Wideband Cryogenic Receiver for VLBI
Compact QRFH

<u>User Manual</u>

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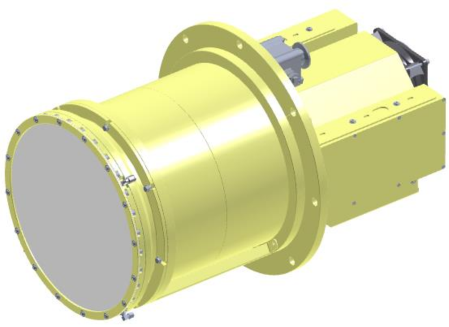

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1. INTRODUCTION

1.1 Purpose

This document describes the details of the QRFH Compact Wideband Cryogenic Receiver; including system description, details of interfaces, installation, user and operating instructions.

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 Reference Documents

RD 1 Wideband Cryogenic Receiver for VLBI for AuScope Patriot Antenna, Interface Control Document ICD/1704/4068 Issue 1.0, 21/02/2017.

RD 2 Wideband Cryogenic Receiver for VLBI for MTM Antenna, Interface Control Document ICD/1704/4069 Issue 0.1, 21/02/2017.

RD 3 Wideband Cryogenic Receiver for VLBI for Intertronic Solutions Antenna, Interface Control Document ICD/1704/4070 Issue 0.1, 21/02/2017.

RD 4 Wideband Cryogenic Receiver for VLBI for Vertex Antenna, Interface Control Document ICD/1704/4071 Issue 0.1, 21/02/2017.

RD 5 Hittite HMC-C018 datasheet v03.0310

RD 6 CryoTel Exported Vibration Testing, CT & GT Results, Sunpower Ametek, v1.3 dated 9/05/2013

2. SYSTEM DESCRIPTION

2.1 Subsystem Overview

The wideband compact cryogenic QRFH receiver is a state-of-the-art RF reception system. It combines a very low noise temperature at the receiver output over a wide frequency band and extremely compact size, low weight and low power consumption compared to standard cryogenic systems using GM coolers.

The sub-system is divided in 5 modules described in the following diagram:

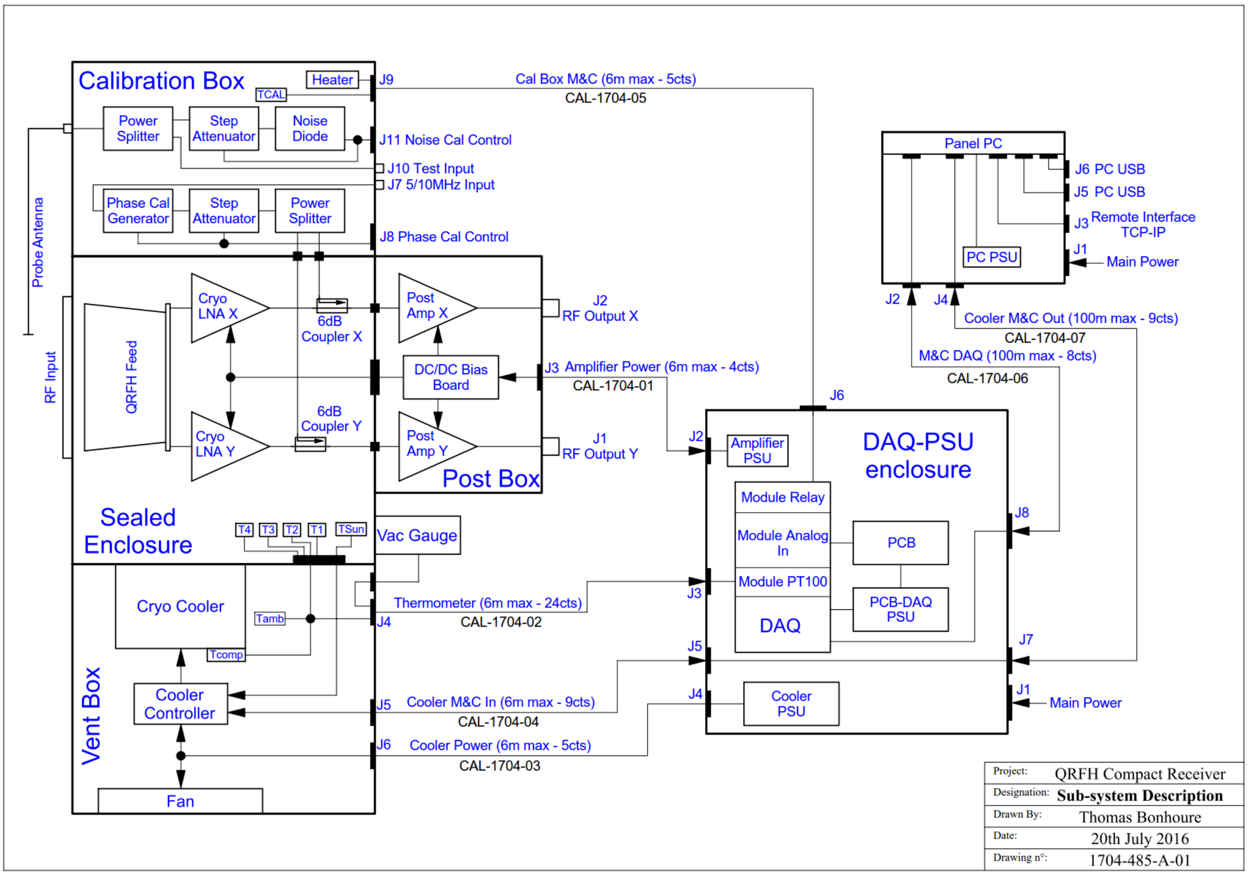


Figure 2-1: Subsystem Description

The modules are:

- A "**sealed enclosure**" containing the QRFH feed, the LNAs, a cryogenic cooler and electrical and RF hermetic interfaces to the environment. The sealed enclosure contains a solid thermal insulation system which is under high vacuum during nominal operation but return to rough vacuum (<100 mbar) when the cryogenics is stopped. This system is patented by Callisto. It allows for cryogenic cooldowns and warmups without the need for connecting a vacuum pump or any human action other than pressing a button, for a period of around five years. After this period a regeneration of the rough vacuum may be required to recover nominal performance. The enclosure is equipped with a large diameter hermetic RF window which is the RF input of the receiver. The QRFH is positioned inside the enclosure in front of this window.

- A "**post box**" attached to the sealed enclosure; it contains an electronic board to power the cryogenic LNAs and post amplifiers. These post amplifiers increase the overall gain at the output of the receiver. The post box presents the two RF outputs of the receiver (coaxial SMA connectors, one per polarization).
- A "**calibration box**" attached to the sealed enclosure; it houses the phase and noise calibration circuits. This box is thermally insulated from the environment in order to maintain the calibration components at constant temperature thanks to the combined actions of a thermometer and a heater connected to a thermostat. This box is equipped with a safety feature to prevent overheating the components.
- A "**vent box**" attached to the sealed enclosure; it is surrounding the body of the cryocooler to provide air cooling to the cryocooler compressor; it also contains a controller for the cryocooler.

The design of the phase and noise calibration circuit allows for the option of not including the calibration box with the delivered system depending on user's requirements.

The 4 modules described above are grouped in one single unit: the **receiver**. This receiver is installed at the apex of an antenna and connected by cables to the monitoring and control (M&C) modules which can be installed far from the receiver, typically in the hub cabin and in the basement of the antenna.

The **M&C module** is composed of two units: a "**DAQ-Power Supply Unit (PSU)**" and a **"PC" unit**; both are wall mount enclosures. The first unit (DAQ-PSU) contains electrical power supplies for the receiver modules (including the cryocooler), electronic boards for signals and power management and data acquisition (DAQ). This unit should not be installed more than 6m away from the receiver. The second unit includes a panel PC with central monitoring software and man-to-machine interface. This PC runs the M&C software dedicated to the system and developed by Callisto. It manages the acquisition and the control of various parameters of the receiver, processes them to display values and status to the user and generate alarms as required, records critical parameters in files written on the hard drive and transfers some of these parameters via an Ethernet/TCPIP interface, for instance to the antenna central command room. This second unit should not be installed more than 100m from the first unit.

The Figure 2-2 is an illustration of the receiver with detailed legend (the M&C modules are not represented).

The external interfaces to the Wideband Cryogenic Receiver for VLBI are as follows:

- RF Input
- RF Output X Polarisation.
- RF Output Y Polarisation.
- Phase Calibration Control (Optional – CalBox)
- Noise Calibration Control (Optional – CalBox)

- 10MHz Frequency Input for Phase Cal circuit (Optional – CalBox)
- Auxiliary phase cal input for feed + LNA verification (RF Test Input) (Optional – CalBox)
- Mains power input (DAQ-PSU Unit and PC Unit)
- Remote monitor and control Interface (PC Unit)

These interfaces are further described in section §2.4

2.2 RF Specifications at Cryo Temp

Parameter	Specification
Frequency Range	2 – 14GHz
Gain	>55dB
Noise Temperature	<40K max
O/P Power 1dB Compression	+20dBm
Gain Flatness	10dBpp
Output Return Loss	10dB min
Input Interface	Free space radiation
Output Interface	SMA

Table 2-1: RF Performance Summary at cryo temperature

2.3 Cryogenic Specifications

Parameter	Specification
Cooldown time to reach RF specification	5 hours
Cryogenic temperature	Regulated to 75K [1] at 25°C ambient for 160W maximum cooler consumption

Table 2-2: Cryogenic Performance

Prolonged operation in a high temperature environment will increase power consumption and reduce the lifetime of the cooler. In order to maximise service life, it is recommended to operate the receiver in an environment where the average temperature over 24 hours and over 1 year is 25°C or less.

2.4 LNA Interfaces

2.5 RF Signal Input / Efficiency

Free space radiation input. The CalTech designed QRFH feed model used in the wideband receiver depends on the optics of the antenna it is used on:

- for Patriot type Antenna the feed used is the QRFH-45-6-2-2P3 which has half opening angle of 45°.
- for Ring Focus Antenna the feed used is the QRFH-60-6-2P3 which has half opening angle of 60°.

2.6 RF Signal Output X POL and Y POL.

Label: J1 & J2

Interface: Coaxial

Type: SMA female.

Location: Back face of Dewar (cooler side)

Frequency: 2 to 14 GHz.

Return Loss: 14dB typical, 10dB minimum

2.7 Phase Calibration (Optional –CalBox)

2.7.1 Phase Level Control

Allows control of the level of the phase calibration signal injected into the couplers by means of a digital serial controlled attenuator type Hittite HMC-C018 integrated inside the Calibration Box. Control signal interfaces are CMOS compatible digital signals.

Label: J8

Interface: Multipin J8

Type: Sub-D 15 Female.

Location: Back face of Calibration Box (cooler side)

Pin/signal allocations

Pin Number	Name	Description
1	Vdc Att phase	Digital attenuator supply voltage -5V dc ± 10% (9mA max). For more information see the Hittite HMC-C018 datasheet [RD 5]
2	GND Att phase	Digital attenuator grounding. For more information see the Hittite HMC-C018 datasheet [RD 5]
3	Shift Clock Att phase	TTL Clock signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
4	Serial Input Att phase	TTL Serial signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
5	Reset Att phase	TTL Reset signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
6	Latch enable Att phase	TTL Latch Enable signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
7	+15VDC	Comb generator supply voltage (70mA typical current consumption).
8	GND	Comb generator ground.

Table 2-3: Phase Level Control

For all other interface specifications and serial data protocols see RD 5.

2.7.2 Phase Calibration Input Frequency

This signal is the input signal of the comb generator

Label: J7

Interface: Coaxial

Type: SMA female.

Location: Back face of Calibration Box (cooler side)

Signal: 10 MHz sinewave, Level +10dBm ±3dBm.

2.8 Noise Calibration Control (Optional –CalBox)

This function allows the control of the noise diode. The level of the noise calibration signal injected into the feed can be controlled by means of a digital serial controlled attenuator type HMC-C018 integrated inside the Dewar. Control signal interfaces are CMOS compatible digital signals.

Label: J11

Interface: Multipin

Type: Sub-D 9 Male.

Location: Back face of Calibration Box (cooler side)

Pin/signal allocations

Pin Number	Name	Description
1	+VDC diode	Control the ON/OFF of the noise diode +28Vdc (30mA Max)
2	GND diode	GND noise diode
3	Vdc Att noise	Digital attenuator supply voltage -5V dc ± 10% (9mA max). For more information see the Hittite HMC-C018 datasheet [RD 5]
4	GND Att noise	Digital attenuator grounding. For more information see the Hittite HMC-C018 datasheet [RD 5]
5	Shift Clock Att noise	TTL Clock signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
6	Serial Input Att noise	TTL Serial signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
7	Reset Att noise	TTL Reset signal. For more information see the Hittite HMC-C018 datasheet [RD 5]
8	Latch enable Att noise	TTL Latch Enable signal. For more information see the Hittite HMC-C018 datasheet [RD 5]

Table 2-4: Noise Calibration Control

For all other interface specifications and serial data protocols see RD 5.

2.9 Auxiliary Phase Cal Input

This function allows the injection of RF signal into feed input via noise calibration coupler.

Label:	J10
Interface:	Coaxial
Type:	SMA female.
Location:	Back face of Calibration Box (cooler side)
Signal:	2 to 14 GHz RF signal, max level -20dBm.

2.10 DAQ-PSU Unit Mains Power Interfaces (mains power is provided by the antenna)

Electrical Service:	Input voltage: 85VAC-264VAC.	
	Input frequency: 47Hz to 63Hz	
Power required:	400Wmax.	(340W typical during normal operation)
Connector:	IEC 3 pin mains socket	
Location:	Wall mount enclosure bottom panel	
Label:	J1	

2.11 PC Unit Mains Power Interfaces (mains power is provided by the antenna)

Electrical Service:	Input voltage: 90VAC-264VAC.	
	Input frequency: 47Hz to 63Hz	
Power required:	40Wmax.	(20W typical during normal operation)
Connector:	IEC 3 pin mains socket	
Location:	Wall mount enclosure bottom panel	
Label:	J1	

2.12 PC Unit Remote Interface

Interface:	Multipin
Type:	RJ-45
Location:	Wall mount enclosure bottom panel
Interface Protocol:	Ethernet - TCP/IP
TCP/IP Address:	User configurable via Operating System.
Port Number:	Fixed to 2000
Response time:	< 500ms
Monitor block:	Details in the following Table 2-5.
Control:	Details in the following Table 2-6.
File location:	Log Files folder. TCP/IP events and error are logged in the above directory in the 2 following files: TCP-IP Errors Log.txt and TCP-IP Errors Log.Old.txt.

Communication protocol in accordance with the following tables.

Function Name	Comments
Interface Socket TCP/IP ETHERNET	Microsoft TCP/IP Driver used
Local/Remote Mode	Function implemented in local but no remote control of this function
Max number of simultaneous remote controls	2 max.

Table 2-5 : Functions Implemented– Part 1

Function Name	Comments
IP address	User defined via PC OS interface
Length of monitoring block	Fixed ; 31 bytes
Code	ex. 0011xxxx
Termination	CRLF
Mode	Question (from client system): TBS?<CR><LF> Reply (from server = from cryo receiver system): LMQ<List><CR><LF>

Table 2-6 : Functions Implemented– Part 2

2.12.1.1 Monitored Variable List

See section 4.2.6.

2.13 Mechanical & Environmental Specifications

2.13.1 Cryogenic Enclosure Assemblies

2.13.1.1 Mechanical

Overall Dimensions: L618.15mm x Ø311mm at RF Input Window (Ø381mm at base plate for mechanical mounting interface) See also Figure 2-3.

Weight: ~27kg

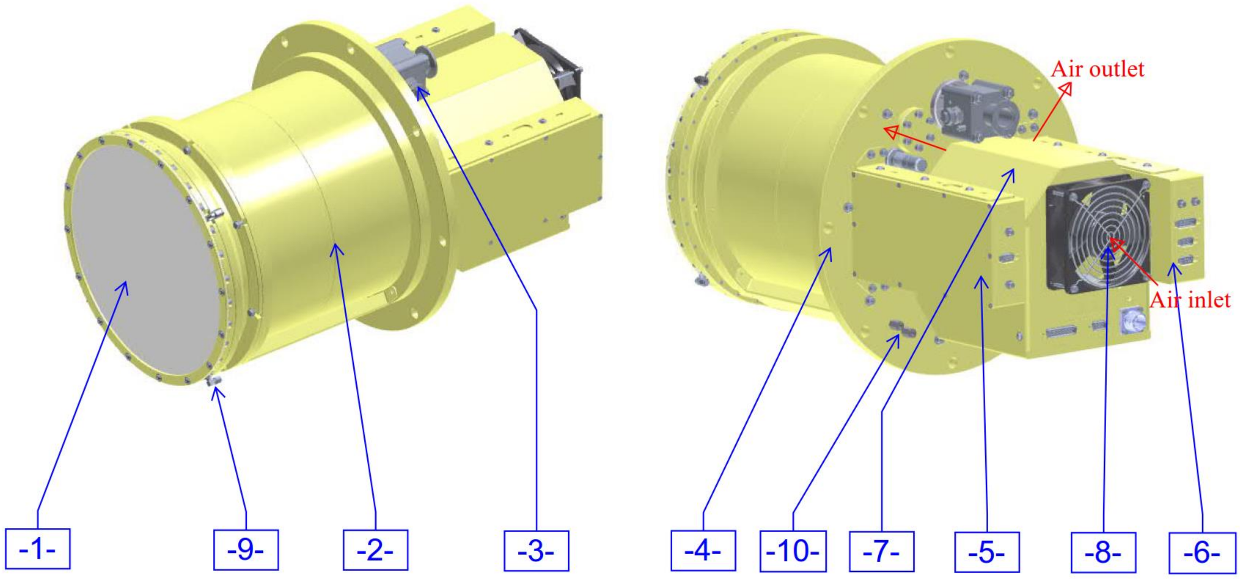


Figure 2-2: Receiver Mechanical Overview

1. Large RF vacuum window (RF Input) including radome
2. Sealed enclosure (receiver body with feed phase center marker line)
3. Vacuum valve
4. Base plate (with mechanical interface to antenna structure)
5. Post Box, with RF outputs (coaxial SMA connectors)
6. Calibration box (optional, for phase and noise calibration)
7. Vent box, with a fan providing air cooling to the cryocooler compressor and containing the cryocooler power controller
8. Air inlet port (source supplied by customer (AC for instance); see section 2.13.1.6
9. Coaxial SMA connector for Noise antenna probe (located inside the radome). This port is connected to the CalBox.
10. Pressurized dry air input and output ports for radome (pressurized dry air provided by customer)

2.13.1.2 Receiver mounting recommendations

The base plate has 8 holes to attach the receiver to the antenna structure (all are ϕ13mm holes). It is highly recommended to use a vibration passive damper interface at the mounting interface between the receiver and the antenna structure. The type of passive damper and its implementation depends on the mechanical structure of the antenna and its coupling with the receiver. The cooler integrated into the receiver generates vibrations mainly at 60Hz (with peak force at <30N) and 120Hz (with peak force <15N). The following table gives the root mean square forces measured on the cooler with a hard mount setup (RD 6).

RMS Accel. (mG)	RMS Fx (N)	RMS Fy (N)	RMS Fxy (N)	RMS FZ (N)	RMS Fxyz Vector Magnitude (N)
9.74	3.56	1.41	3.83	8.44	9.26

Table 2-7: Cooler vibrations - Root mean square forces for Sunpower CryoTel CT hard mount

The modules located below the base plate of the receiver (Vent box, PostBox, CalBox, vacuum valve, etc…) must be protected from direct exposure to sunlight and external weather conditions (rain, etc…).

