor to ensure a reliable and accurate measurement.
    d. Frequency Range= 2-14GHz
2. Configure the System on the Port X
3. Place in front of the DUT the "Hot" load and run a frequency swept to measure the power with the SA in dBm (Phot).
4. Save the power measured by the spectrum analyser.
5. Repeat steps 3 to 4, two more times to have an average value of the NT.
6. Note the results in the Test Result Sheet.
7. Configure the System on Port Y
8. Repeat steps 3 to 6

2.3.3.3 Output VSWR

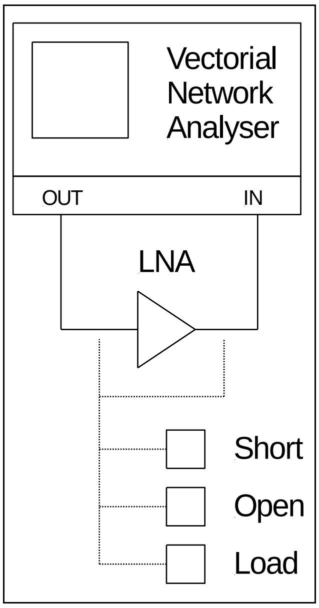

Figure 2-3: Test configuration for VSWR measurement

Method

1. Configure the frequency swept from 2 to 14GHz.
2. Configure the VNA in Return Loss measurement mode and process a calibration session on Port 1 with the Amplifier Under Test (AUT) replaced by a short circuit, an open circuit and then a Load.
3. Connect the Amplifier Under Test on Port X,
4. Check if there is any effect on the measurement if the main input (feed horn) is loaded or not with RF foam.
5. Plot Output Return Loss versus frequency.
6. Note the worst case return loss in the 2-14GHz bandwidth on the Test Results Sheet
7. Repeat steps 4 to 6 Port Y.

2.3.3.4 Gain via test input

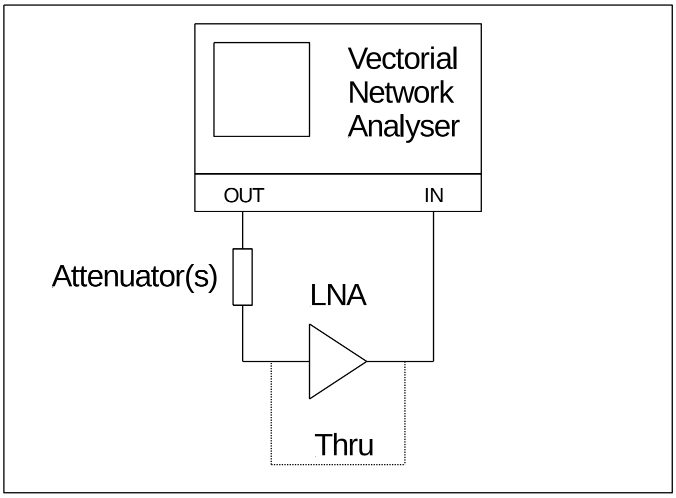

Figure 2-4: Test Configuration for Gain measurement via the test input

These parameters can be measured using a Vector Network Analyser. Configure the frequency swept from 2 to 14GHz.

Method

1. Configure the frequency swept from 2 to 14GHz.
2. Calibrate the VNA with test cables attached using the Calibration kit.
3. Connect VNA to Receiver Test Input and RF output Port X
4. Measure the minimum and maximum gain in the 2 to 14GHz bandwidth.
5. Check if there is any effect on the measurement if the main input (feed horn) is loaded or not with RF foam.
6. Note results on Test Result Sheet.
7. Repeat steps 3 to 6 for Port Y.

2.3.3.5 Noise calibration operation (optional)

This test is only performed on receiver with calibration box.

The aim of this test is to demonstrate the operation of the noise calibration circuit and not to make an accurate noise temperature measurement.

The purpose of this circuit is to inject two levels of noise in the QRFH receiver in order to do a noise measurement using the Y-factor method. The noise is generated by a noise diode and the level of noise is set using a variable attenuator. This noise signal is injected inside the QRFH feed by a probe antenna.