The parts above the base plate (receiver main body, RF input window) can be exposed to external weather conditions thanks to the Alodine protected aluminium body and to the radome covering the RF window. However, in hot environment it is recommended to use a sun shield with thermal insulation around the body of the receiver in order to reduce the heat load on the receiver cryogenics and so reduce the impact on the NT performance.

2.13.1.3 Location of phase centre of feed

The **QRFH feed phase centre** installed into the Dewar is as shown in the drawing below:

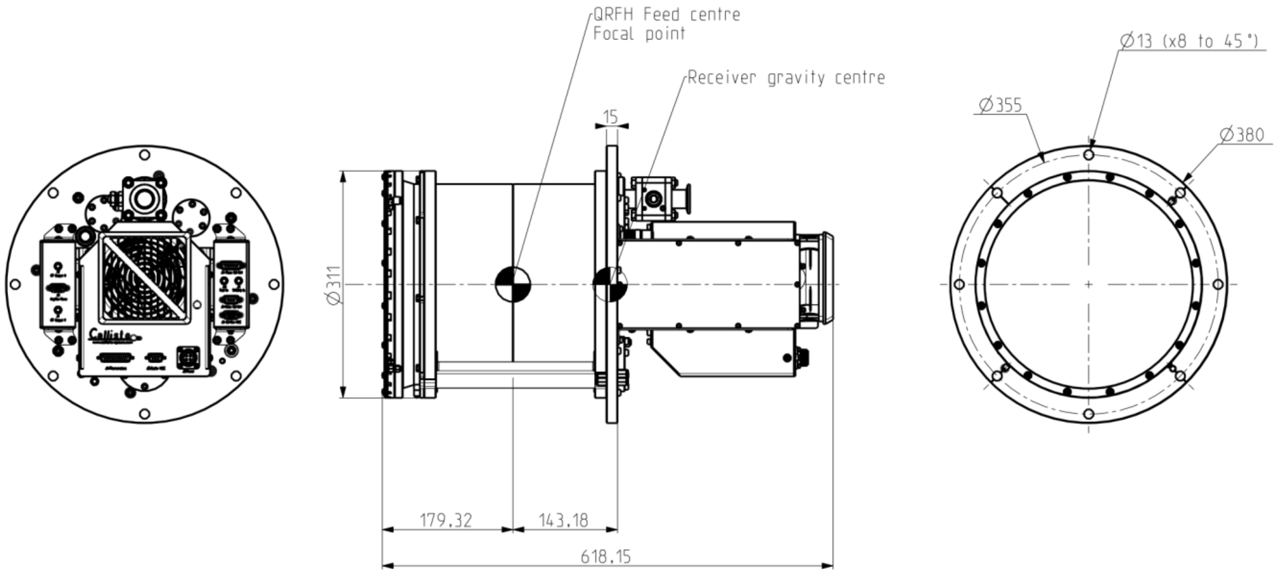


Figure 2-3: Receiver dimensions and feed phase centre location

This location is aligned precisely within the Dewar structure such that the Dewar mechanical reference (top plate or bottom plate) can be used to know the position of the feed phase centre and its orientation to the antenna structure.

The line engraved on the receiver main body (see above Figure 2-3) indicates the position of the feed phase centre in Z axis. There are four additional engraved lines located on the base plate of the receiver that are aligned with the ridges of the QRFH feed, corresponding to polarizations X and Y.

The feed phase centre is co-aligned with the central geometric axis of the Dewar with an accuracy of ±1mm in X, Y and Z and ± 1° of tilt.

2.13.1.4 Dewar to antenna structure mechanical interface

The base plate of the receiver is the main mechanical interface of the enclosure. It has 8 holes Ø13mm equally distributed (45°) on a Ø355mm diameter (see above Figure 2-3). These holes must be used to attach the receiver to a mechanical support in lab or in antenna.

2.13.1.5 Environmental

Operating Temperature: -10°C to +40°C[1] (+25°C recommended in order to increase the cooler lifetime see footnote [1])

[1] Prolonged operation in a high temperature environment will reduce the lifetime of the cooler. In order to maximise service life, it is recommended to operate the receiver in an environment where the average temperature over 24 hours and over 1 year is 25°C or less. See also the ventilation requirement section 2.13.1.6.

	+40°C to +55°C[1] (Degraded Performance, see section 2.13.1.2 for mounting recommendations in hot environment)
Storage Temperature:	-40° to +60°C
Relative Humidity:	To 90% non-condensing (Condensation on vacuum window can occur on high humidity conditions unless radome is used with dry air (see section 2.13.1.7). Above 90% relative humidity, there is risk of condensation on top of radome. In such conditions, it is recommended to add a hot air blower on top of the radome) Note on corrosion, see RD 1.

2.13.1.6 Ventilation Requirements

Warning: The Wideband Cryogenic Receiver uses continuously a fan to extract the heat from the cooler. The mounting location must provide unobstructed air vent space in front of the inlet and outlet of air flow. Do not run the receiver with obstructed fan inlet/outlet.

See figure below (and Figure 2-2) for identification of air inlet and outlet ports.

Warning: Beware of air flow loops that might bring hot air to the fresh air inlet. Such situation will degrade the cryogenic temperature of the receiver. Always ensure that the air inlet is provided with fresh air and that the hot air from the outlet is driven away from the receiver surroundings.

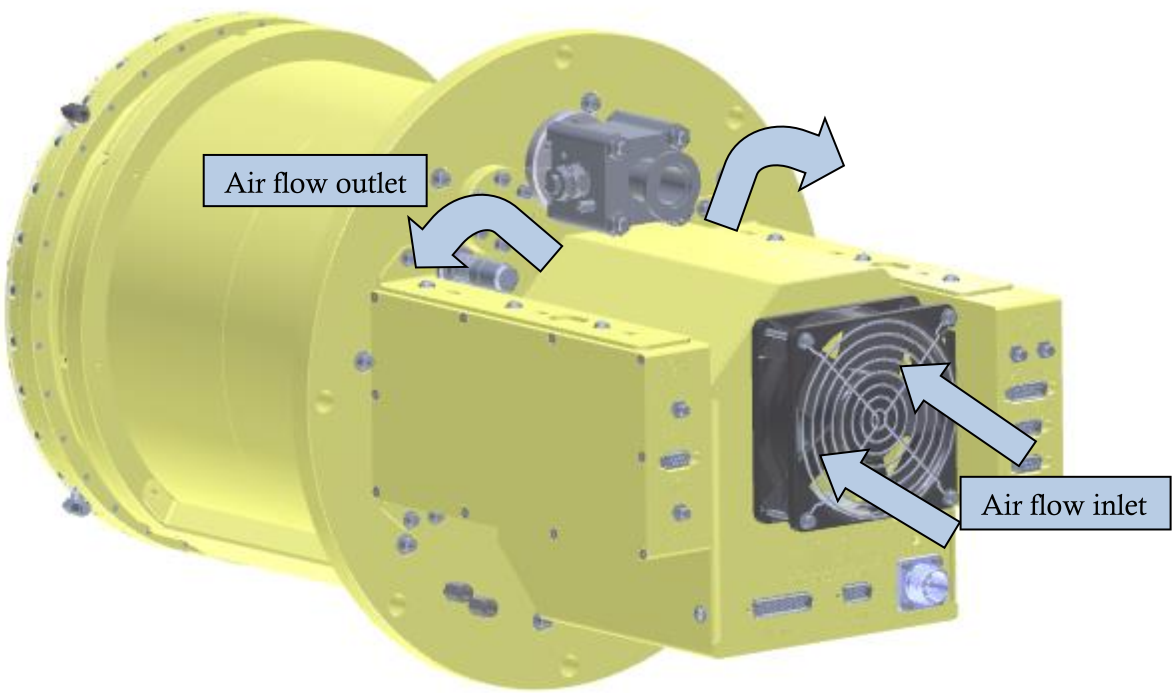


Figure 2-4: Direction of the air flow

2.13.1.7 Radome Dry Air Requirement

Condensation on vacuum RF window can occur, depending on atmospheric humidity levels. To avoid this the space between the radome and the vacuum window should be pressurized with dry air. The radome is provided and is already assembled to the receiver RF input window. This radome structure also includes thermal insulation to reduce the thermal impact of direct and indirect infrared sun illumination of the receiver window, which is essential to achieve the thermal performance and stabilization of the cryogenic components.

The specified NT performance of the receiver is given including this radome.

The vacuum window has two gas ports connected to the base plate of the receiver (see Figure 2-2). These two ports (input/output, no predefined direction) available on the base plate of the receiver can connect to 6 mm outer diameter plastic tube in order to inject dry air between the radome and the vacuum window. The output port is used to allow initial purging of the air passage and afterwards to allow controlled circulation of dry air. The dry air supply is not delivered with the receiver.

Critical Warning: The dry air pressure between the radome and the vacuum window must remain below +50mbar from the atmospheric pressure. **Higher pressure may damage the window** and the receiver with, in extreme case, a rupture of the vacuum window.

2.13.2 M&C Units

2.13.3 DAQ-PSU Enclosure

Wall mounted, indoor installation.

Bottom interface panel dimension: 322 mm x 142 mm

Overall PSU dimension: W396.4mm x D210mm x H396.4mm, Weight: 14 Kg (approx.)

Connectors (all on bottom interface panel, facing down):

1. Mains Power Input [J1]: IEC standard single phase main power connector (phase, neutral & Earth) including fuse terminal

2. Chassis Earth terminal (M6 screw terminal)

3. Cooler power connector [J4]: Amphenol MS3102A-14S-2P

4. Amplifier Power connector [J2]: sub-D15HD-M

5. Cooler monitoring and control input connector [J5]: sub-D9F

6. Thermometer connector [J3]: sub-D25F

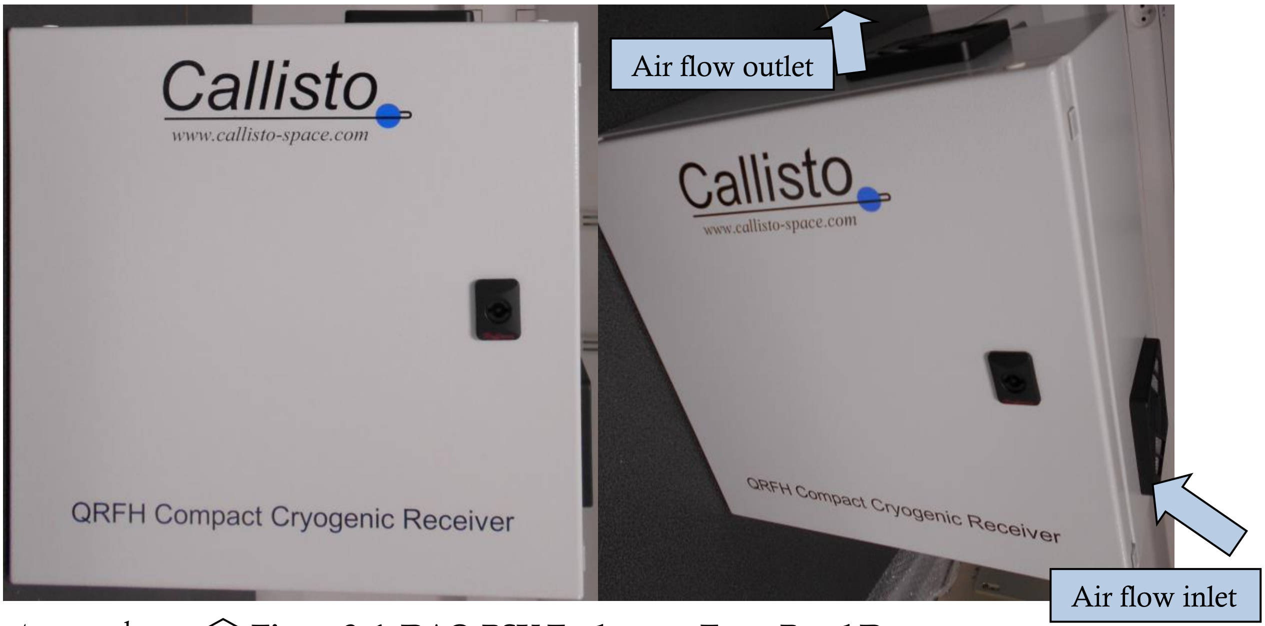
7. Calibration Box (CalBox, optional) monitoring and control connector [J6]: sub- D15HD-F

8. Cooler monitoring and control output connector [J7] (to PC Enclosure): sub-D9M

9. Monitoring & Control data acquisition (DAQ) connector [J8] (to PC Enclosure): RJ45

   Note: Room must be reserved below the unit in order to allow connection of the cables. 200mm is the minimum recommended (so this adds to the 400mm of the unit); see below picture for example.

Figure 2-5: DAQ-PSU Enclosure - Cables routing space



Connectors panel located below the unit

Figure 2-6: DAQ-PSU Enclosure - Front Panel Door

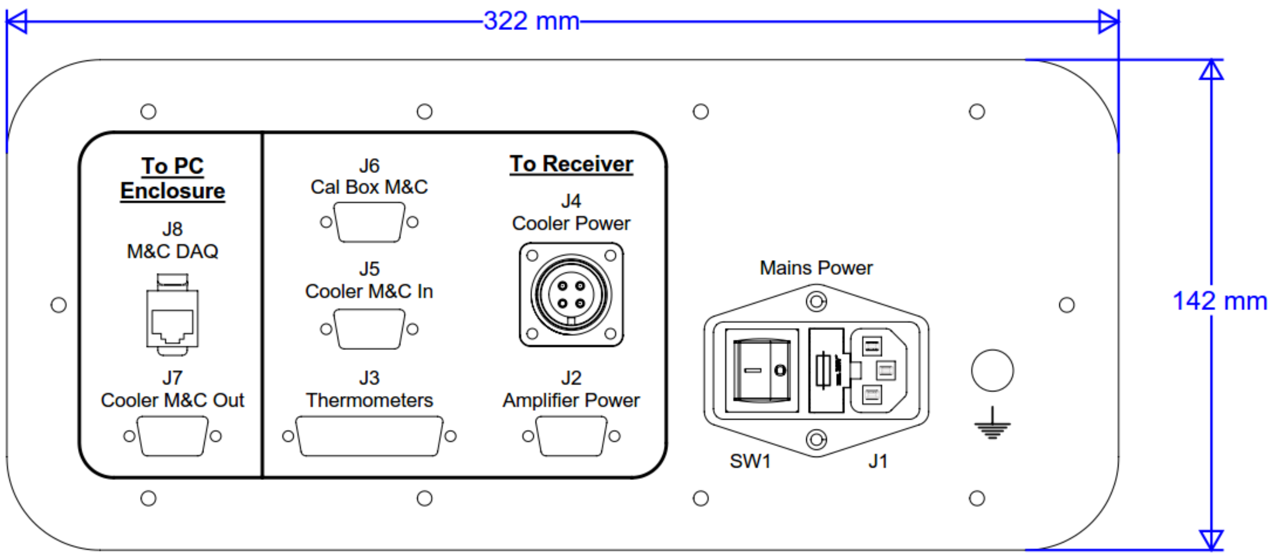


Figure 2-7: DAQ-PSU Enclosure – Bottom interface panel

2.13.3.1 Environmental

Operating Temperature:	-10° to +40°C
Storage Temperature:	-40° to +60°C
Relative Humidity:	To 90% non-condensing

2.13.4 PC Enclosure

Wall mounted, indoor installation.

Bottom interface panel dimension: 322 mm x 142 mm

Overall PSU dimension: W396.4mm x D210mm x H396.4mm, Weight: 12 Kg (approx.)

Connectors (all on bottom interface panel, facing down):

1. Mains Input connector [J1]: IEC standard single phase main power connector (phase, neutral & Earth)
2. Chassis Earth terminal (M6 screw terminal)
3. Monitoring & Control data acquisition (DAQ) connector [J2] (to DAQ-PSU Enclosure): RJ45
4. Remote interface connector [J3]: RJ-45
5. Cooler monitoring and control output connector [J4] (to DAQ-PSU Enclosure): sub-D9F
6. PC extension port [J5]: USB-F
7. PC extension port [J6]: USB-F

   Note: Room must be reserved below the enclosure in order to allow connection of the cables. 200mm is the minimum recommended (so this adds to the 400mm of the enclosure).

Figure 2-8: PC Enclosure - Front Panel Door

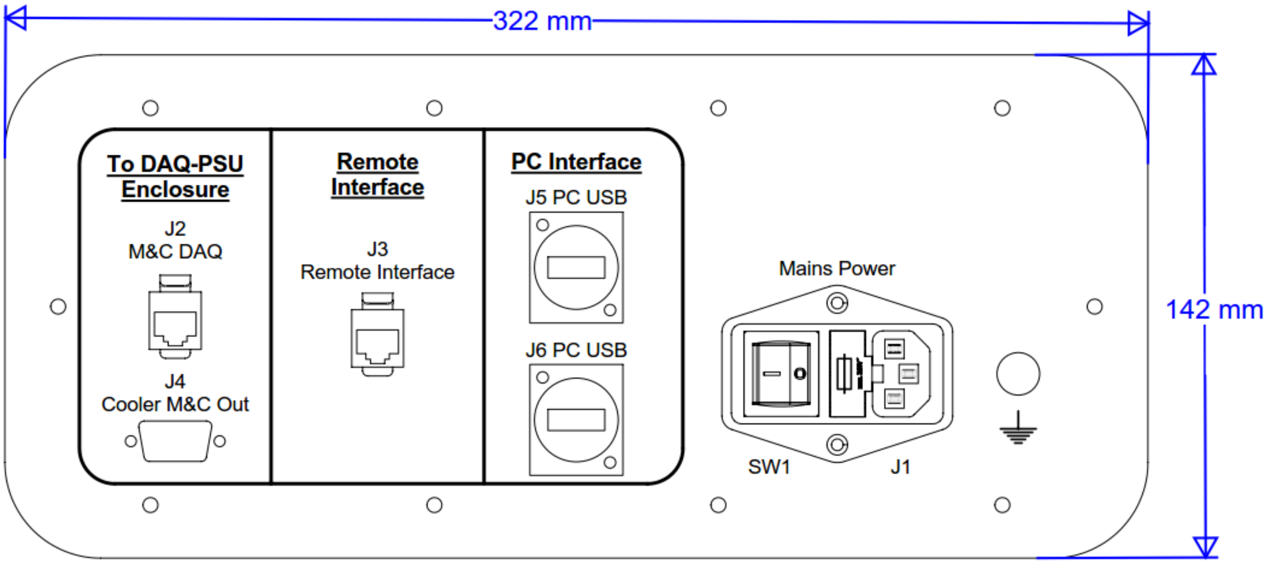


Figure 2-9: PC Enclosure – Bottom interface panel

2.13.4.1 Environmental

Operating Temperature:	-10° to +40°C
Storage Temperature:	-40° to +60°C
Relative Humidity:	To 90% non-condensing

2.14 RF System Description

2.14.1 Inside the Sealed Enclosure

The two RF chains (one for each polarization) connected at the output of the QRFH feed are independent and identical. The components used are the same for both chains:

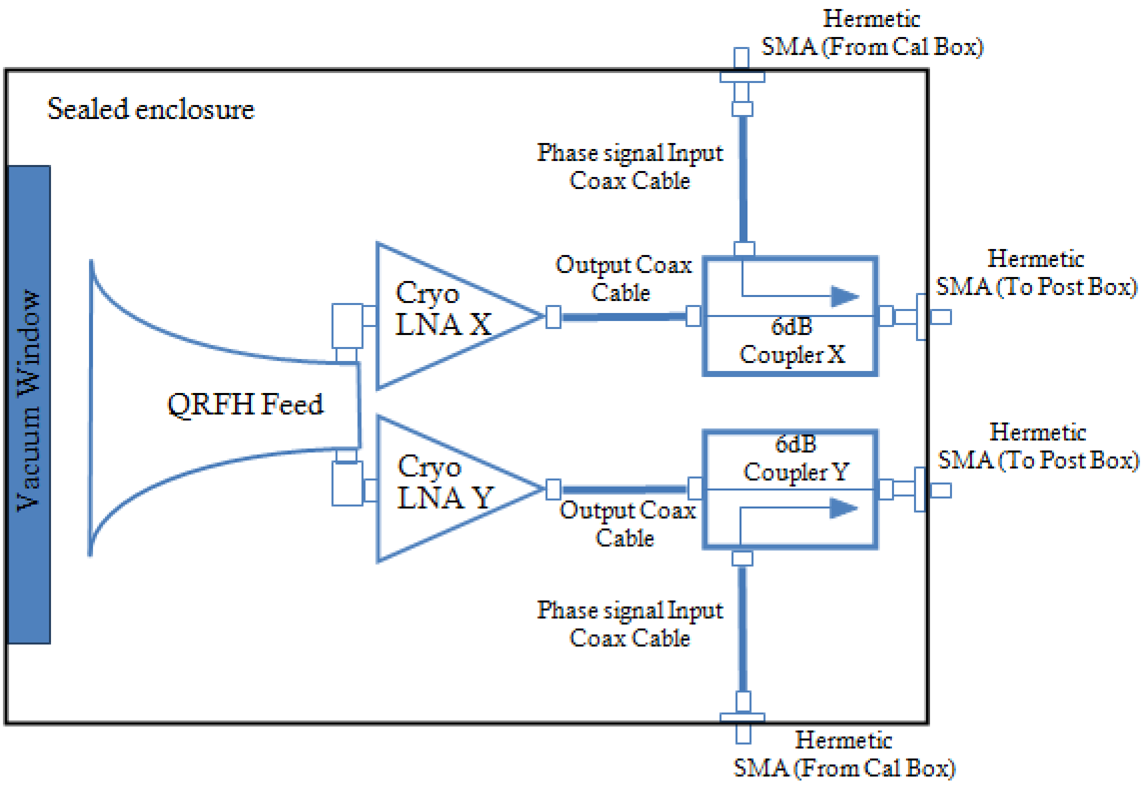


Figure 2-10: RF chain inside the enclosure

The RF circuit inside the enclosure comprises the following elements:

1. QRFH feed from Caltech (common to both chains).
2. One LNF Low Noise Amplifier per chain. It is a connectorized LNA female SMA.
3. One cryogenic rated output coaxial cable male-male per chain.
4. One 6dB directional coupler per chain.
5. One cryogenic rated phase signal input coaxial cable male-male per chain.
6. Two hermetic SMA female-female per chain.

Only the QRFH feed and the LNF LNAs are cryo-cooled. The 6dB couplers allow the injection of the phase calibration signal (see section 2.7).

2.14.2 **Inside the Post Box (Room Temperature Section)**

In order to ensure that the RF equipment installed after the receiver does not degrade the System Noise Temperature; the overall gain needs to be increased. A post amplifier at room temperature is installed just after the cryogenic section. The components used are the same for both chains:

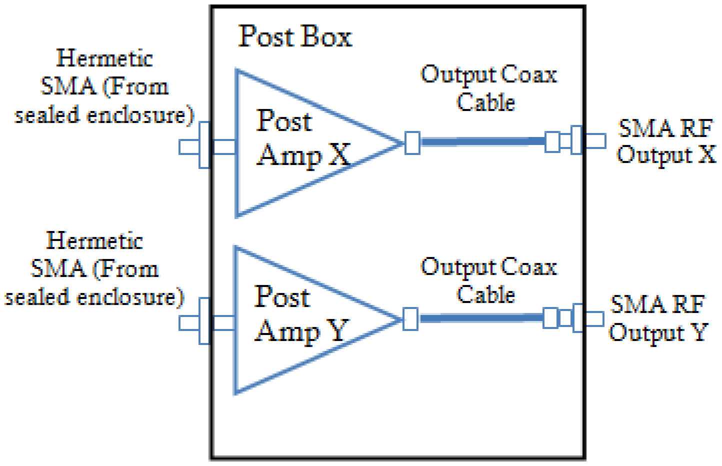


Figure 2-11: RF chain inside the post box

The RF circuit inside the post box comprises the following elements:

1. One connectorized wide band amplifier per chain.
2. One output coaxial cable male-male per chain.

2.15 Cryogenic Dewar Description

The term "Dewar" means a sealed enclosure which isolates the LNAs and other cooled components within it from the external environment.

WARNING: The LNA Dewar is a sealed enclosure and should not be opened under any circumstances otherwise the LNAs will no longer function correctly.

The design of the Compact LNA is based on a commercially available 77K "Cryocooler" manufactured by Sunpower Inc. The refrigerator is a closed cycle Stirling refrigerator model CT which has a proven high reliability and which does not need maintenance intervention.

The cryo amplifiers are attached to the cold finger of the cryocooler and are cooled down to around 85K. The heat is extracted by the cooler compressor fins and ventilation is required to limit the compressor temperature below +70°C. This is the maximum temperature of the compressor, above this limit the compressor is automatically switched off to prevent from critical damages to the cooler. A compressor temperature below 42°C (average) is recommended to ensure the lifetime of the cooler.

Thermal isolation between cold parts and ambient parts is provided by solid isolation combined with dry gas. This design concept is protected by a patent.

The system has been designed to operate for 5 years without intervention if the enclosure is kept sealed.

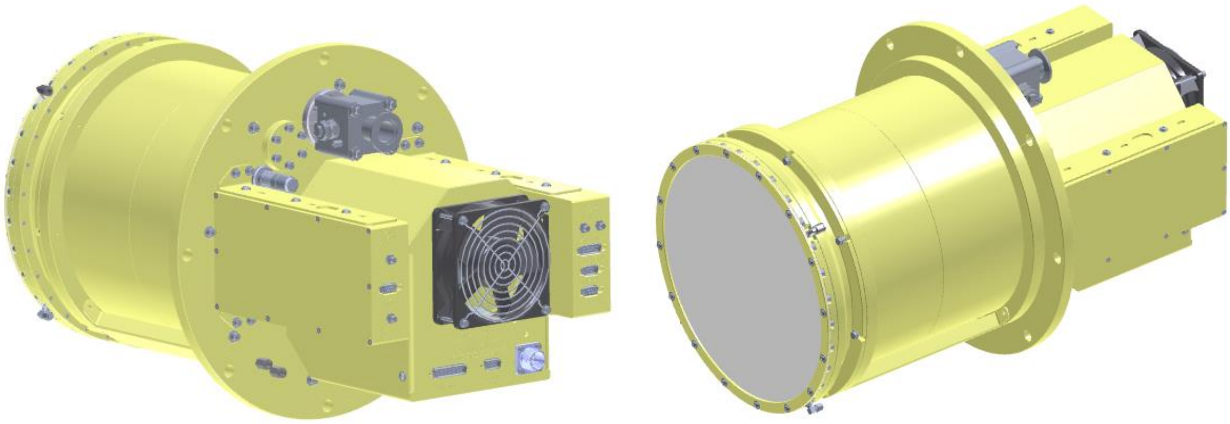


Figure 2-12: Illustration of the Compact QRFH Cryogenic LNA

Please refer to Figure 2-2 for detailed overview of the receiver.

2.16 Monitoring & Control Description

2.16.1 Introduction

The Compact QRFH Cryogenic LNA Subsystem is designed to be integrated into an operational VLBI ground station (telescope). In common with all other ground station equipment it has an interface to the ground station central monitor and control network (i.e. Front End Controller - FEC), which allows the ground station systems to be operated from a centralized position. In addition, it is possible to take control of the system remotely via a TCP/IP connection and/or using the MS Windows Remote Desktop. The M&C system is based on two wall mount units:

- the "PC unit" enclosure containing a fanless computer with touch screen. The software running on the computer has been adapted to the touchscreen interface.
- the "DAQ-PSU unit" enclosure containing a remote acquisition board plus all power supplies required by the receiver system.

The cryogenic receiver is connected to the DAQ-PSU enclosure then this enclosure is connected to the PC unit enclosure. The M&C system collects analogue data from the receiver equipment. The information is digitised in a data acquisition module installed inside the DAQ-PSU enclosure. On the PC unit, the computer runs application software based on the National Instrument LabView system. This application processes the data collected from the hardware and displays the results on a user interface based on a touchscreen. This local user interface also allows the user for taking control of the receiver system, for instance to start or stop the cryogenic cooling. This local mode can be protected by a password to restrict the access.

2.16.2 Monitor & Control Functions

The following is a list of the top-level functions required for the LNA monitor and control circuit.

The DAQ-PSU provides:

- A Thermometer module for Platinum Resistance Thermometer (PRT).
- An Analogue module for voltage measurement.
- Optional Relay module to heat the Calbox (optional).
- Voltage measurement (ADC) for PSU and temperatures.
- Cryo-cooler power supply monitoring.
- LNA PSUs Monitor
- Local and Remote control of compressor (Cooling On or Off)
- Telnet Interface for remote Monitor & Control.
- Optional Ethernet interface to allow access to remote desktop

The PC unit provides:

- A power supply for the PC
- A PC with a touch screen which has the M&C software installed on it.

The LNA M&C Software (LMS) provides:

- Voltage to Temperature conversion.
- Out-Of-Limits threshold detection and alarm generation.
- Local/Remote Control & Monitoring
- Log files generation
- Display of Monitoring Parameters on history charts
- Cryo-cooler management with cold temperature regulation
- Telnet protocol to command and monitor parameters.

2.16.3 **Monitor Parameters**

The following is a list of monitored parameters present on the LMS Local and/or the LMS Remote interfaces:

Parameter	Monitored Data	LMS Local	LMS Remote	Comments
Cold Tip Cryogenic temperature (Tcryo1)	Temp. - K	✓	✓	Cold tip temperature of the cryocooler in Kelvin
Compressor temperature (Tcomp)	Temp. - °C	✓	✓	Crycooler Compressor temperature in degree Celsius
Ambient temperature (Tamb)	Temp. - °C	✓	✓	Ambient temperature in degree Celsius
Local/Remote mode	Status Indicator	✓	✓	Local/Remote configuration of the LMS
Operating/Maintenance Status	Status Indicator	✓	✓	LMS running mode (Operating/maintenance)
Vacuum	Pressure - mbar	✓	✓	Pressure inside the Dewar
Calibration Box temperature (Tcal)	Temp. - °C	✓	✓	*Optional: Calibration box internal temperature in degree Celsius only visible if system has a Calbox*
Cooler Power consumption	Power-W	✓	✓	Cooler electrical input consumed Power in W
Summary Alarm	0= No error, 1 = Error	✓	✓	Indicator ON when one or more errors are on.
Cooler Status	Status Indicator	✓	✓	Status could be: Cooldown, Cool OK or Cooler off.
Log File path	Path	✓	X	Path to the repository of the system log files.
Log File interval	Time in min	✓	X	Interval between each logfile
IP address	String IP address	✓	X	IP address for remote connection
TCP State	Connected or Disconnected	✓	X	Remote connection status
Port number	Number	✓	X	Remote connection TCP port
Targeted base temperature (Tsetpoint)	Temp. - K	✓	X	Cold tip temperature set point in Kelvin

Table 2-8: Parameters monitored

2.16.4 **Alarm Indications**

The following is a list of monitored status and alarms present on the LMS Local and/or the LMS Remote:

Parameter	Status/Alarm Meaning	LMS Local	LMS Remote	Comments
DAQ to PC Communications	0=No Error, 1= Error	✓	✓	Communication error with Data Acquisition

Cooler controller to PC Communication	0=No Error, 1= Error	✓	✓	Communication error with the cooler controller
Cold Tip Cryogenic temperature (Tcryo1)	0=No Error, 1= Error	✓	✓	Tcryo 1 alarm
Compressor temperature	0=No Error, 1= Error	✓	✓	Tcomp Alarm
Ambient temperature	0=No Error, 1= Error	✓	✓	Tamb Alarm
Summary Alarm	0=No Error, 1= Error	✓	✓	Indicator on when one or several others error indicators are on.
Amplifiers current consumption	0=No Error, 1= Error	✓	✓	Amplifier current consumption alarm
Vacuum Alarm	0=No Error, 1= Error	✓	✓	Pressure alarm
Fan status	Alarm indicator	✓	✓	Status of the ventilation box fan
Calbox temperature	Alarm indicator	✓	✓	Tcal Alarm only visible if system is with Calbox

Table 2-9: Status and Alarm Indications

2.16.5 **Controls**

Parameter Description	**LMS Local**	**LMS Remote**	**Detail**
Cooling On/Off	✓	✓	From LMS Local mode, LMS Remote mode
Maintenance Operating Mode	✓	X	Change the mode to modify parameters
Change Alarms Limit	✓	X	Change the alarms limits
Tcryo	✓	X	Change the High and Low limits of Tcryo
Tamb	✓	X	Change the High and Low limits of Tamb
Tcomp	✓	X	Change the High and Low limits of Tcomp
LNA Status	✓	X	Change the High and Low limits of LNA current consumption
Fan Speed	✓	X	Change the High and Low limits of Fan Speed
Vacuum	✓	X	Change the High and Low limits of Fan Vacuum
Tcal	✓	X	*Not present if System without Calbox* Change the High and Low limits of Tcal
Clear Data in alarms tab	✓	X	Erase the 5 alarms Events table
Change Alarms display	✓	X	Enable or disable the alarm visibility only on the MMI still visible in Logfile and TCP list
Tamb	✓	X	Enable or disable the alarm visibility on the MMI
Tcryo	✓	X	Enable or disable the alarm visibility on the MMI
Tcomp	✓	X	Enable or disable the alarm visibility on the MMI
Tcal	✓	X	Enable or disable the alarm visibility on the MMI *Not present if System without Calbox*
Vacuum	✓	X	Enable or disable the alarm visibility on the MMI
LNA Status	✓	X	Enable or disable the alarm visibility on the MMI

Fan Speed	✓	X	Enable or disable the alarm visibility on the MMI
Exit	✓	X	Button to quit the LMS
Change Logfile Parameters	✓	X	Change the timer and the place to save the logfile
Change TCP/IP Settings	✓	X	Enable or disable the TCP/IP log error

Table 2-10: Controlled Parameters

From the local control MMI it is possible to select an Operational or Maintenance control mode. However, this selection is not available at the remote interface. The selection of maintenance mode allows access to a number of configuration facilities. Again, these are only available at the local MMI.

The configuration facilities available are:

- Change log file sampling interval and path
- Enable/disable parameter alarm generation (only affects local MMI)
- Set parameters upper and lower alarms thresholds
- Enable/disable TCP/IP error file generation

3. INSTALLATION & INTEGRATION

The LNA assembly (receiver) and the DAQ-PSU Unit (drawer) should be ideally installed in the antenna Apex cabin. If there is no room available, the DAQ-PSU Unit can be installed in the pedestal of the antenna while the receiver assembly remains at the apex. The maximum distance between the two units is 6m. The PC Unit can be installed anywhere from the antenna to a remote-control room considering that the maximum distance between the PC unit and the DAQ-PSU unit is 100m.

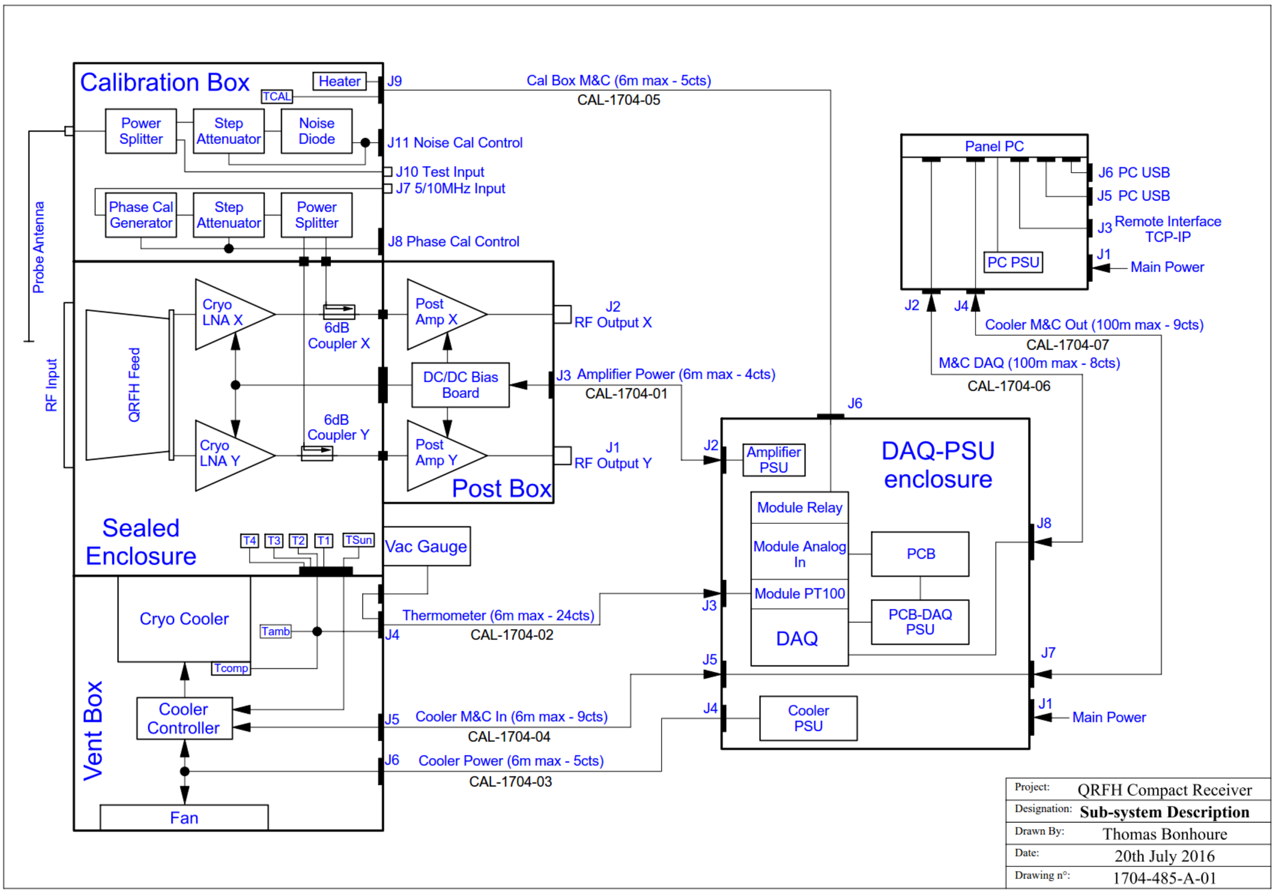


Figure 3-1: Subsystem configuration and interconnection cables

3.1 LNA Assembly (Receiver)

The LNA assembly (or receiver) is installed at the apex of the antenna, at the focal point. The LNA assembly should be firmly supported by a suitable framework in the antenna cone area. The LNA assembly is provided with fixing points (see ref. 4 on Figure 2-2 and also Figure 2-3). It is recommended to use suitable vibration dampers at the mounting interface of the receiver and antenna structure (see section 2.13.1.2).

The Feed phase centre can be adjusted by moving the LNA assembly on the antenna support structure. This adjustment (recommended ±25mm) must be provided by the antenna mounting structure. There is no adjustment structure delivered with the LNA assembly.

Recommendation to avoid vibrations

It is recommended to use suitable rubber anti-vibration (for instance "silent-blocks") to attach the LNA assembly to the framework of the antenna in order to attenuate the vibration generated by the cryo-cooler. (see section 2.13.1.2)

Recommendation to avoid corrosion

If the Dewar enclosure is to be exposed to weather conditions, it is recommended to use anti-corrosion mounting elements to prevent galvanic corrosion between the Aluminium of the LNA assembly and the stainless steel the fixing screws.