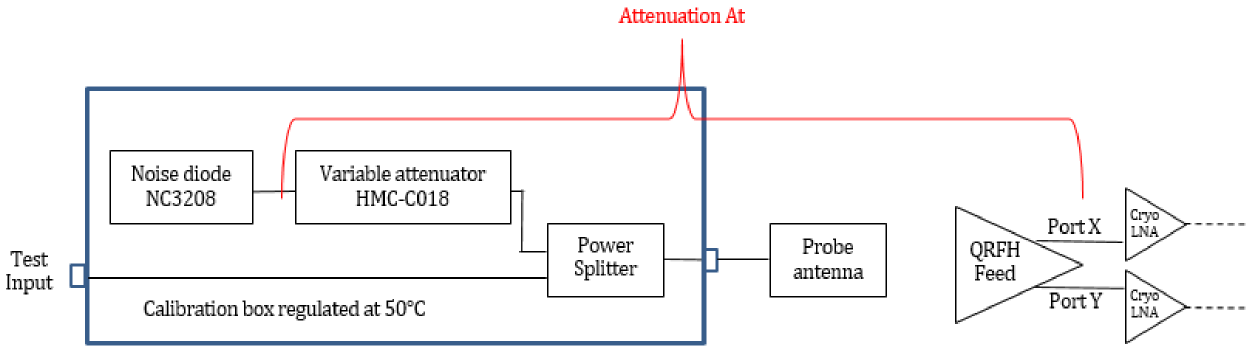

Figure 2-5: Noise calibration circuit

The two levels of noise have been defined by UTAS Tn1=10K and Tn2=0.5K. The theoretical attenuation (At) required to achieve Tn1 and Tn2 has been calculated according to the ENR of the noise diode at 50°C from the calibration data given by the noise diode manufacturer. The following tables is an example of variable attenuator settings to generate Tn1 and Tn2:

1704 QRFH SN01 Attenuator Settings for Noise Calibration Port X (ND AE849)										
Freq (GHz)	ND ENR (dB) @50°C	Td ND @50°C (K)	At1 calculated for Tn1=10K (dB)	Att1 set on HMC-C018 (dB)	At1 measured (dB)	Effective Tn1 (K)	At2 calculated for Tn2=0.5K (dB)	Att2 set on HMC-C018 (dB)	At2 measured (dB)	Effective Tn2 (K)
2	31.99	458851.93	46.62	10.0	46.60	10.04	59.63	23	59.5	0.51
3	31.70	429231.43	46.33	21.0	46.40	9.83	59.34	31.5	56.8	0.90
4	31.61	420433.84	46.24	14.0	46.00	10.56	59.25	27.5	59.4	0.48
5	31.51	410870.20	46.14	18.0	45.90	10.56	59.15	31	59.3	0.48
6	31.45	405236.82	46.08	14.5	45.90	10.42	59.09	27.5	59	0.51
7	31.28	389691.84	45.91	15.5	46.10	9.57	58.92	27.5	58.5	0.55
8	31.11	374743.59	45.74	13.0	45.70	10.09	58.75	25.5	58.5	0.53
9	31.21	383465.73	45.84	8.0	46.10	9.41	58.85	20.5	58.9	0.49
10	31.23	385234.39	45.86	7.5	45.90	9.90	58.87	20	59	0.48
11	31.26	387902.70	45.89	6.0	45.80	10.20	58.90	19	58.8	0.51
12	31.38	398762.17	46.01	4.0	45.80	10.49	59.02	17.5	59	0.50
13	31.56	415624.49	46.19	1.5	46.30	9.74	59.20	14.5	59.2	0.50
14	31.55	414669.25	46.18	0.0	47.00	8.27	59.19	12.5	59.3	0.49