Note: the fan box, postbox, calbox and vacuum valve **must remain protected from liquid water** (rain, fog, etc...). If exposed to weather conditions the large input window of the LNA assembly must be protected by a radome. Callisto provides this protective radome pre-mounted on the receiver.

3.2 DAQ-PSU Unit

The DAQ-PSU Unit should be located indoor in the antenna apex cabin or antenna pedestal, in a suitable racking system, taking care of the allowable cable length for the interconnections between the unit and the LNA assembly (receiver). The maximum distance between the LNA assembly (receiver) and the DAQ-PSU unit is 6m.

Important Note: the DAQ-PSU unit includes DC power supplies generating heat which is extracted from the unit by a fan to prevent internal overheating. If the DAQ-PSU unit is located in the same room space as the receiver, it is highly recommended to provide an air-conditioning (A/C) fresh air supply (ideally around 20°C) to the receiver fan to prevent from overheating the cryogenic system and degradation of NT performance of the receiver, and to prevent from accelerated aging of the cryogenic cooler system (i.e. reduction of lifetime of the cryocooler).

3.3 PC Unit

The PC Unit provides a local man-to-machine (MMI) interface for the operator and should be located indoor anywhere from the antenna to a remote-control room, in a suitable racking system, taking care of the allowable cable length for the interconnections between the unit and the DAQ-PSU unit. The maximum distance between the PC unit and the DAQ-PSU unit is 100m.

3.4 Inter-Units Cables

All inter-units cables for the LNA subsystem have been supplied with the equipment. All the cables have been labelled to ease identification. The cable connections and their labels are indicated on the table below.

The remote M&C cables (Ethernet) connecting the M&C drawer to the station control room are not delivered with the system.

Cables details are shown below.

Cable	End1	End1 & End2	End2
CAL-1704-01	J2 PSU-DAQ	CAL-1704-01 Amplifier Power	J3 Post Box
CAL-1704-02	J3 PSU-DAQ	CAL-1704-02 Thermometers	J4 Venting Box
CAL-1704-03	J4 PSU-DAQ	CAL-1704-03 Cooler Power	J6 Venting Box
CAL-1704-04	J5 PSU-DAQ	CAL-1704-04 Cooler M&C In	J5 Venting Box
CAL-1704-05	J6 PSU-DAQ	CAL-1704-05 Cal Box M&C	J9 Cal Box
CAL-1704-06	J8 PSU-DAQ	CAL-1704-06 DAQ M&C	J2 PC
CAL-1704-07	J7 PSU-DAQ	CAL-1704-07 Cooler M&C Out	J4 PC

Table 3-1: Cables details

4. OPERATION INSTRUCTIONS

The Compact Cryo LNA can be operated from 2 positions:

- From the PC Unit front panel (Touch screen computer).
- From remote TCP/IP interface using the station FEC.

4.1 PC Unit Front Panel Operation

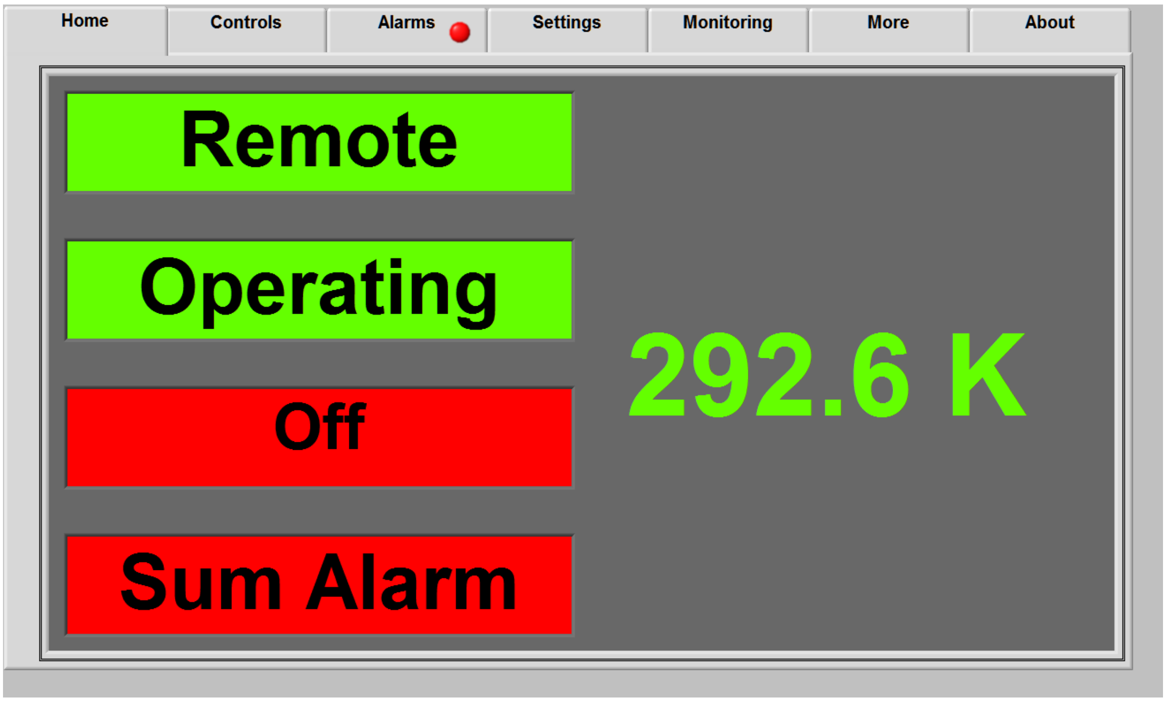
There is no physical control on the front panel of the PC Unit. The software installed on the touch screen computer allows for the main operation of the LNA.

For any operation, make sure both units (PC unit and DAQ-PSU unit) are switched on.

4.1.1 Cooldown Procedure

To switch on the LNA from the PC Unit front panel proceed as follows:

1. Install the equipment as indicated in section 3.
2. Switch on the DAQ- PSU unit (SW1).
3. Switch on the PC unit (SW1).
4. Wait until the home front panel of the software appears on the touchscreen computer, as shown below:



5. The software detects the last status of the cooler: if it was running then the cooler will start automatically (to recover after un power break for instance); if it was stopped (i.e. after a voluntary warmup) the cooler will remain off. In that case follow the steps below to start a cooldown manually:
    a. Switch to "local" control in the software
    b. Select "Cooldown OFF. Press it to switch cooler ON" in the controls tab. After 30 seconds, the cooler will start and the cooler status on the LMS will be "Cooldown"

WARNING: Do not turn back the switch before the 30 seconds has elapsed. In other words, after turning on the cooling, wait at least 30 seconds before turning back off the cooling if required.

The **Alarm** indicator will remain lit until the cryogenic temperature falls to operating levels. This will take around 2 hours.

4.1.2 Warmup Procedure

1. Switch to "local" control
2. Select "Cooldown ON. Press it to switch cooler OFF" in the controls tab. After 30 seconds, the cooler will stop and the cooler status on the LMS will be "Off-In Progress" then "Off-Confirmed"

WARNING: Do not turn back the switch before the 30 seconds has elapsed. In other words, after turning off the cooling, wait at least 30 seconds before turning back on the cooling if required.

3. Then the LNA temperature will slowly warmup to ambient temperature in around 12 hrs.

WARNING: The receiver Dewar is a sealed enclosure and should not be open under any circumstances otherwise the LNAs will no longer function correctly.

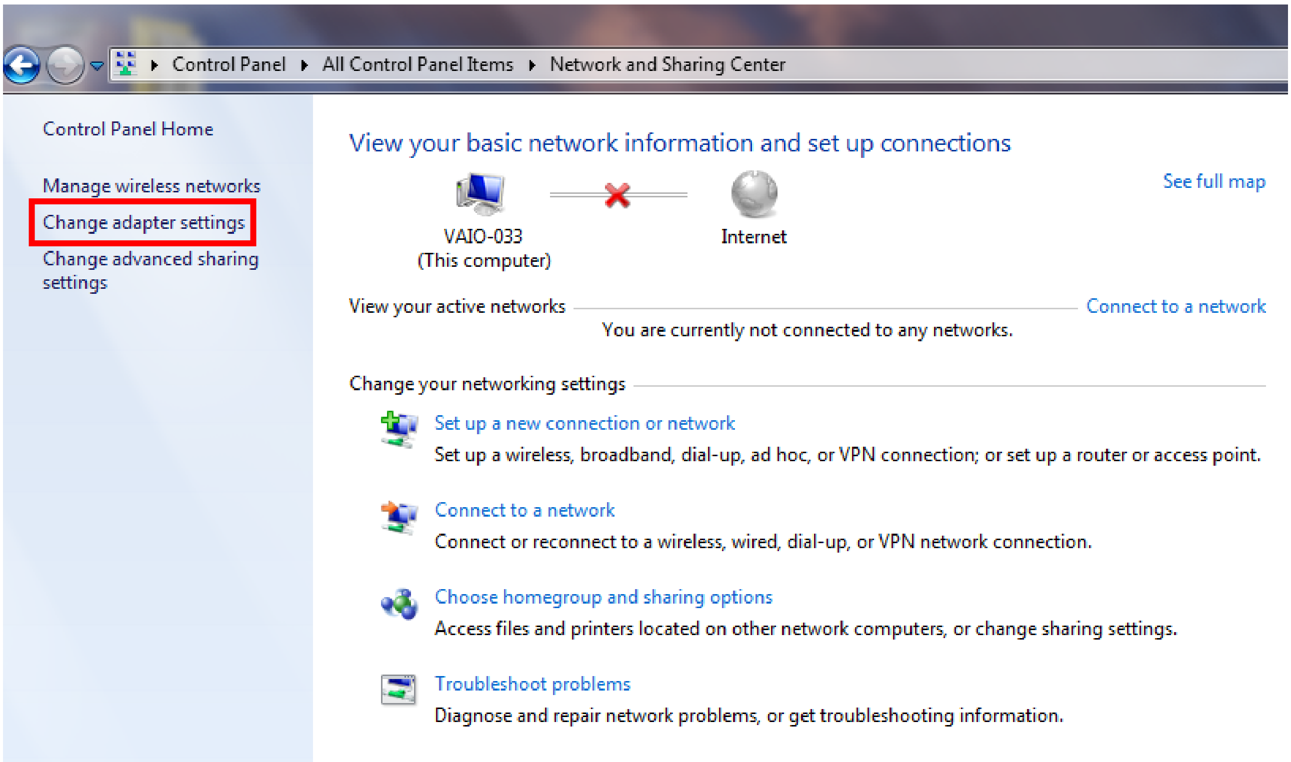
4.2 Remote Computer Operation (using MS Windows Remote Desktop)

The system can be monitored and control via a TCP/IP connection using Microsoft Windows Remote Desktop. The remote computer should be connected to the RJ45 connector J3 of the PSU Drawer via a LAN cable.

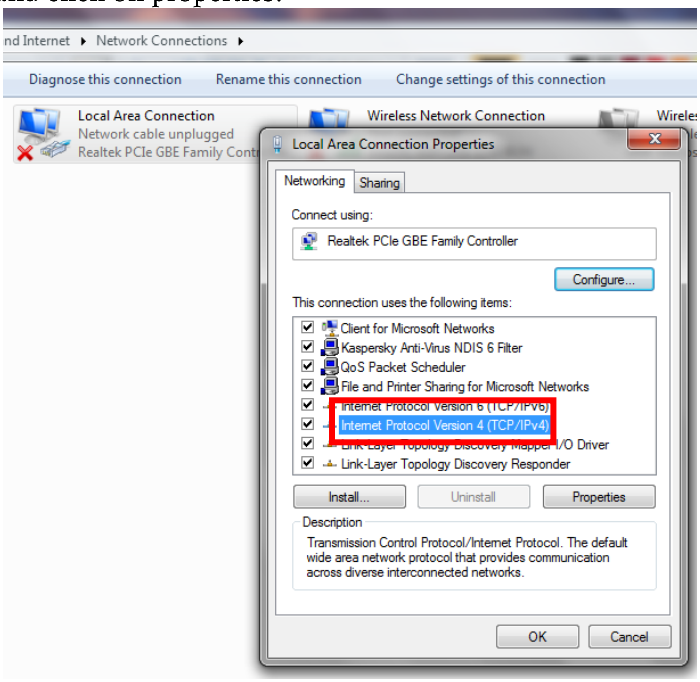
4.2.1 Set up the TCP/IP connection

Ensure the remote computer is connected to the same network (physically and with subnet mask) and has a unique IP address assigned. If you need changing one of these, please follow the instructions below.
The following procedure is for MS Windows 7 Pro (steps might change for other versions):

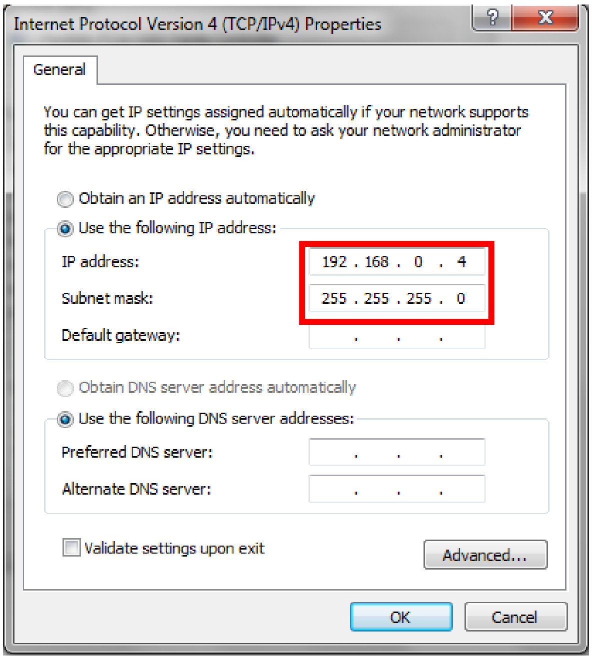
1. On the remote computer, Open MS Windows Control Panel and double click on "Network" icon, then change adapter setting



2. Right click on Local Area Connection, choose Properties and Select the sub-menu "Protocol internet version 4" and click on properties.



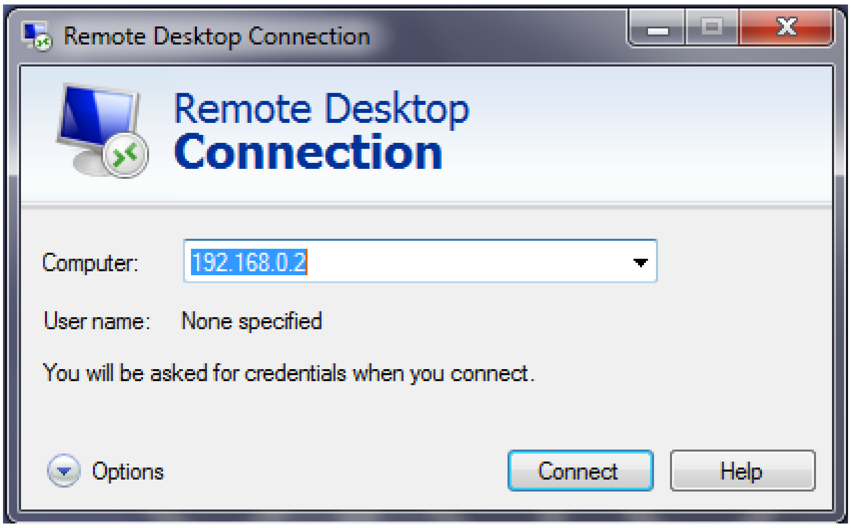
3. Enter a new valid IP Address for example **192.168.0.4** with a subnet mask **255.255.255.0** in the corresponding window



4. Click OK and close all tabs

4.2.2 Set up the MS Windows Remote Desktop

1. Open Start menu and search the remote desktop connection icon on the PC connected to the PSU drawer
2. Enter the IP address of the embedded PC (factory set to 192.168.0.2) and click connect



3. A popup appears requiring a login and a password.
   a. Enter the login ".\CallistoQRFH" (without quotes).
   b. Enter the password "QRFH@31290" (without quotes).

4. Click Ok, the embedded PC desktop should be visible now. (It is possible that a popup appears to ask for a certificate, this is normal and you can skip it by clicking OK)

4.2.3 Main Control Panel

The LNA M&C Software (LMS) presents the operator with the Main Control Panel as shown in Figure 4-1:

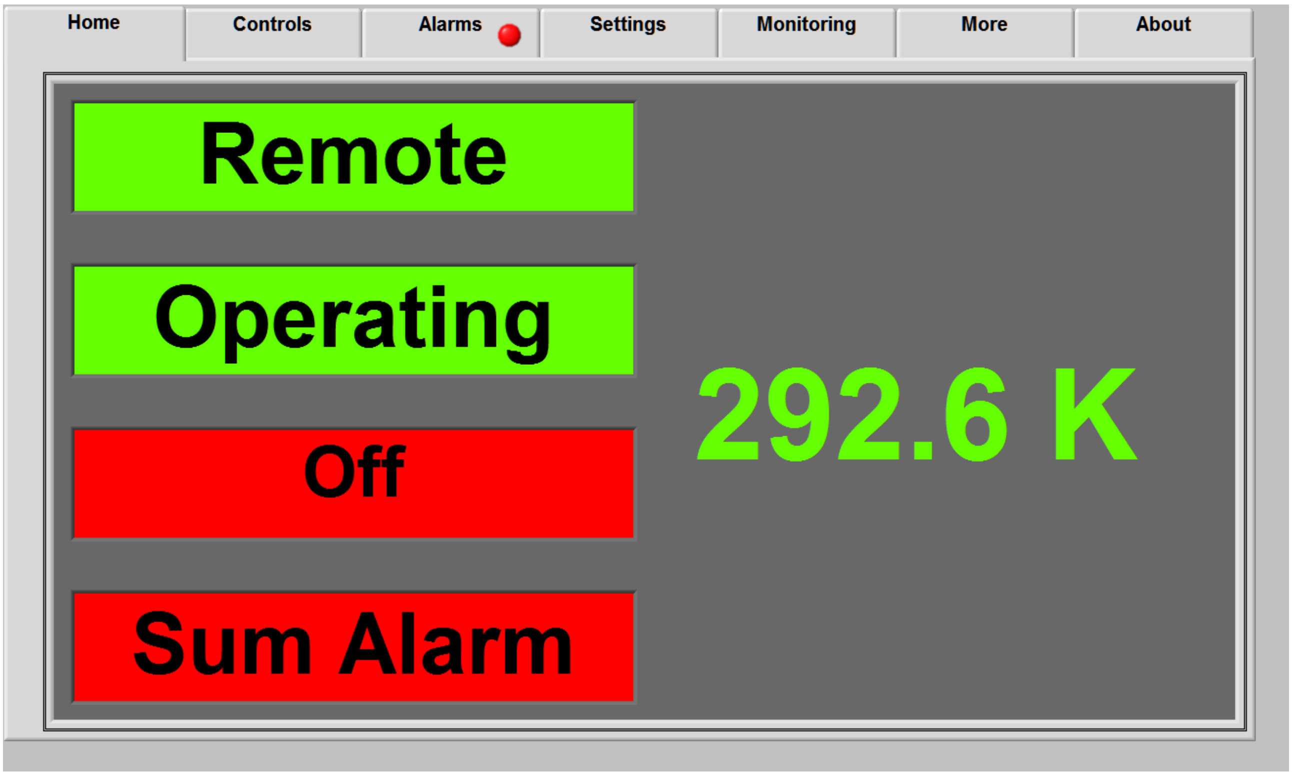


Figure 4-1: Local M&C Operator Interface MMI (Remote Computer)