1704 QRFH SN01 Attenuator Settings for Noise Calibration Port Y (ND AE849)										
Freq (GHz)	ND ENR (dB) @50°C	Td ND @50°C (K)	At1 calculated for Tn1=10K (dB)	Att1 set on HMC-C018 (dB)	At1 measured (dB)	Effective Tn1 (K)	At2 calculated for Tn2=0.5K (dB)	Att2 set on HMC-C018 (dB)	At2 measured (dB)	Effective Tn2 (K)
2	31.99	458851.93	46.62	10.0	46.60	10.04	59.63	23	59.5	0.51
3	31.70	429231.43	46.33	21.0	46.40	9.83	59.34	31.5	56.8	0.90
4	31.61	420433.84	46.24	14.0	46.00	10.56	59.25	27.5	59.4	0.48
5	31.51	410870.20	46.14	18.0	45.90	10.56	59.15	31	59.3	0.48
6	31.45	405236.82	46.08	14.5	45.90	10.42	59.09	27.5	59	0.51
7	31.28	389691.84	45.91	15.5	46.10	9.57	58.92	27.5	58.5	0.55
8	31.11	374743.59	45.74	13.0	45.70	10.09	58.75	25.5	58.5	0.53
9	31.21	383465.73	45.84	8.0	46.10	9.41	58.85	20.5	58.9	0.49
10	31.23	385234.39	45.86	7.5	45.90	9.90	58.87	20	59	0.48
11	31.26	387902.70	45.89	6.0	45.80	10.20	58.90	19	58.8	0.51
12	31.38	398762.17	46.01	4.0	45.80	10.49	59.02	17.5	59	0.50
13	31.56	415624.49	46.19	1.5	46.30	9.74	59.20	14.5	59.2	0.50
14	31.55	414669.25	46.18	0.0	47.00	8.27	59.19	12.5	59.3	0.49

Find below a description of each column of the table above:

- ND ENR @50°C (dB): ENR of the noise diode @50°C from the calibration data given by the noise diode manufacturer.

- Td ND @50°C (K): Noise generated by the noise diode in Kelvin. Derivate from the noise diode ENR @50°C.

- At1 calculated for Tn1=10K (dB): Attenuation At1 calculated in order to inject Tn1=10K in the QRFH receiver.

- Att1 set on HMC-C018 (dB): Attenuation set on the variable attenuator to achieve the closest value of AT1 calculated in order to inject Tn1. The variable attenuator has a minimum resolution of 0.5dB.

- At1 measured (dB): Due to the resolution of the variable attenuator it is not possible to achieve the exact calculated value of At1. At1 measured is the closest value achievable.

- Effective Tn1 (K): According to the At1 measured the effective Tn1 has been re-calculated.

The last 4 columns are identical to the previous ones but for the Tn2=0.5K.

The operating of the noise calibration has been tested. The Y-factor of the receiver has been measured when the noise diode is off and when the noise calibration circuit injects Tn=10K. The measurement has been performed at 4GHz and 9GHz on both port. The receiver noise temperature has been calculated using the Noise Adding Radiometer formula:

$$NT(K) = \frac{Tn}{(Y-1)}$$

Method

1. With clear sky condition move the Dewar outside to point at zenith
2. Configure the spectrum analyser as follow:

- Attenuation = 0dB
- RBW = 28MHz
- VBW = 1Hz
- Swep time = 10s
- Span = 0

3. Connect the spectrum analyser to the receiver output Port X

4. Set the spectrum analyser center frequency to 4GHz

5. Start the sweep on the spectrum analyser

6. After 5s of sweep, switch on the noise diode.

7. Note the power when the noise diode is on and when the noise diode is off. The difference between these two values gives the Y-factor. Note the result in the Test Results Sheet

8. Repeat the action from 5 to 7 but with the center frequency of the spectrum analyser set to 9GHz

9. Repeat the action 4 to 8 for port Y

2.3.3.6 Phase calibration operation (optional)

This test is only performed on receiver with calibration box.

The aim of this test is to demonstrate the operation of the phase calibration circuit.

The purpose of the phase calibration circuit is to generate a comb spectrum signal up to 14GHz with spectral lines at 10MHz spacing, which are derived from an input reference frequency signal available in the station. The phase calibration circuit configuration is shown below:

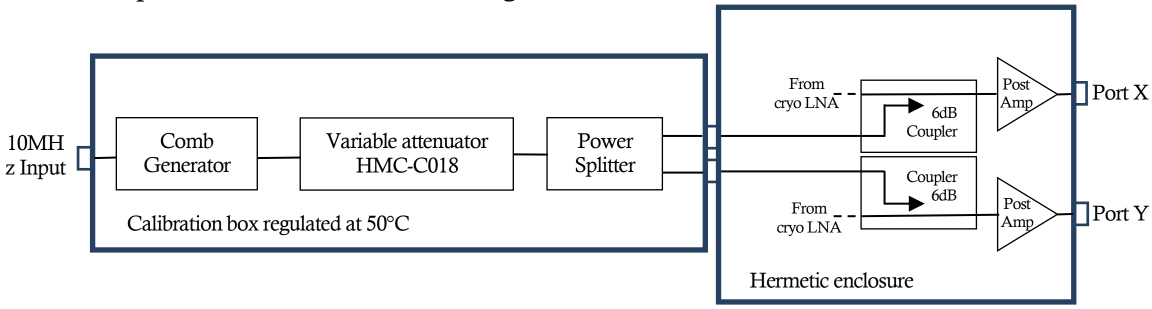

Figure 2-6: Noise calibration circuit

Method

1. Configure the spectrum analyser as follow:
- Attenuation = 20dB
- RBW = 5kHz
- VBW = 10Hz
- Span = 200MHz
- Center frequency = 14GHz