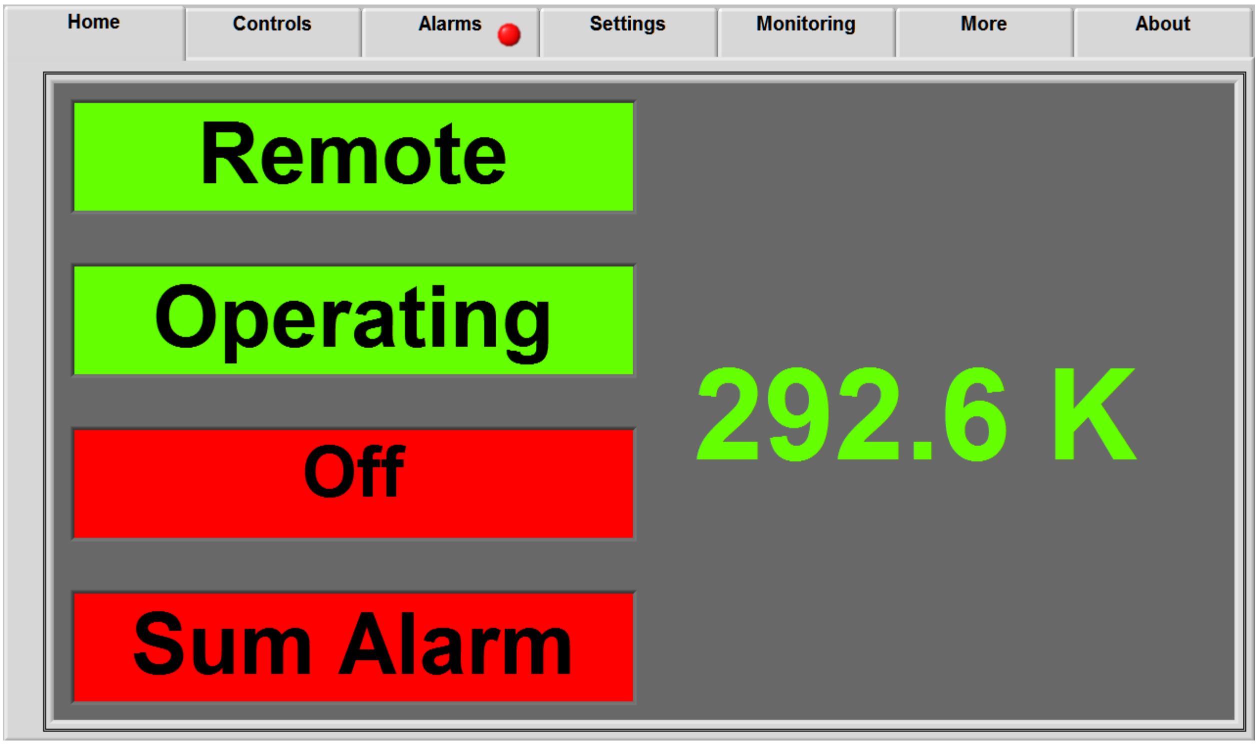
4.2.4 General Description of panel, Controls and Indicators

The elements on this panel are grouped by functions. The elements follow the color code described below:

- White background → Indicators (display value/status only, cannot be edited/modified)
- Blue border → Controls (value/status can be modified)
- Red → Alarm / Error / Critical Status
- Orange/Yellow → Warning / Pay attention
- Green → Nominal Status / All ok!

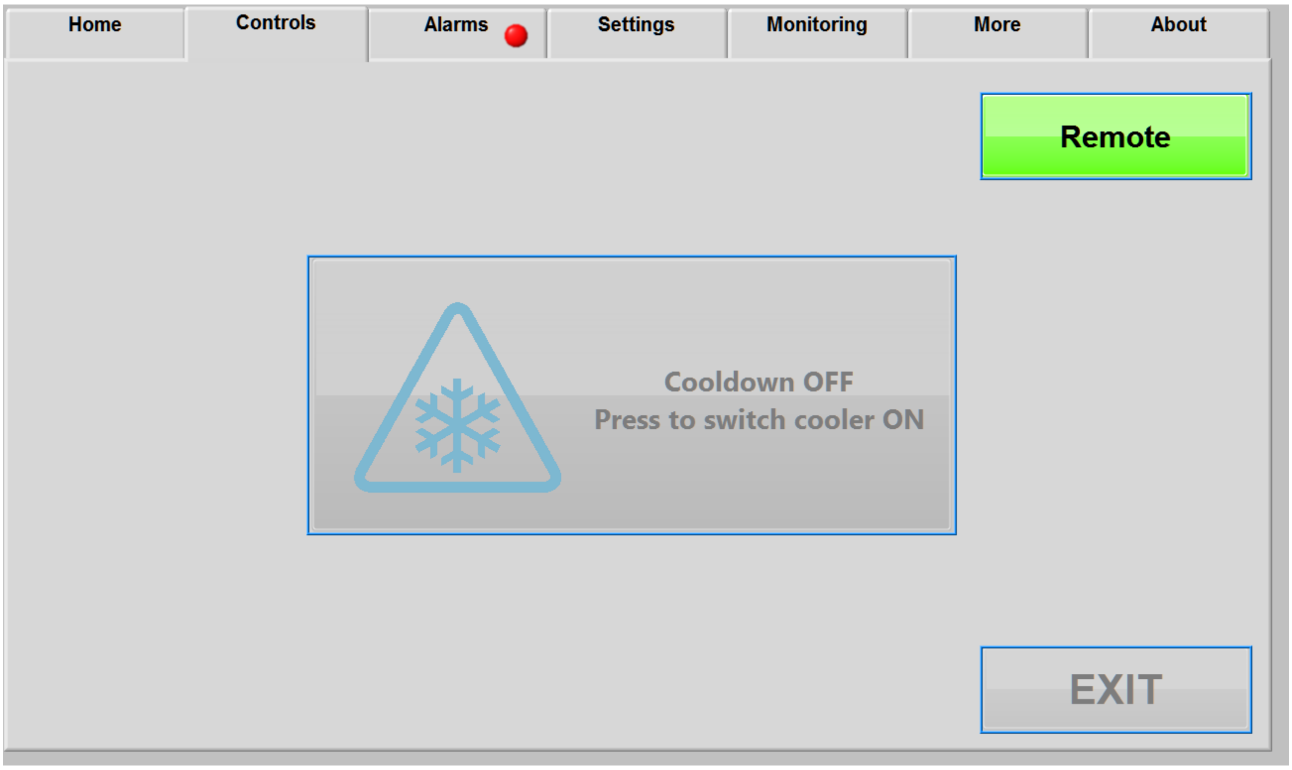
The following is the description of the parameters on the sections of the panel.

4.2.4.1 Main Parameters Display

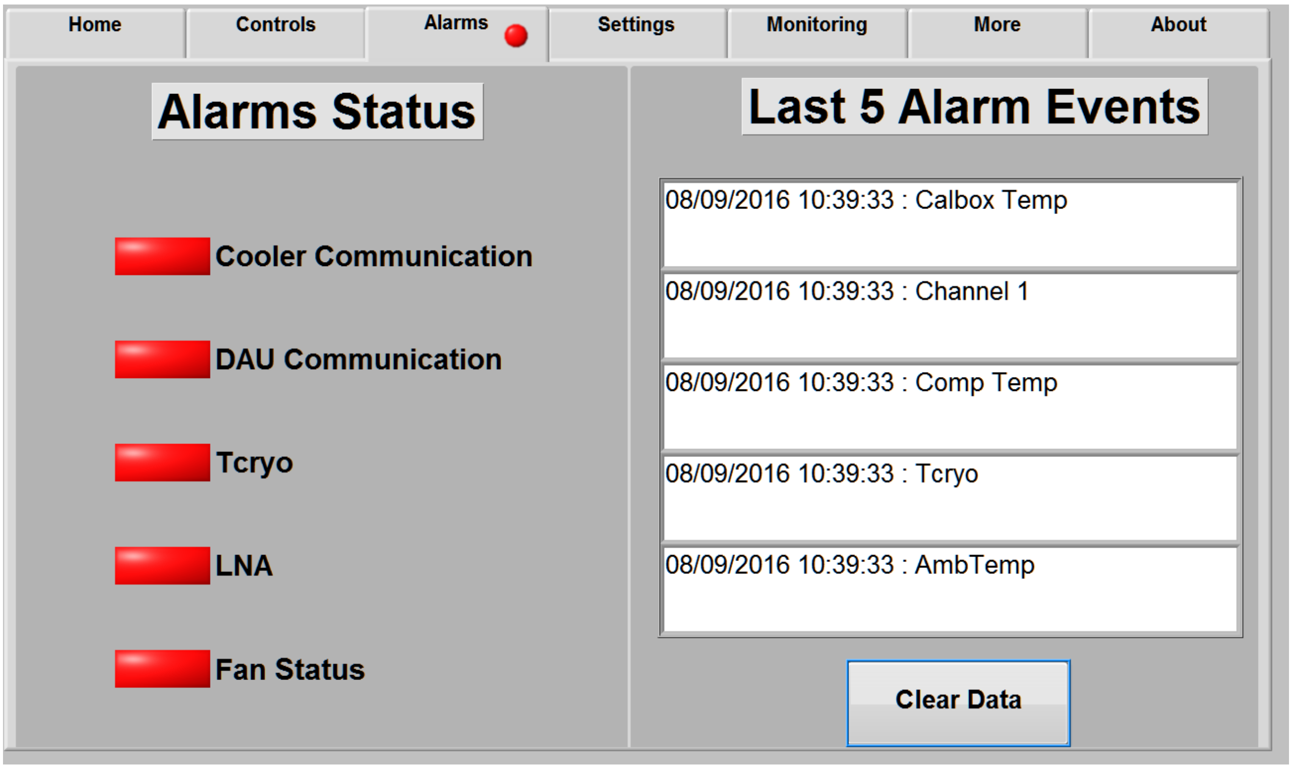


Home Tab	Description	Nominal or Default Value
Local/Remote	Selection of Local (MMI) or Remote (FEC) control mode. Green when in Remote, Red when in Local.	Remote (Green)
Maintenance/Operating	Indicator switch between Maintenance and Operating Mode.	Operating (Green)

Cooler Status	Operation mode of the cooler. “Cooldown”: Cooldown in progress. “Cool Ok”: Base temperature reached. “Off-In progress”: The cryo-cooler is switched off is in process. “Off-Confirmed”: The cryo-cooler is switched off.	Cool Ok
Sum Alarm	Summary (Logic OR) of all the alarms generated by the system.	Green(no alarm)
TCryo	LNA Cryogenic Temperature in Kelvin (K)	80K



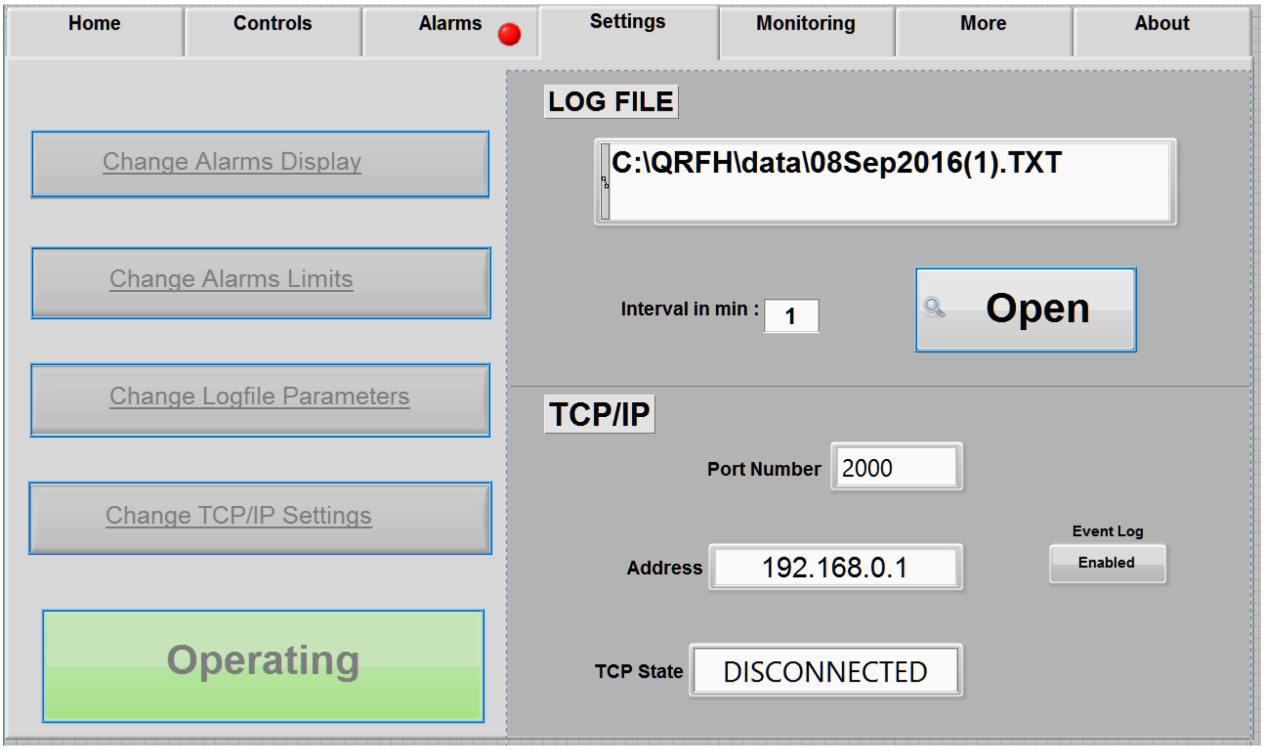
Controls Tab	Description	Nominal or Default Value
Local/Remote	Selection of Local (MMI) or Remote (FEC) control mode. Green when in Remote, Red when in Local.	Remote (Green)
Cooldown On/Off	Control to switch On/Off the cryo-cooler. Note: This control will be greyed-out when control is not possible from the local interface.(e.g when the LMS is in remote mode)	On
EXIT	Selector to stop software execution and return to MS Windows desktop.	NA



Alarms Tab	Description	Nominal or Default Value
Cooler Communication	Communication alarm between the cooler controller board and the embedded computer.	Dark Green (no alarm)
DAU Communication	Communication alarm with the PCI data acquisition board.	Dark Green (no alarm)
Tcryo	Status of the temperature of the system. Hidden when the temperature is in the limits, red if out of limits	Hidden (no alarm)
LNA	Status of the LNA of the channel (Cryo LNA + Post amplifier). Hidden when the current consumption of the RF chain is nominal, red if not.	Hidden (no alarm)
Fan Status	Status of the fan of the ventilation box. Hidden when the fan is On and red when the fan is Off.	Hidden (no alarm)
Last 5 alarm events	Five line indicator. Displays the five last alarm events which occurred, with the date/time of the occurrence. Display "None" when no alarm has occurred. Possible to erase the table with the button Clear data.	None.

4.2.4.2 Operation and Configuration

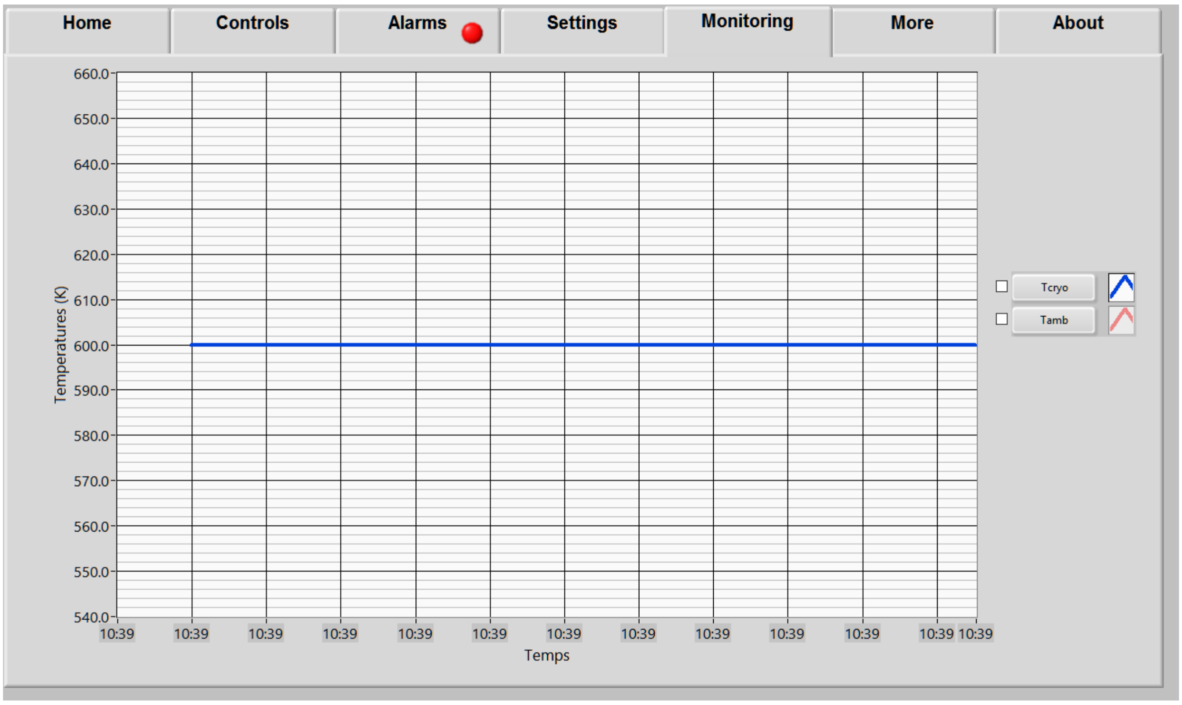
The "Open" button opens up the log files container folder. All the other parameters are indicators only (white background). To change the values (for instance log files path, interval log time, etc...) the Maintenance mode must be enabled.



Settings Tab	Description	Nominal or Default Value
Maintenance/Operating	Control to switch between Maintenance Mode and Operating Mode. The selection of maintenance mode gives access to a number of configuration parameters as described in §4.2.5. A password must be provided. If an incorrect Password is entered the software stays in Operating mode.	Operating (Green)
Change Alarms Display	Pop up window to allow the display of alarms see 4.2.5.4	Greyed out. The software must be in Maintenance Mode to access to this control.
Change Alarms Limit	Pop up window to allow the change the threshold of alarms see 4.2.5.5	Greyed out. The software must be in Maintenance Mode to access to this control.
Change Logfile parameters	Pop up window to allow the change of logfile configuration see 4.2.5.2	Greyed out. The software must be in Maintenance Mode to access to this control.
Change TCP/IP Settings	Pop up window to allow the change of TCP/IP logging see 4.2.5.3	Greyed out. The software must be in Maintenance Mode to access to this control.

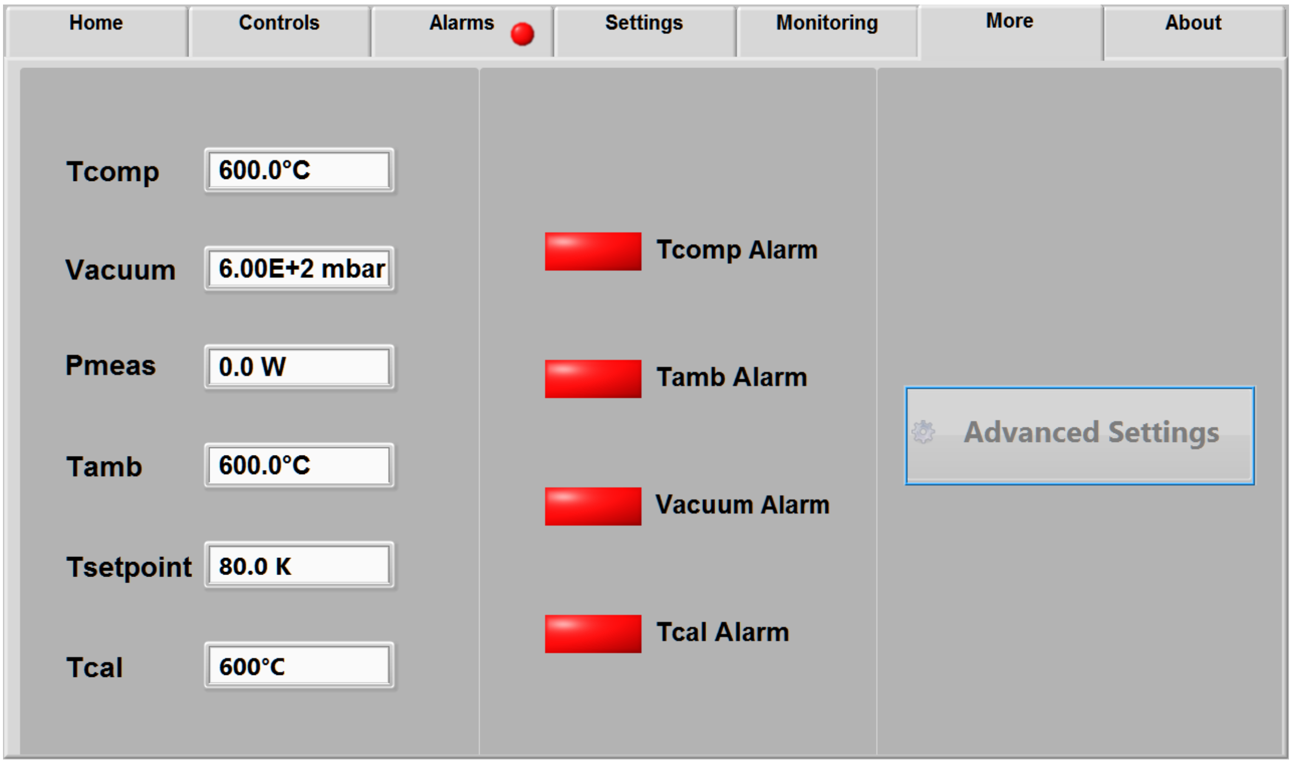
Log File Name	Path and name of log file. Selectable in Maintenance mode.	C:\QRFH\data
Log File interval	Time in seconds between log file records 1 to 5 min. Selectable in Maintenance mode.	1 min
Open	Control button to access directly the folder containing the log files.	
TCP/IP Address	TCP/IP Address of the PC (Please note this is a display parameter only. To change the address, access the MS Window Control Panel see §4.3.4)	192.168.0.1
TCP/IP Port Number	TCP/IP port number of the PC (set to 2000)	2000
TCP/IP State	Status of the TCP/IP connection (Connected or disconnected)	Disconnected
Event Log	Indicates if the TCP/IP events/errors logging is enabled or disabled	Enabled

4.2.4.3 Time History chart display



Monitoring Tab	Description	Nominal or Default Value
Charts display	Charts display up to 3 parameters. Parameters selectable/unselectable from button next to the charts display.	Tcryo

4.2.4.4 Details Parameters Display



More Tab	Description	Nominal or Default Value
TComp	Temperature of the compressor in degree Celsius (°C)	~33°C
Pmeas	Power consumption of the cryo-cooler in W.	~160W max.
TAmb	Environment Temperature at the vacuum window in degree Celsius (°C)	~25°C
Tsetpoint	Set point for the cryogenic temperature. This parameter is factory set.	80K
Vacuum	Vacuum pressure in the Dewar	<100 mbar
TCal	Temperature inside the Calibration Box (optional) in degree Celsius (°C)	50°C±2°C
Vacuum Alarm	Status of the pressure in the Dewar. Hidden when the Vacuum is in the limits, red if out of limits	Hidden (no alarm)
Tcomp Alarm	Status of the temperature of the compressor. Hidden when the temperature is in the limits, red if out of limits	Hidden (no alarm)

Tamb Alarm	Status of the ambient temperature. Hidden when the temperature is in the limits, red if out of limits	Hidden (no alarm)

4.2.5 Configuration of the LNA Sub-system

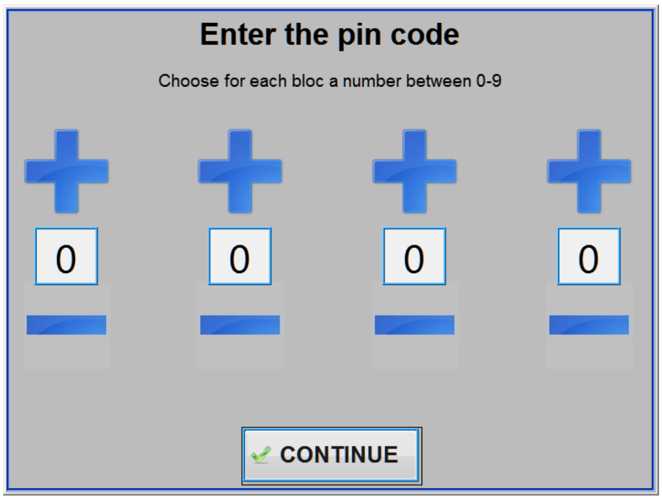
The only user configurable part of the sub-system is the ability from the monitor PC to place the sub-system into a maintenance mode and hence get access to the configuration facilities described below. This selection is not available from the remote interface. The selection of maintenance mode allows access to a number of configuration facilities. Again, these are only available at the local MMI in local mode.

The configuration facilities available are:

- Enable/Disable TCP/IP Log
- Change log file sampling interval and files destination
- Enable/disable parameter alarm generation (only affects local MMI, it does not affect the log files or the TCP/IP remote list)
- Set parameter upper and lower alarm thresholds.

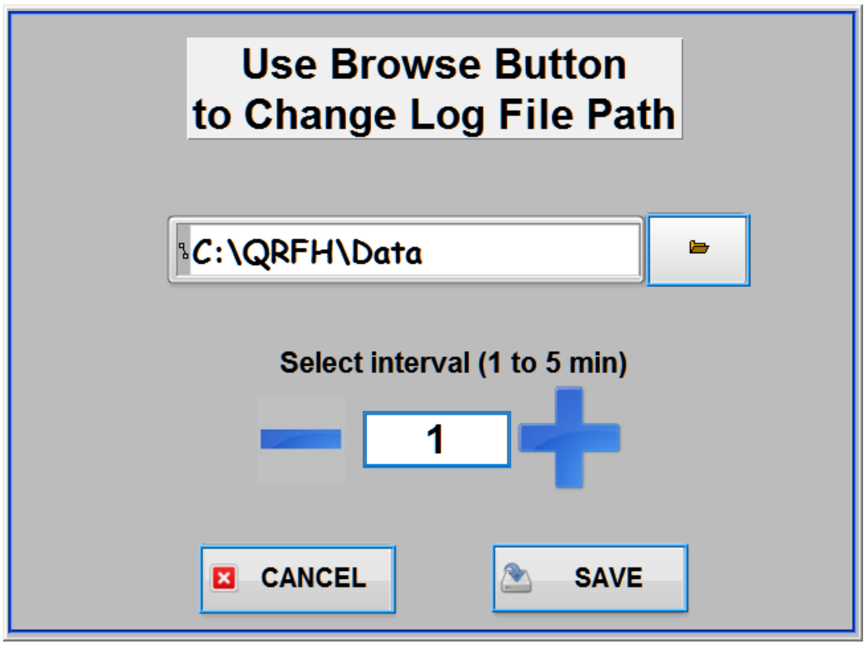
The detailed instructions for performing these maintenance mode configurations are described in the following paragraphs.

4.2.5.1 Maintenance Mode Access



This mode is enabled when the user selects “Maintenance” on the Settings Tab. After selection, the password window is displayed. Type the password and click on "CONTINUE" button. The password is configured as "1989".

4.2.5.2 Changing the Log File Sampling Interval



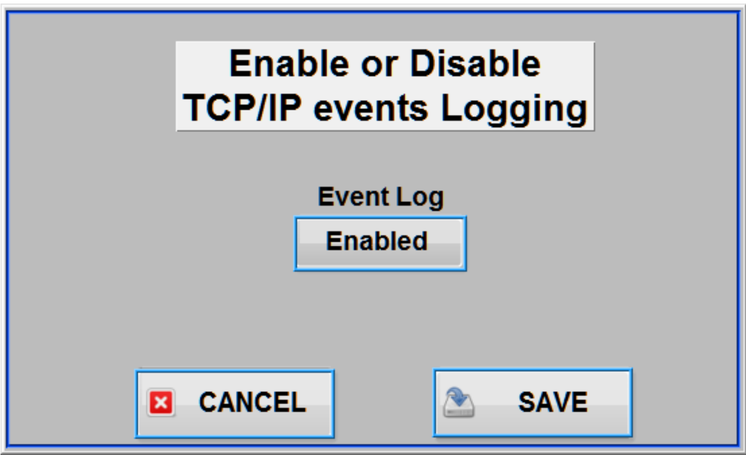
This function is only available when the MMI is in maintenance mode (see §4.2.5.1).

1. Click on "Change Logfile Parameters" button,.
2. Select the interval between log file entries to be from 1 to 5 min.
3. Use the arrow key or type directly in the "Select Interval" controller the required value.
4. When all required changes have been completed, click on the "SAVE" button.
    a. If you want to discard changes, click on the "CANCEL" button.

[You can change the Log file path by browsing folder when you click on the folder icon.]

[Do not change this setting unless you are sure the required directory already exists.]

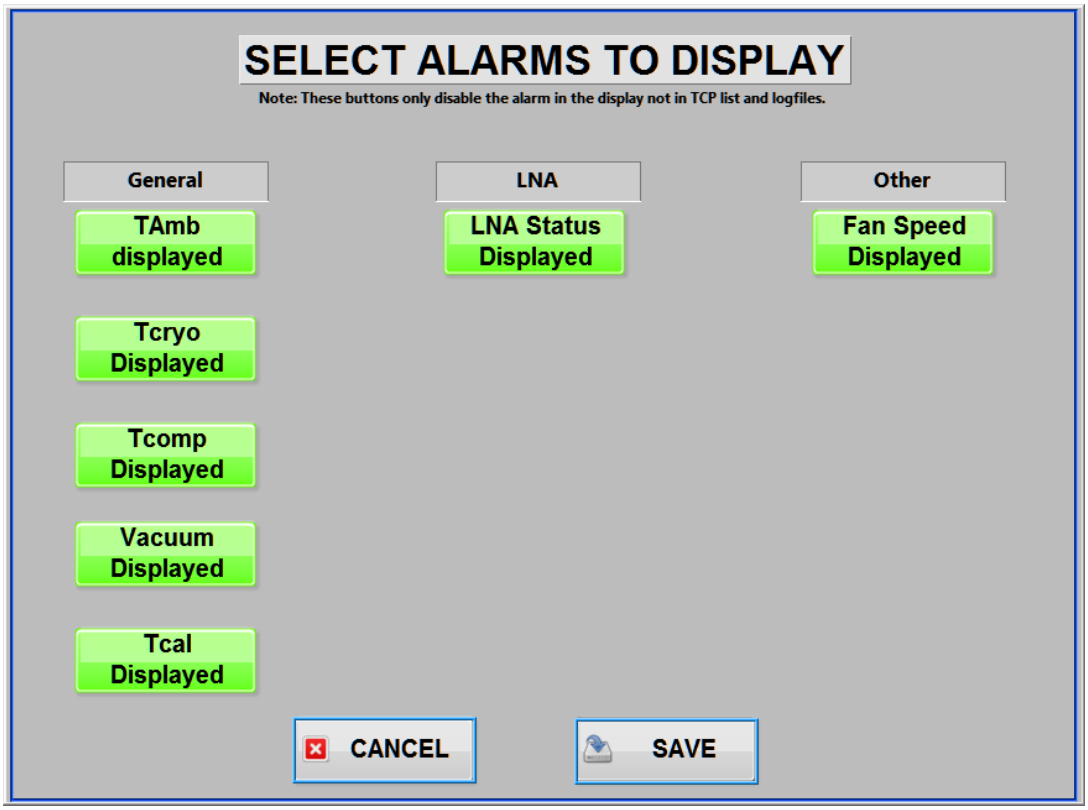
4.2.5.3 Enabling and Disabling TCP/IP Logging



This function is only available when the MMI is in maintenance mode (see §4.2.5.1).

1. Click on "Change TCP/IP Settings".
2. Click on the "Event Log" box to enable/disable the TCP/IP events/errors logging to file.
3. When all required changes have been completed, click on the "SAVE" button.
    a. If you want to discard changes, click on the "CANCEL" button.

4.2.5.4 Enabling and Disabling Parameter Alarms

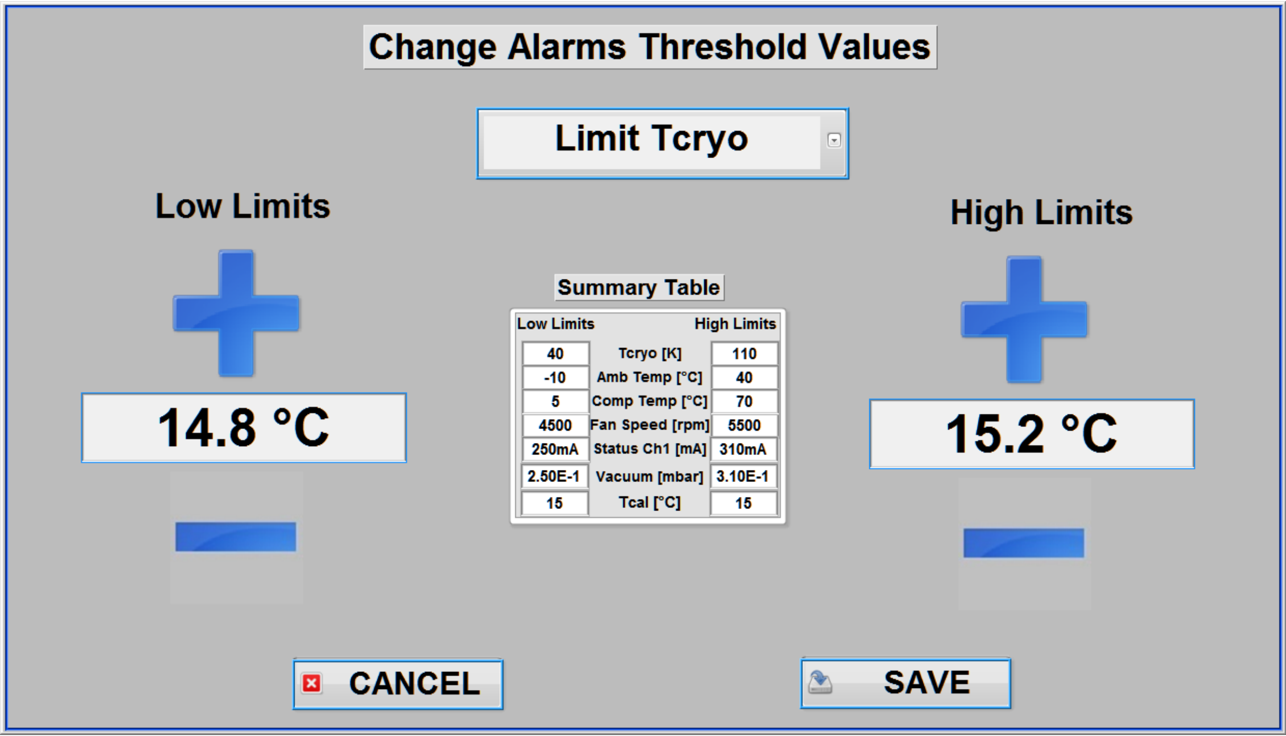


Note: This only affects the local MMI i.e. the display of the alarms on the front panel. Alarms will still be logged in log files and passed over the TCPIP interface.

This function is only available when the MMI is in maintenance mode (see §4.2.5.1).

1. Click on "Change Alarms Display".
2. Click on the desired parameter(s) to enable/disable the alarm generation. When the alarms are displayed the buttons is green and the text is explicit.
3. When all changes have been completed, click on the "SAVE" button.
    a. If you want to discard changes, click on the "CANCEL" button.

4.2.5.5 Setting Parameter Alarm Thresholds



This function is only available when the MMI is in maintenance mode (see §4.2.5.1).

1. Click on "Change Alarms Limit".
2. Select the desired parameter by using the selector
3. Change High/Low limits values of desired parameter by using arrow keys or by typing directly the new value required in the field between the +/- signs.
4. When all changes have been completed, click on "SAVE" button.
    a. If you want to discard changes, click on the "CANCEL" button.

4.2.5.6 Recovering Log Files

This operation can be performed in any mode.

4.2.5.6.1 Via a USB stick

The log files can be recovered with a USB stick connected to the PC-Unit drawer.

Click on "Open" button in the Log File frame. The folder containing the log file will pop-up.

1. You can double-tap (i.e. double-click) on the script file named "Get_Logfiles"; this will automatically copy all the files from the log files folder to the USB stick inside a folder named "Logfiles".

OR

1. You can recover the desired log file by doing a copy of the file and paste it in any chosen directory (local folder, USB key…).
    a. Note: to copy the file, press the file with one finger and maintain for about 2 seconds; a focus is activated on the file, then release your finger and an optional menu will be displayed (similar to the right click of a mouse). Select the "Copy" action; In order to paste the file, open the detination folder in a window, press and maintain in a blank area of the window of the destination folder then release; the sub-menu will be displayed; select "Paste".

4.2.5.6.2 Via the remote desktop

The log files can be recovered with a computer connected to the PSU Drawer optional connector (J8) via a LAN cable.

1. Click on "Open" button in the Log File frame. The folder containing the log file will pop-up.
2. Recover the desired log file by doing a copy and paste and save it in the chosen directory (Folder, USB key…).

Note: By default, the log files are located in C:\QRFH\data

4.2.6 Remote Interface

4.2.6.1 Monitored Variable List

The following list is delivered by the cryogenic receiver software in reply to the remote request « TBS? » sent in ASCII. The list length is fixed as described in Table 2-6.