2. Connect the spectrum analyser to the receiver output Port X
3. Switch on the comb generator
4. Note the value of the lowest picket in the Test Result Sheet
5. Repeat the action 2 to 4 for port Y

ANNEX

3. TEST RESULT SHEETS

3.1 TEST RESULTS SUMMARY

Result "R" column = Passed (P), Marginal (M), Failed (F)

Parameter	Specifications	Results	Verification Method	R	Comments
Frequency Band	2 – 14 GHz		AT		
Port X					
Port Y					
Noise Temperature	<40K		AT		at cryogenic temperature
Port X					TLNA=??K
Port Y					TLNA=??K
Gain	>55dB		AT		
Port X					Gain extracted from NT meas
Port Y					
Gain Flatness	10dBpp		AT		
Port X					Worst case, gain extracted from NT meas
Port Y					
Output Return Loss	10dBmin		AT		
Port X					14dB typical
Port Y					14dB typical
Pout 1dB	+20dBm		CT; D		
Port X					

Port Y					
Gain via test input			AT		No specification defined for this parameter
Port X					
Port Y					
Cooldown Time to reach NT<40K	<5 hours		AT		
Port X					
Port Y					
Noise calibration	None		AT		The NT measurement performed with the noise diode is comparable with the NT measurement done with the sky method
Phase calibration	None		AT		The minimum picket level at 14GHz available at the output of the receiver is around -70.5dBm.
Cold Head Base Temperature	80K		AT		
Cooldown Time to base temperature	not specified		AT		
Warm-up Time (base temp-->280K)	not specified		AT		
RF Input	Free space radiation		D		
RF output connector	SMA		I		
Port X					
Port Y					
10MHz Phase Calibration Input	SMA		I		

Dimensions (mm)	l=612 * Phi=311		I		Excluding supports and connectors
Weight (kg)	<27kg		AT		Excluding supports and cables
Operating Orientation	Any		D		
Operating Temperature	-10°C to +40°C		D		
Storage Temperature	-40°C to +60°C		D		
Relative Humidity	to 90% non condensing		D		
Ventilation Requirement	Forced air cooling		I		
Max Power Consumption	400W		AT		
Input Voltage	90—264VAC / 47—63Hz		D		
Distance between receiver and PSU Drawer	<20m		AT		Split M&C – 5m between receiver and DAQ-PSU enclosure – 20mbetween DAQ-PSU enclosure and PC enclosure
LMS parameters display			AT		
LMS functions			AT		
LMS log files			AT		
Remote communication			AT		
Cryocooler MTTF	200,000 hours		D		

Table 3-1: Test Results Summary

3.2 M&C Tests

Result "R" column = Passed (P), Marginal (M), Failed (F)

Ref	Parameter / Requirement	Spec	Result	R	Comments
	Date:				
	VISUAL INSPECTIONS				
	Check the labelling of…	Labels must be clearly visible and readable and must correspond to the item attached to.			
	…the receiver	"			
	…the DAQ-PSU Drawer	"			
	…the PC Drawer	"			
	…the connectors	"			
	…the cables	"			
	Length of cables…				
	…for Receiver to DAQ-PSU Drawer	5m			
	…for DAQ-PSU Drawer to PC Drawer	20m			
	Maximum power consumption of the system	400W			When all M&C units are switched on and the cooler is at maximum power, typically during initial cooldown
	Software display and update of…	On "HOME" tab			