Type	Byte n°	Bits								Description
		7	6	5	4	3	2	1	0	
Header										
	1	0	1	0	0	1	1	0	0	ASCII "L" (**L**NA)
	2	0	1	0	0	1	1	0	1	ASCII "M" (**M**onitor)
	3	0	1	0	1	1	0	0	0	ASCII "Q" (**Q**RFH)
Alarms										
	4	*DAU Comm Error*								*Communication error with Data Acquisition Unit*
		0	0	1	1	0	0	X	0/1	0 = False ; 1 = True
		Cooler Comm Error								*Communication error with cooler controller*
		0	0	1	1	0	0	0/1	X	0 = False ; 1 = True

Type	Byte n°	Bits 7	6	5	4	3	2	1	0	Description
	5	*Cryo Temp Alarm*								*Cryogenic temperature alarm (value is out of threshold defined by the user)*
		0	0	1	1	X	X	X	0/1	0 = False ; 1 = True
		Comp Temp Alarm								*Cryocooler Compressor Temperature Alarm (value is out of threshold defined by the user)*
		0	0	1	1	X	X	0/1	X	0 = False ; 1 = True
		Ambient Temp Alarm								*Environment (Ambient) Temperature Alarm (value is out of threshold defined by the user)*
		0	0	1	1	X	0/1	X	X	0 = False ; 1 = True
		CalBox Temp Alarm								*(Optional) Calibration Box Temperature Alarm (value is out of threshold defined by the user)*
		0	0	1	1	0/1	X	X	X	0 = False (default) ; 1 = True
	6	*Amplifiers PSU Current Alarm*								*Amplifiers' Supply Current Alarm (value is out of threshold defined by the user)*
		0	0	1	1	0	X	X	0/1	0 = False ; 1 = True
		Fan Alarm								*Cryogenic Cooler Fan Alarm (fan is not working correctly)*
		0	0	1	1	0	X	0/1	X	0 = False ; 1 = True
		Vacuum Alarm								*Vacuum Alarm (value is out of threshold defined by the user)*
		0	0	1	1	0	0/1	X	X	0 = False ; 1 = True
		Sum. Alarm								*Summary Alarm (at least one of the alarms of the system is true) (It can be other alarm than those listed in the remote list)*
		0	0	1	1	0	0/1	X	X	0 = False ; 1 = True
Modes										
	7	*Operating Mode*								*Local/Remote configuration of the software*
		0	0	1	1	X	X	X	0/1	0 = Local ; 1 = Remote
		LNA Mode								*Cryogenic Receiver Operating Availability*
		0	0	1	1	X	0/1	X	X	0 = Maintenance ; 1 = Operating
		Cooler Mode								*Cryogenic Cooler Operating Mode*
		0	0	1	1	0/1	X	X	X	0 = Cooler Off ; 1 = Cooler On
	8	*Target Temp Status*								*Cryogenic Cooler's Target Base Temperature Status*
		0	0	1	1	0	0	0	0/1	0 = Not Reached ; 1 = Ok
Values										
		Cryo Temp								*Cryogenic Temperature in Kelvin (XYZ Kelvin (K) ; ex. 270 K) This returns "999" when value monitored is incorrect*
	9	X (ASCII string)								Hundreds K ; "0" ≤ X Value ≤ "9" ; ex. 2
	10	Y (ASCII string)								Tens K ; "0" ≤ Y Value ≤ "9" ; ex. 7

Type	**Byte n°**	**Bits**								**Description**
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
	11	Z (ASCII string)								Units K ; "0" ≤ Z Value ≤ "9" ; ex. 0
		Comp Temp								*Cryocooler Compressor Temperature in °C (XYZ °C ; ex. +45°C)* *This returns "-99" when value monitored is incorrect*
	12	X (ASCII string)								Sign ; X Value is + or - ; ex. +
	13	Y (ASCII string)								Tens °C ; '0' ≤ Y Value ≤ '9' ; ex. 4
	14	Z (ASCII string)								Units °C ; '0' ≤ Z Value ≤ '9' ; ex. 5
		Amb Temp								*Environment (Ambient) Temperature in °C (XYZ °C ; ex. +25°C)* *This returns "-99" when value monitored is incorrect*
	15	X (ASCII string)								Sign ; X Value is + or - ; ex. +
	16	Y (ASCII string)								Tens °C ; '0' ≤ Y Value ≤ '9' ; ex. 2
	17	Z (ASCII string)								Units °C ; '0' ≤ Z Value ≤ '9' ; ex. 5
		CalBox Temp								*(Optional) Calibration Box Temperature in °C (XYZ °C ; ex. +50°C)* *This returns "-99" when value monitored is incorrect*
	18	X (ASCII string)								Sign ; X Value is + or - ; ex. +
	19	Y (ASCII string)								Tens °C ; '0' ≤ Y Value ≤ '9' ; ex. 5
	20	Z (ASCII string)								Units °C ; '0' ≤ Z Value ≤ '9' ; ex. 0
		Cooler Power								*Cryogenic Cooler Power Consumption in W (XYZ W ; ex. 160 W or 080 W)* *This returns "999" when value monitored is incorrect*
	21	X (ASCII string)								Hundreds W ; "0" ≤ X Value ≤ "9" ; ex.1
	22	Y (ASCII string)								Tens W ; "0" ≤ Y Value ≤ "9" ; ex.6
	23	Z (ASCII string)								Units W ; "0" ≤ Z Value ≤ "9" ; ex. 0
		Vacuum								*Vacuum in mbar (WXYE-Z mbar ; ex. 350E-6 mbar)*
	24	W (ASCII String)								Hundreds ; "0" ≤ W Value ≤ "9" ; ex. 3
	25	X (ASCII String)								Tens ; "0" ≤ X Value ≤ "9" ; ex. 5
	26	Y (ASCII String)								Units ; "0" ≤ Y Value ≤ "9" ; ex. 0
	27	0	1	0	0	0	1	0	1	"E" ; ASCII ; power of 10
	28	Sign (ASCII String)								Sign Value is + or - ; ex. -
	29	Z (ASCII string)								Exponent ; "0" ≤ Z Value ≤ "9" ; ex. 0
End										
	30	0	0	0	0	1	1	0	1	ASCII "CR"
	31	0	0	0	0	1	0	1	0	ASCII "LF"

Table 4-1 : Monitored Parameters List

4.2.6.2 Remote Commands

The software manages remote commands sent by a client system via the LAN using TCP/IP protocol. Remote commands format must be as described in the following Table 4-2.

<u>Note:</u> In order to reply to a remote command (other than a TBS? for the monitoring list request), the software must be "Remote" mode. If the software is in "Local" mode, it won't reply to remote commands.

Type	Byte n°	Bits								Description
	min/max	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Monitoring List Request**
	1/6	0	1	0	0	0	1	0	0	ASCII "T"
	2/7	0	1	0	0	0	0	1	0	ASCII "B"
	3/8	0	1	0	0	0	0	1	1	ASCII "S"
Parameter										
	4/9	*Monitoring List Request*								*Request monitoring list to the cryo receiver software*
		0	0	1	1	1	1	1	1	ASCII "?"
Separator										***Only when two remote commands are grouped in one single request.***
*	5	0	0	1	1	1	0	1	1	ASCII ";" (semicolon) separates two remote commands grouped in one single request.
End										
	5/10	0	0	0	0	1	1	0	1	ASCII "CR"
	6/11	0	0	0	0	1	0	1	0	ASCII "LF"

Type	Byte n°	Bits								Description
	min/max	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**Cryocooler Command**
*	1/6	0	1	0	0	0	0	1	1	ASCII "C" (Cryocooler)
	2/7	0	1	0	0	0	0	1	1	ASCII "C" (Cooling)
	3/8	0	1	0	0	0	0	1	1	ASCII "C" (Command)
Parameter										
*		*Cryocooler Operation*								*Cryocooler (Cooling) On/Off command*
		0	0	1	1	0	0	0	0/1	0 = Cryocooler OFF ; 1 = Cryocooler ON
Separator										***Only when two remote commands are grouped in one single request.***
*	5	0	0	1	1	1	0	1	1	ASCII ";" (semicolon) separates two remote commands grouped in one single request.
End										
	5/10	0	0	0	0	1	1	0	1	ASCII "CR"
	6/11	0	0	0	0	1	0	1	0	ASCII "LF"

Table 4-2 : Remote Commands

* **Note :**

The “cryocooler operation” command will NOT be executed if the software is in “Local” Mode. The user must switch the software in “Remote” mode (which can be done only from the software MMI interface) to allow users to send remote commands. However the software mode (Local/Remote) does not restrict the response to the monitoring list request (TBS?). For instance, the software is in local mode, the user wants to switch on the cryocoooler from remote, the remote command will be received by the software but it won’t be executed, the cryocooler will remain off.

Examples of remote commands sent by a client in ASCII:

Ex1: Remote command to switch off the cryocooler (and so warmup up the receiver):

CCC0<CR><LF>

Ex2 : Remote command to switch on the cryocooler (and so cooldown the receiver):

CCC1<CR><LF>

Ex3 : Remote command to request a monitoring list:

TBS?<CR><LF>

Ex4 : Grouped remote commands to switch off the cryocooler and request a monitoring list :

CCC0;TBS?<CR><LF>

4.3 Offline Operations

4.3.1 Recovering Log Files

See section 4.2.5.6.

4.3.2 Open the log files using MS Excel.

Log files are readable by using MS Excel.

The procedure to follow is:

1. Recover the log file as explained in §4.2.5.6
2. Run MS Excel by selecting on the Taskbar: Start, Programs, Microsoft EXCEL
3. Select "Open"
4. In the "File of type" option select "Text" file then select the required log file to open
    a. If the file selected is currently used by the LMS, you will be prompted to use it as read-only, continue with read-only.
5. Now you can work on the log file (note values, create charts, etc...)
6. When finished close file without saving (or do a "save as" if required)

4.3.3 Log File Format

The log file format is shown in the following table. The majority of the column headings are self-evident. Particular codes for the "alarms" and for the "status" fields are given below:

Date:Time	Com Alarm	Tsun	LNA Cold Temp	LNA Tip Temp	Comp Temp	LNA Amb Temp	Cooler Power	PCB PSU	LNA Ch1 V	Cooler PSU	LNA Ch1 I	Fan Speed
27:03:00:00:01	0	297.3	293.8	293.9	21.7	20.7	-600	23.7	14.9	25.2	1	17

Tcryo3	Tcryo4	Tcal	Tset	Pheater	Alarms	Status	Comp Status	Alm High TAmb	Alm Low TAmb	Alm High TCryo1	Alm Low TCryo1	Alm High Tcomp
600	600	600	105	3000	0	12	2	40	-10	110	40	70

Alm Low Tcomp	Alm High CH1	Alm Low CH1	Alm High 15VDC1	Alm Low 15VDC	Alm High 24V	Alm Low 24V	Alm High Vcooler V	Alm Low Vcooler V
10	0.8	0.7	16	14	26	24	26	24

Alm High Fanspeed	Alm Low Fanspeed	Alm High Tcal	Alm Low Tcal	Alm High Vheater	Alm Low Vheater	Alm High Vacuum	Alm Low Vacuum
7500	6500	52	48	24	0	200	0

Vacuum mbar	Vacuum Gauge	S/N Dewar	S/N PSU
1.19E-01	0	4.61	1B792F3

Table 4-3: Log File Format

Column 2: "Com Alarm"

- "0" means no alarms
- "1" means DAU communication Alarm
- "2" means Cooler communication Alarm
- "3" means DAU and cooler communication Alarm

Column 3: "Tsun"

This is the temperature in Kelvin (K) monitored on the cold tip of the cryocooler. This value is used for automated temperature regulation of the cryocooler.

Column 4: "LNA Cold Temp"

This is the temperature in Kelvin (K) monitored on one of the two Low Noise Amplifiers (LNAs) connected to the cryocooler. Both LNAs are assembled symmetrically so this temperature can be extrapolated as the temperature of each LNA.

Column 5: "LNA Tip Temp"

This is the temperature in Kelvin (K) monitored on the cold tip of the cryocooler.

Column 6: "Comp Temp"

This is the temperature in degrees (°C) monitored on the compressor. If this temperature exceed 60° the cryocooler is stopped.

Column 7: "Amb Temp"

This is the temperature in degrees (°C) monitored on the extern of the system.

Column 8: "Cooler Power"

This is the power in Watt (W) monitored on the Cryocooler.

Column 9: "PCB PSU"

This is the Voltage in Volts (V) monitored on the PCB in the DAQ-PSU.

Column 10: "LNA Ch1 V"

This is the Voltage in Volts (V) monitored on the LNA in the Dewar.

Column 11: "Cooler PSU"

This is the Voltage in Volts (V) monitored on cryocooler power supply.

Column 12: "LNA Ch1 I"

This is the Current in Amps (A) monitored on the LNA in the Dewar.

Column 13: "Fan Speed"

This is the Speed in rpm (rpm) monitored on the fan in the Ventbox.

Column 14: "Tcryo3"

This is the temperature in Kelvin (K) monitored in the Dewar.

Column 15: "Tcryo4"

This is the temperature in Kelvin (K) monitored in the Dewar.

Column 16: "Tcal"

This is the temperature in degrees (°C) monitored on the Calbox

Column 17: "Tset"

This is the temperature in Kelvin (K) monitored on the compressor

Column 18: "Pheater"

This is the power in Watt (W) monitored on the heater's power supply in the calbox.

Column 19: "Alarms"

10 alarms are coded as a byte, each alarm corresponds to one bit.

Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Comments
									0/1	LNA Cold Temp Alarm 4.5.64.5.6.1
								0/1		Comp Temp Alarm 4.5.6
							0/1			Amb Temp Alarm 4.5.6.1.1 4.5.6
						0/1				CH1 Current Alarm 4.5.3
					0/1					PCB PSU Voltage Alarm 4.5.3
				0/1						Cooler PSU Alarm 4.5.3
			0/1							Ch1 PSU Alarm 4.5.3
		0/1								Fan Speed Alarm 4.5.4
	0/1									Vacuum Alarm 4.5.3
0/1										Tcal Alarm 4.5.6

Table 4-4: Table to decode the Alarms

- "0" means no alarm
- "1" means alarm

$$Value = Bit0 * 2^0 + Bit1 * 2^1 + ... + Bit9 * 2^9$$

e.g: Value = 17 means PCB PSU Voltage Alarm and LNA Cold Temp Alarm (Bit 4 and 0)

Column 20: "Status"

4 Status are coded as a byte, each status correspond to one bit.

Bit 3	Bit 2	Bit 1	Bit 0	Comments

			0/1	Local/Remote Status of Software: Local=1 and Remote =0
		0/1		Local/Remote Status of PSU: Local=1 and Remote =0
	0/1			Operation Mode: Maintenance=0 and Operating=1
0/1				Fan status: Running=1 and Off=0

Table 4-5: Table to decode the Status

$$Value = Bit0 * 2^0 + Bit1 * 2^1 + ... + Bit8 * 2^8$$

e.g: Value = 6 means PSU in Local Mode and Channel in Operating (Bit 1 and 2)

Column 21: "Comp Status"

- "0" means Cool (System is cooling down)
- "1" means Cool Ok (targeted base temperature reached)
- "2" means Off (Cooler stopped)

Column 22 to 43 "Limit Low or High for each parameter present

This is the value of the limit of the parameter. For example column 22 "Alm High TAmb" corresponds to the high limit sets in the software for the Tamb parameter, and the column 23 "Alm Low TAmb" corresponds to the low limit of this parameter (TAmb).

Column 44: "Vacuum mbar"

This is the pressure in the Dewar in millibar (mbar).

Column 45: "Vacuum Gauge"

- "0" means the gauge is for air-type residual gas (default)
- "1" means the gauge is for other type of residual gas (not applicable on production units)

Column 46: "S/N Dewar"

This is the Serial number of the Dewar.

Column 47: "S/N PSU"

This is the Serial number of the DAQ-PSU.

4.3.4 Changing the TCP/IP Address

This function is not available on MMI but via the operating system (the LMS must be stopped).

1. Connect to the PSU embedded PC remote desktop as explained in section 4.2
2. Exit LNA Monitoring Software then open MS Windows Control Panel and double click on "Network" icon (this is valid for MS Windows 7).
3. Select the sub-menu "Protocol" then double click on TCP/IP Protocols icon.
4. Enter a new valid IP Address in the corresponding window.

4.3.5 Set automatic PC clock via NTP

It is possible to synchronize the PC Clock to a NTP server as describe below:

1. Connect to the PSU embedded PC remote desktop as explained in section 4.2.
2. Open Date&Time window in the control panel and select on "Internet time" then click on synchronize to internet time provider.
3. Select the NTP server to synchronize to.
4. To change the time interval between synchronisations open the MS Windows Register editor.
5. Click on the start menu, write "regedit" in the taskbar and open it.
6. Then go to the key : HKEY_LOCAL_MACHINE\SYSTEM\ControlSet001\Services\w32time\TimeProviders\NtpClient
7. Double click on the value SpecialPollInterval and enter the new value in second for the interval time.
8. Click on OK then close the register interface and reboot computer.

[Warning: changing register could be a risky operation that could lead to computer failure if the wrong parameter is modified. Only qualified technician/engineer should perform this task.]

4.3.6 Configure the regional settings

1. Click on start menu, Settings , Control panel then Open the "regional Settings"utility
2. Choose 'English(United Kingdom) in the list
3. Choose the following format for the date dd/mm/yyyy

[Warning: if the date format is not correctly configured the automatic logging of parameters (log files) will not work]

4.3.7 M&C Software Update

The M&C software is installed from a USB stick or a downloaded installer provided by CALLISTO.

You have to uninstall the old version first:

1. Click on start menu, Settings , Control panel then Open the "Add or Remove Programs" utility
2. Click on "LMS QRFH" icon in the list then click on "Remove" button.
3. Use the Browse Option to reach Start Menu/Program/Start-up/QRFH.exe; right click on the icon and select "Delete" option.

Now **install** the new M&C software

1. Use MS Windows Explorer to locate the following directory or the downloaded installer file:
   E:\
   Where E:\is the USB drive name.
2. Run the setup.exe program in the selected directory
3. During the installation dialogue use the Browse" button to locate C:\QRFH folder (or create it if it does not exist) then click on "OK" and install the software by clicking on "Next" button.

4. Restart the PC
5. Check that all the following files are created on C:\QRFH
   C:\QRFH\QRFH.exe
   C:\QRFH\QRFH.ini
   C:\QRFH\QRFH.aliases
   C:\QRFH\data\Para default.txt

4.4 Remote Monitoring and Control

The LNA sub-system can be monitored and controlled remotely by the ground station FEC via a TCP/IP LAN interface. A complete list of remote monitor parameters and remote control parameter is provided in§4.2.6.

Note: To be able to control the LNA sub-system from remote the LNA Software must be set in Remote control mode – see §4

4.5 Faults and Alarms

4.5.1 General

The Compact QRFH Cryogenic LNA sub-system has been designed with a high degree of automatic fault detection and alarm generation. Faults and/or alarms detected are indicated on the local PC Main Control Panel, in the Log File and in the Remote monitor message sent to the FEC. A summary alarm is also displayed on the PSU drawer front panel. The following sections provide a guide to the first steps which can be taken in the diagnosis or resolution of faults and alarms.

4.5.2 Communications Alarms

1. Between the Dewar and the DAQ-PSU and between the DAQ-PSU and the PC-Unit.(Cooler Com Alarm on the MMI)

In case of problems first check the cable connections of the cable CAL-1704-03 “Cooler Power” and CAL-1704-04 “Cooler M&C In”. Check the cable connections of the cable CAL-1704-07 “Cooler M&C Out”. Check the connection on the ventilation box (J6), (J5); the DAQ-PSU (J4), (J5),(J7) and the PC-Unit (J4) .

2. Between the PC-Unit and the FEC

The communications is based on Ethernet LAN and TCP/IP. Check the cable connections on both sides.

There could be a large number of problems associated with TCP/IP networks and LAN configurations. In the first instance it is suggested you contact your network administrator to check the IP addresses assignation, subnet masks and the firewall configuration. For instance a ping test can inform on the good status of the connection but with firewall issues at software level.

4.5.3 Power Supply Voltage/Current level Alarms

There are three voltage levels and one current level which are monitored in the system. The following table gives the nominal values of each of these as well as the default threshold values for out-of-limit alarm generation.

Parameter Name	Unit	Nominal level	Upper Limit	Lower Limit	Comments
Status Ch1	mA	710	730	690	Current consumption of the Channel 1 (Cryo LNA + Post amplifier)
+15VDC1	V	15	15.5	14.5	Voltage supply to the Channel 1. This alarm is only visible in the logfile (4.3.3)
+24VDC	V	24	24.5	23.5	Voltage use inside the PSU Drawer. This alarm is only visible in the logfile (4.3.3)
+Vcooler	V	25.4	25.9	23.9	Voltage supplied to the cryo-cooler. This alarm is only visible in the logfile (4.3.3)

Table 4-6: Power Supply Voltage/Current Level Alarms

There is no mean for adjustment of any of the voltage levels in any power supply. In case of any voltage going out of limits then the associated Power Supply Drawer Unit (DAQ-PSU) must be replaced with a spare. All voltages are generated from the DAQ-PSU.

4.5.4 Fan Speed Alarm

The speed of the fan of the ventilation box is monitored. An alarm will occur if the speed of the fan is below the threshold limit.

Parameter Name	Unit	Nominal level	Upper Limit	Lower Limit	Comments
Fan speed	rpm	6200	6500	5500	Speed of the fan.