Ref	Parameter / Requirement	Spec	Result	R	Comments
	…Cryogenic Base temperature	A value between 1K and 350K			
	…Remote/Local Mode	Actual status must be displayed			
	…Cooler Status	Actual status must be displayed			
	…Summary of Alarms	Actual status must be displayed			If at least one parameter alarm is active, then the summary alarm must be active.
	FUNCTIONAL TESTS				
	Software correct switching from remote to local control modes	Button must accept switching and status must change			According to User Manual procedure
	Software correct switching from operating to maintenance control modes	Button must accept switching, password must be requested and status must change			According to User Manual procedure
	Software correct logging of status and parameters in the log files	Log files must be created and updated as described in the User Manual			
	Power loss/recovery	Hardware and Software must recover functionalities after a power loss/recovery event			
	Response to remote communication requests	The software must respond to remote communication requests (via TCPIP) as described in the User Manual			

Table 3-2: Test Result Sheet – M&C Tests

3.3 Vacuum & Thermal Tests

Result "R" column = Passed (P), Marginal (M), Failed (F)

Ref	Parameter / Requirement	Spec	Result	R	Comments
	Date:				
2.3.2	**Pressure increase rate**	≤1e-5 mbar.l/s		-	Calculated at least over 1 hour Vacuum Volume of Receiver ~17 Litres
2.3.2	**Cooldown time**	---			This parameter is given for information only
	to RF specification	5 hours			5 hours expected to reach RF specification (NT<40K)
	on cold head	295K to <100K		-	*Typically 0h21 (Unit-1 in cold environment)*
	""	295K to Base temperature		-	*Typically 1h16 (Unit-1 in cold environment)*
	on LNA	295K to <100K		-	*Typically 0h27 (Unit-1 in cold environment)*
	""	295K to Base temperature		-	*Typically 7hrs (Unit-1 in cold environment)*
	on feed base plate	295K to <150K		-	*Typically 4h46 (Unit-1 in cold environment)*
	""	295K to Base temperature		-	*Typically 15hrs (Unit-1 in cold environment)*
2.3.2	**Base Temperatures**	**Tset = 75K**			
	Cold head	~75K±0.5K			
	LNA	<85K			
	Feed [base]	<130K			
	Feed [top]	<150K			
2.3.2	**Cooler Input Power**				Minimum Power = 60W, Maximum Power = 160W
2.3.2	**Compressor Temperature**	<70°C			

Ref	Parameter / Requirement	Spec	Result	R	Comments
2.3.2	**Ambient(Room) Temperature**				*Describe quickly test environment conditions*
2.3.2	**Warmup time (no heaters)**	100K to 295K No spec.			

Table 3-3: Test Result Sheet – Vacuum & Thermal Tests

3.4 RF Tests

Result "R" column = Passed (P), Marginal (M), Failed (F)

<table>
<tr><th>Ref</th><th>Parameter / Requirement</th><th>Spec</th><th colspan="3">Result</th><th>R</th><th>Comments</th></tr>
<tr><td></td><td>Cryogenic Temperature</td><td>---</td><td colspan="3"></td><td></td><td>TcryoLNA =</td></tr>
<tr><td>2.3.3</td><td>Frequency Band</td><td>2 – 14 GHz</td><td colspan="3"></td><td></td><td></td></tr>
<tr><td rowspan="6">2.3.3.1</td><td rowspan="6">Noise Temperature</td><td rowspan="6">Max<40K</td><td></td><td>Port X</td><td>Port Y</td><td rowspan="6"></td><td rowspan="6"></td></tr>
<tr><td>Min Meas</td><td></td><td></td></tr>
<tr><td>Max Meas</td><td></td><td></td></tr>
<tr><td>Mean Meas</td><td></td><td></td></tr>
<tr><td>Min Trend</td><td></td><td></td></tr>
<tr><td>Max trend</td><td></td><td></td></tr>
<tr><td rowspan="2">2.3.3.2</td><td rowspan="2">Gain</td><td rowspan="2">>55dB</td><td colspan="2">Port X</td><td>Port Y</td><td rowspan="2"></td><td rowspan="2">Gain extracted from NT meas</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td>2.3.3.2</td><td>Gain Flatness</td><td>10dBpp</td><td colspan="2"></td><td></td><td></td><td>Worst case gain extracted from NT meas</td></tr>
<tr><td>2.3.3.3</td><td>Output Return Loss</td><td>>10dB</td><td colspan="2"></td><td></td><td></td><td>14dB typical</td></tr>
<tr><td></td><td>Pout 1dB</td><td>+20dBm</td><td colspan="3"></td><td></td><td>By design</td></tr>
<tr><td>2.3.3.4</td><td>Gain via test input (Port X)</td><td>-</td><td colspan="3"></td><td></td><td></td></tr>
<tr><td>2.3.3.4</td><td>Gain via test input (Port Y)</td><td>-</td><td colspan="3"></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="3"></td><td></td><td></td></tr>
</table>

Ref	Parameter / Requirement	Spec	Result	R	Comments
2.3.3.4	**Gain via test input stability (Port X)**	-	@2GHz / 60min: @8GHz / 60min: @14GHz / 60min: @2GHz / 60sec: @8GHz / 60sec: @14GHz / 60sec:		Most of the gain variation is probably due to the measurement set-up. A specific calibration of the VNA must be performed at 14GHz to improve the test set-up stability.
2.3.3.4	**Gain via test input stability (Port Y)**	-	@2GHz / 60min: @8GHz / 60min: @14GHz / 60min: @2GHz / 60sec: @8GHz / 60sec: @14GHz / 60sec:		Most of the gain variation is probably due to the measurement set-up. A specific calibration of the VNA must be performed at 14GHz to improve the test set-up stability.

Table 3-4: Test Result Sheet - RF Tests

LIST OF ABBREVIATIONS

Acronym	Meaning
Ø	Diameter or Phase, depending on context
°	Degree
°C	Degree Celsius
<CR>	Carriage Return (ASCII character)
<LF>	Line Feed (ASCII character)
A/C	Air Conditioning
AC or ac	Alternative Current
AD	Applicable Document
AIL	Action Item List
Amb	Ambient
ASCII	American Standard Code for Information Interchange
Att	Attenuation
CAL	Calibration or Callisto, depending on context
CalBox	Calibration Box
CalTech	California Institute of Technology
CDR	Critical Design Review
Comp	Compressor
Cryo	Cryogenic (very low temperature)
DAQ or DAU	Data Acquisition Unit
DC or dc	Direct Current
dB	Decibel
dBm or dBmw	Decibel-Milliwatt
dBpp	Decibel pic-to-pic
etc	Et Cetera
FAT	Factory Acceptance Test
FEC	Front End Controller i.e. Ground station (telescope) central monitor and control network
g	g-force, gravitational force or gram, depending on context
G	g-force, gravitational force
GHz	GigaHertz
GND	Ground
h or hrs	Hour(s)
Hz	Hertz
I/P	Input
ICD	Interface Control Document
IP	Internet Protocol
IPC	Industrial PC
K	Kelvin
kg	Kilogram
kW	KiloWatt
LAN	Local Area Network
LNA	Low Noise Amplifier

LMS	**LNA Monitor Software**
m	**Meter**
mG	**Milli-g-force (gravitational force)**
mm	**Millimeter**
M&C	**Monitoring and Control**
max	**Maximum**
mbar	**Millibar**
meas	**Measure, Measured, Measurement**
min	**Minimum**
MHz	**MegaHerts**
MMI	**Man-to-Machine Interface**
ms	**Millisecond**
MS	**Microsoft**
MTBF	**Mean Time Between Failure**
MTM	**MT Mechatronics**
N	**Newton**
NF	**Noise Figure**
NI	**National Instruments**
NT	**Noise Temperature**
NTP	**Network Time Protocol**
O/P	**Output**
OOL	**Out Of Limits**
OS or os	**Operating System**
PC	**Personal Computer**
PCB	**Printed Circuit Board**
PDF	**Portable Document File**
POL	**Polarization**
PostBox	**Post-Amplification Box**
PSU	**Power Supply unit**
PT	**Platinum Resistance (thermometer)**
PWD	**Password**
QRFH	**Quad-Ridge Flared Horn**
RD	**Reference Document**
RF	**Radio Frequency**
RMS	**Root Mean Square**
s or sec	**Second**
SMA	**SubMiniature version A connector**
Soft	**Software**
SoW	**Statement of Work**
SW	**Switch**
USB	**Universal Serial bus**
T	**Temperature**
TBC	**To Be Confirmed**
TBD	**To Be Defined**
TCP	**Transmission Control Protocol**
Temp	**Temperature**

TTL	**Time To Live (signal)**
V	**Volt**
Vac	**Vacuum**
VAC	**Volt AC**
VentBox	**Ventilation Box**
VLBI	**Very Large Base Interferometry**
W	**Watt**
Wdw	**Window**
WO	**Work Order**
WP	**Work Package**