Table 4-7: Fan Speed Alarm

In case of alarm, first check the ventilation box, make sure the fan is not blocked and room is available in front of the fan. If the fan is not blocked follow the steps below depending on the situation:

1. The fan is not running.
    a) Switch off the cryo-cooler. (A hardware protection is implemented to automatically stop the cryo-cooler when TComp>70°C, a software protection is implemented when TComp >60°C)
    b) Contact Callisto (see section 5.2)

2. The fan is running but is dirty (full of dust for example)

a) Stop the cooler with the software
b) Switch off the system (Main power switch (SW1) on the DAQ-PSU and PC-Unit, it will turn off the PC and the cooler power supply)
c) Clean the fan with dry gas and lint free tissues
d) Switch On both system DAQ-PSU and PC-Unit (SW1)
e) If the fan speed alarm is still on, DO NOT restart the cooler, contact Callisto (see section 5.2).

4.5.5 Vacuum Alarm

The vacuum in the Dewar is monitored. An alarm will occur if the vacuum is below the threshold limit. If this alarm is ON, please refer to 5.3

Parameter Name	Unit	Nominal level	Upper Limit	Lower Limit	Comments
Vacuum	mbar	<100	100	1e-5	Vacuum limit.

Table 4-8: Vacuum Alarm

4.5.6 Temperature Alarms

There are four physical temperatures which are monitored. These are the cryogenic LNA temperature, the compressor body temperature and the ambient temperature (on the receiver body).

Parameter Name	Unit	Nominal level	Upper Limit	Lower Limit	Comments
Amb Temp	°C	NA	40	-10	Temperature at the RF input and vacuum window
Tcryo	K	105	300	15	Cryogenic temperature.
Comp Temp	°C	NA	60	5	Skin temperature of the compressor
Tcal	°C	50	52	48	Temperature of the Calibration box

Table 4-9: Temperature Alarms

4.5.6.1 Cryogenic LNA Temperature

The nominal value is 80 Kelvin with upper alarm limit of 110K, when the cooler is operating and the temperature stabilized. It should be noted that the LNA will function correctly even if the cryogenic LNA temperature is above the nominal or above the alarm limit. In fact the LNA will function correctly even at ambient temperature (295K = +22°C). However, at elevated cryogenic temperature the noise temperature of the LNA will be degraded and the RF gain will slightly degrade, compared to nominal values.

There are two basic reasons why the LNA cryo temperature should rise above the nominal operating level (excluding (obviously) a case of physical damage to the unit or failure of the PSU). These are:

- External ambient temperature outside operating limits (see section 2.13.1.5).

- Degradation of the performance of the cooler.

Each of these cases is described below as an aid to diagnosis and rectification:

4.5.6.1.1 External ambient temperature outside operating limits

The cryogenic cooler is designed to operate within certain limits of ambient temperature. The refrigerator compressor generates heat in the cooling process and the heat generated is dissipated from the compressor by the ventilation box. If the compressor body temperature rises above safe operational limits the system stops the cooler to prevent critical damage. Before the safe operational compressor temperature is reached the cryogenic temperature can increase because of the loss in cooling efficiency. The compressor body temperature of the LNA is also monitored (see §4.5.6.2). If the LNA cryo temperature alarm is accompanied by a compressor body temperature alarm then the recommended diagnosis procedure is as follows:

- Check the antenna air conditioning system is functioning correctly.
- Check the LNA ventilator fans are functioning correctly (see 4.5.4).

Note: Both seasonal and diurnal variations in ambient temperature can also cause small variations of cryo temperature, even in a nominal system.

4.5.6.1.2 Degradation of performance of the cryo-cooler

The cryocooler is stated as very reliable by the manufacturer and has a MTBF better than 10 years.

Slight degradation of cooling performance (shown by an increase of the cooler power consumed in normalized environmental conditions) is expected over the years (our estimation is 1W electrical power consumption increase per year).

In case the cooler power reached is constantly at maximum value (around 160W) with ambient temperature below 25°C and the cryogenic temperature is increasing above 110K) we recommend to stop the cooling and to replace the full Dewar by a spare.

It should be noted that even with the cooling "Off" the RF part still works but with degraded performance (less gain and more noise).

4.5.6.1.3 Vacuum early degradation

The pressure in a sealed vacuum enclosure will always increase over time, first because a sealing is never perfect but also because the gas sources inside a vacuum system are numerous. The main question is then the speed of this increase, i.e. the pressure increase rate. Depending on the application, the increase rate may be a critical parameter.

This is the case for the QRFH Compact Receiver, where the vacuum level inside the sealed receiver directly drives the thermal insulation performance of the receiver, so the heat load on the cryogenic cooler, then the cryogenic temperature of the feed and LNAs and in the end the Noise Temperature of the entire receiver!

Controlling this parameter can be very difficult due to the variety of gas sources in a complex, multi components, multi materials system such as a cryogenic RF receiver. Callisto implements specific procedures during the production of the receiver to ensure minimizing the pressure increase rate at factory to a maximum level of 1e-5 mbar.l/s. However, the pressure increase rate depends also on external parameters such as environment temperature and humidity around the vacuum sealed enclosure.

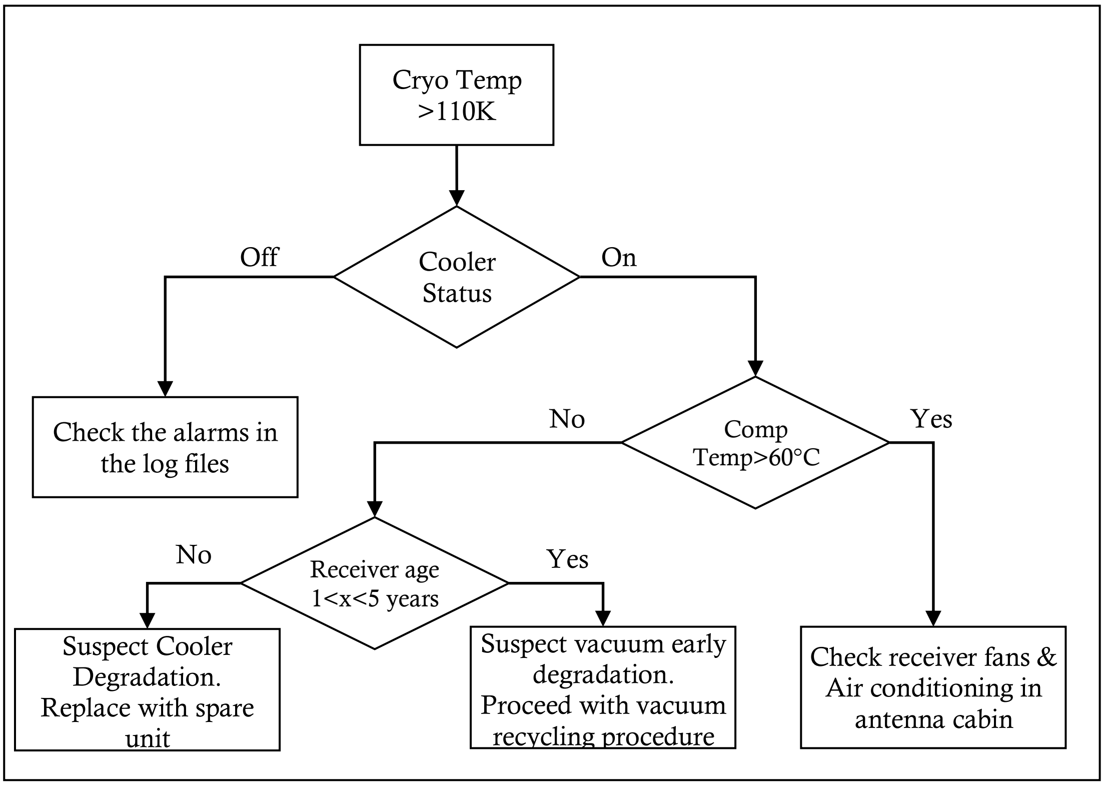
So depending on the combination of all the above conditions, the QRFH Compact Receiver may require, over its operational life, one or more regenerations of the vacuum inside the sealed unit to remove the gas products generating the pressure increase and thermal insulation performance degradation.

In any case if the pressure inside the receiver (warm or cold) is at or above 100mbar then a vacuum recycling is mandatory to regenerate the thermal insulation (see maintenance §5.3 for further information).It should be noted that even with a degraded vacuum level the RF part still works but with degraded performance (less gain and more noise).

4.5.6.2 Compressor Body Temperature

A compressor temperature alarm will occur when TComp>60°C. A hardware protection will automatically stop the cryo-cooler when TComp>70°C. The possible reasons of an alarm condition for the compressor body temperature are described in the previous section 4.5.6.1.2 or can be due to a fan failure (see 4.5.4). The fan of the receiver typically maintains Tcomp 10°C to 15°C above environment temperature.

4.5.6.3 Troubleshooting



5. MAINTENANCE

The Compact QRFH Cryogenic LNA sub-system has been designed to minimize the need for regular maintenance intervention and to maximize the service life (at least 5 years). There is zero Maintenance required on the cryocooler system over this service life; once the performance of the cryocooler is too degraded to allow for nominal NT performance of the receiver, the cryocooler must be entirely replaced. There is one recommended preventative maintenance procedure, which is described below concerning the cleaning of the fans of the ventilation box and the DAQ-PSU unit. Otherwise, only one corrective action can be done on-site (vacuum recycling); any other failure of the operational unit should be rectified by means of replacement with spare equipment and/or return of the faulty equipment to the manufacturer (Callisto) for investigations and repair. The return address and contact is given in the section below;

WARNING

1. The LNA Dewar is a sealed unit. Do not attempt to open it. If the seal is broken the unit will not function correctly and the warranty will be void. There are no user serviceable components inside the LNA Dewar.

2. The LNA Cooler contains pressurised Helium gas. Do not attempt to open it, high pressure gas can be harmful. If the gas seal is broken the unit will not function correctly. There are no user serviceable components inside the cryo-cooler.

5.1 Ventilation box fan cleaning

The fan has to be inspected regularly for dust and dirt accumulation that would impede the flow of air through the ventilation box. The frequency of cleaning the fan depends on the air quality of the site. The user needs to establish the inspection routine according to the operating environment, it can be monthly, every 2 month, every 6 month, annually… If the fan is dirty, clean it following the steps below:

1. Remove the fan filter cover
2. Clean the filter with dry gas
3. If the filter still full of dust, change the filter with the following reference:
   Radiospares : 494-7981 or Ebm-papst FP120T

5.2 DAQ-PSU unit fan filter cleaning

On an annual basis[2], inspect the filter fan for dust and dirt accumulation that would impede the flow of air through the DAQ-PSU. In some cases, the frequency of cleaning the fan depends on the air quality of the site. Both fan filters need to be checked:

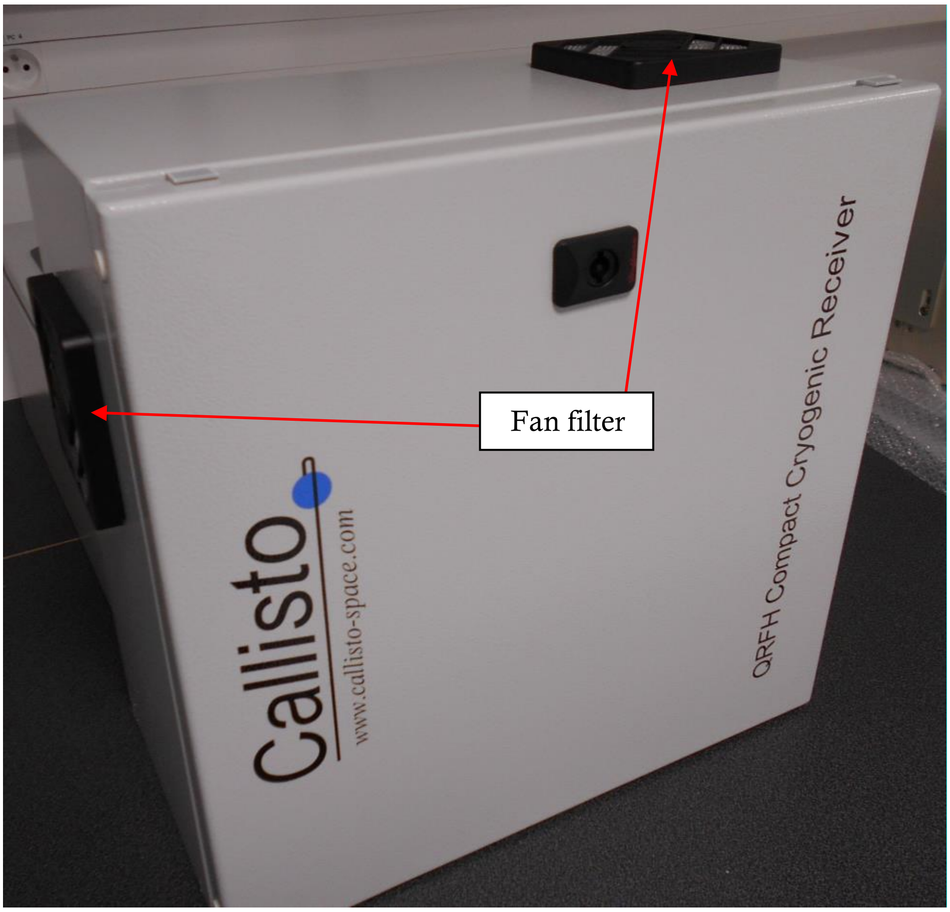


Figure 5-1: DAQ-PSU Unit fan filter location

If the filter fan is dirty clean it following the steps below:

1. Remove the fan filter cover
2. Clean the filter with dry gas
3. If the filter still full of dust, change the filter with the following reference:
   Radiospares : 494-7981 or Ebm-papst FP120T

5.3 Vacuum recycling

The pressure in a sealed vacuum enclosure will always increase over time, first because a sealing is never perfect but also because the gas sources inside a vacuum system are numerous. The main question is then the speed of this increase, i.e. the pressure increase rate. Depending on the application, the increase rate may be a critical parameter.

This is the case for the QRFH Compact Receiver, where the vacuum level inside the sealed receiver directly drives the thermal insulation performance of the receiver, so the heat load on the cryogenic cooler, then the cryogenic temperature of the feed and LNAs and in the end the Noise Temperature of the entire receiver!

Controlling this parameter can be very difficult due to the variety of gas sources in a complex, multi components, multi materials system such as a cryogenic RF receiver. Callisto implements specific procedures during the production of the receiver to ensure minimizing the pressure increase rate at factory to a maximum level of 1e-5 mbar.l/s. However, the pressure increase rate depends also on external parameters such as environment temperature and humidity around the vacuum sealed enclosure.

So depending on the combination of all the above conditions, the QRFH Compact Receiver may require, over its operational life, one or more regenerations of the vacuum inside the sealed unit to remove the gas products generating the pressure increase and thermal insulation performance degradation.

In any case if the pressure inside the receiver (warm or cold) is at or above 100mbar then a vacuum recycling is mandatory to regenerate the thermal insulation.

This procedure is relatively simple and can be done with the receiver still attached to the antenna.

A simple vacuum backing pump is required for this procedure rather than a high-performance pump such as a turbomolecular pump. It is recommended using a dry scroll vacuum pump with pumping speed between 5 and $15m^3/h$, with pressure limit around or below 1.10^{-2} mbar; for instance reference nXDS10i from Edwards Vacuum.

The following section presents the procedure.

5.3.1 Procedure

This is the standard, recommended procedure for vacuum recycling. This should be applied when the cryogenic temperatures of the receiver are severely degraded and/or unstable and the vacuum level inside the receiver is in the 100mbar range.

During the vacuum regeneration procedure the cryocooler should be stopped and the receiver allowed to warm-up to room temperature before cooling down again. Thus, due to the duration of the warm-up, the complete procedure will require many hours of pumping, typically 12 hours before restarting the cooling.
Prepare the following tools:

- Dry Scroll Vacuum Pump, vacuum interface NW25KF
- 1 to 2-m long flexible vacuum pipe ("tombac"), vacuum interface NW25KF, to connect vacuum pump to Receiver vacuum valve (located on receiver base plate, next to fan box)
- Vacuum o-rings and clamps, quantity as required, vacuum interface NW25KF, to connect vacuum pump to Receiver vacuum valve (located on receiver base plate, next to fan box)
- Lint-free tissues for vacuum interfaces cleaning
- Electrical power cord extender for the vacuum pump, length as required
- Ensure access to the vacuum valve on the receiver base plate is available for an operator
- Vacuum valve handle

Procedure:

1. Remove all vacuum interfaces protective plastic caps and ensure the vacuum interfaces and o-rings are perfectly clean, with no small dust/hair particles that could create leaks. If not, clean

carefully the interfaces with dry soft lint-free tissues; do not use solvent such as acetone as this will damage the o-rings and generate leaks, avoid using water and/or alcohol that may increase outgassing rates and permeation of o-rings; if the interface and/or o-ring are damaged (scratches, others) then replace the part by a new one. If the vacuum valve interface of the receiver is damaged, contact Callisto for support (see section 5.4).

2. Connect the vacuum pipe to the receiver vacuum valve (interface NW25KF), ensure o-ring is correctly fitted and clamped on the flange
3. Connect the other side of the pipe to the vacuum pump, ensure o-ring is correctly fitted and clamped on the flange
4. Connect the vacuum pump to the mains and start the pump
5. Wait 5 minutes to ensure good vacuum inside the vacuum pump and pipe; This is critical as the receiver operates at cryogenic temperature.
6. Connect the vacuum valve handle on the receiver valve
7. Actuate the handle to open the valve; the handle must be turned 90° from closed position to ensure 100% opening of the valve
8. Stop the cryogenic cooling of the receiver (switch off the cooler, from the M&C software interface see section 4.1.2)
9. Keep the vacuum pump running and receiver vacuum valve open during the entire warmup time of the receiver. This is typically 12 hours long but it can take as long as 15 hours depending on environmental conditions.
10. Once cryogenic temperature of the receiver reaches room temperature (typically above 285K, depending on environmental temperature) check the vacuum inside the receiver on the M&C software:
    a. if value is above 0.1 mbar (1e-1mbar), continue the pumping, keep the pump running and connected to the open valve of the receiver until pressure decrease further.
    b. if value is below 0.1 mbar (1e-1mbar):
11. Switch back ON the cooler to restart the cooldown (see section 4.1.24.1.1)
12. Close the receiver vacuum valve using the dedicated handle; the handle must be turned 90° from open position to ensure 100% closing of the valve
13. Stop the vacuum pump
14. Check the vacuum inside the receiver on the M&C software: it should remain stable over 1 minute,
    a. If the vacuum increases quickly over few minutes, there may be a leak on the system. We recommend stopping the cooling, leaving the receiver warming up then contact Callisto for support (see section 5.4). Please attach the system log files covering the past 100 hours.
    b. If the vacuum is stable:
15. Disconnect the vacuum pump from the vacuum pipe
16. Disconnect the pipe from the receiver vacuum valve
17. Protect all the vacuum interfaces with plastic caps, including the receiver vacuum valve interface, to prevent dust contamination and scratches.
18. The vacuum recycling procedure is over.
19. Monitor the cryogenic temperature of the receiver over the next 48 hours after the end of the cooldown; you should notice that the cryogenic temperature will decrease and/or be more stable than before the procedure. If not, please contact Callisto (see section 5.4) and attach the system log files covering the past 100 hours.

For any question on this procedure, please contact Callisto (see section 5.4).

5.4 Shipping Address for Returned Items

In case any equipment has to be returned to Callisto for repair, the shipping address is as follows.

Prior to shipping any item please contact Callisto to advise details of the problem and get a RMA number for the equipment to be shipped. Failure to do this may result in the shipment being refused at reception at Callisto.
Callisto France SARL
12 Avenue de Borde Blanche
31290 Villefranche de Lauragais
France
Tel. +33 561 800 807
Fax. +33 534 666 478

Please note that the LNA has been originally supplied and shipped in a re-usable, tailor made shipping container. This container must be retained at the ground station site and it must be used if the receiver has to be shipped back for repair.

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**