QRFH Compact Wideband Cryogenic Receiver for Patriot 12m Telescope

<u>Interface Control Document</u>

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Prepared by	:	**Rémi RAYET**
Reviewed/Approved by	:	**Steve RAWSON**
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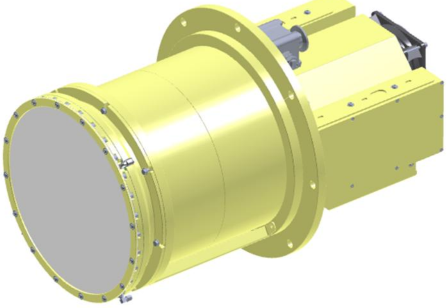

Callisto
12 Av.de Borde Blanche
Villefranche de Lauragais F-31290
Tel. +33 561 800 807
www.callisto-space.com

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1. INTRODUCTION

1.1 Purpose

This document defines all the external interfaces to the Wideband Cryogenic Receiver for VLBI. The purpose of the document is to ensure that the receiver is compatible with the telescope systems where it will be integrated.

1.2 Applicable & Reference Documents

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

1.2.1 Applicable Documents

AD 1 User Manual, Wideband Cryogenic Receiver for VLBI - Compact QRFH, ref. DOC/1704/3991

1.2.2 Reference Documents

RD 1 E-mail from Sandy Weinreb 3.Jul.14 and 21.Jul.14 about location of phase centre of 2-14 GHz QRFH

RD 2 Hittite HMC-C018 0.5dB LSB GaAs MMIC 6-Bit Digital Serial Control Attenuator Module Data Sheet

RD 3 Noise Com NC3200 Series Noise Diode Data Sheet

RD 4 Results of beam pattern measurement for the QRFH Receiver (with feed QRFH-45-6-2-2P3), Callisto Technical Note, ref. TEC/1924/3793

2. SUBSYSTEM OVERVIEW

2.1 General

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:

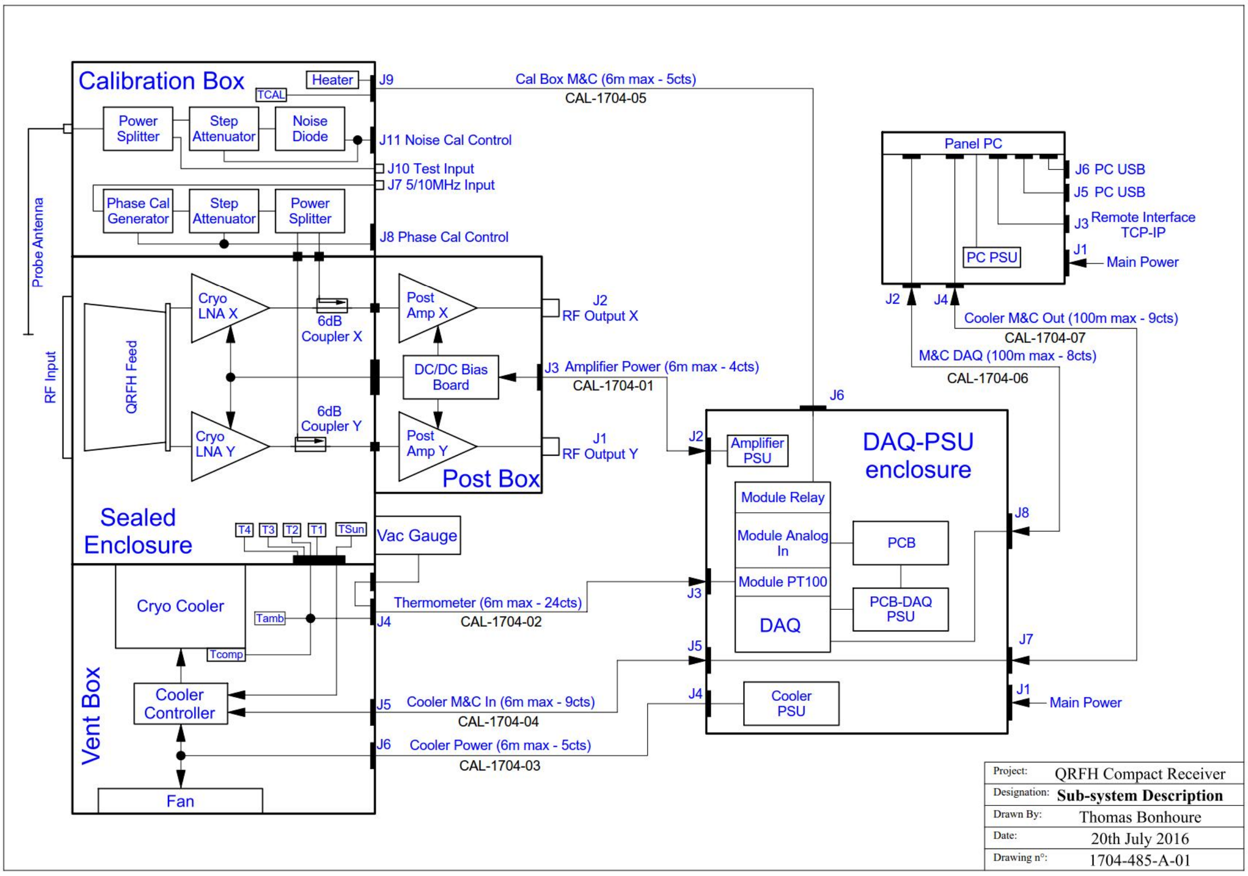


Figure 2-1: Subsystem Description

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 4-1 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)

2.2 Receiver Specifications

Parameter	Specification	Comments
Frequency Band	2 – 14GHz	
Noise Temperature	< 40K	At Dewar window excluding external noise contributions (Tsky, Tg, Tant)
Gain	>55dB	
Gain flatness	10dBpp	
Output Return loss	10dB minimum	14dB typical
Pout 1dB	+20dBm	
Cooldown Time to reach RF Specification	5hrs	Typical value at 20°C environmental temperature
Input	Free space radiation	
RF output connector	SMA	Opposite to input
10MHz Phase Cal I/P	SMA	+10dBm minimum power level
Dimension	L618.15mm x Ø311mm	Ø at RF Input Window (Ø381mm at base plate for mechanical mounting interface)
Weight	<27kg	
Mounting	Any orientation on movable antenna structure.	
Operating temperature	-10°C to +40°C	+25°C average monthly recommended in order to increase the cooler lifetime
Storage temperature	-40°C to +60°C	
Relative Humidity	To 90% non condensing	Condensation on vacuum window can occur on high humidity unless radome is used with dry air.
Ventilation Requirement	Forced air cooling	Air supply ≤25°C recommended.
Maximum Input Power	400W	340W typical during normal operation
Input Voltage	90VAC to 264VAC	Voltage range needs to be selected by the final customer at time of purchase order.
Input Frequency	47Hz to 63Hz	
Distances		
between receiver and DAQ-PSU Drawer	≤ 6m	
between DAQ-PSU Drawer and PC unit	≤ 20m	Up to 100m as an option
Local M&C function	Panel PC (touchscreen)	All functions available locally via touchscreen Limited M&C functions available via remote monitoring (TCP/IP)
Cryo Cooler MTBF	200 000Hrs	Cooler operating at nominal values
MTBM	5 years expected	Time before maintenance

Table 1 Technical specifications for QRFH Compact Wideband Cryogenic Receiver

3. INTERFACE SPECIFICATIONS

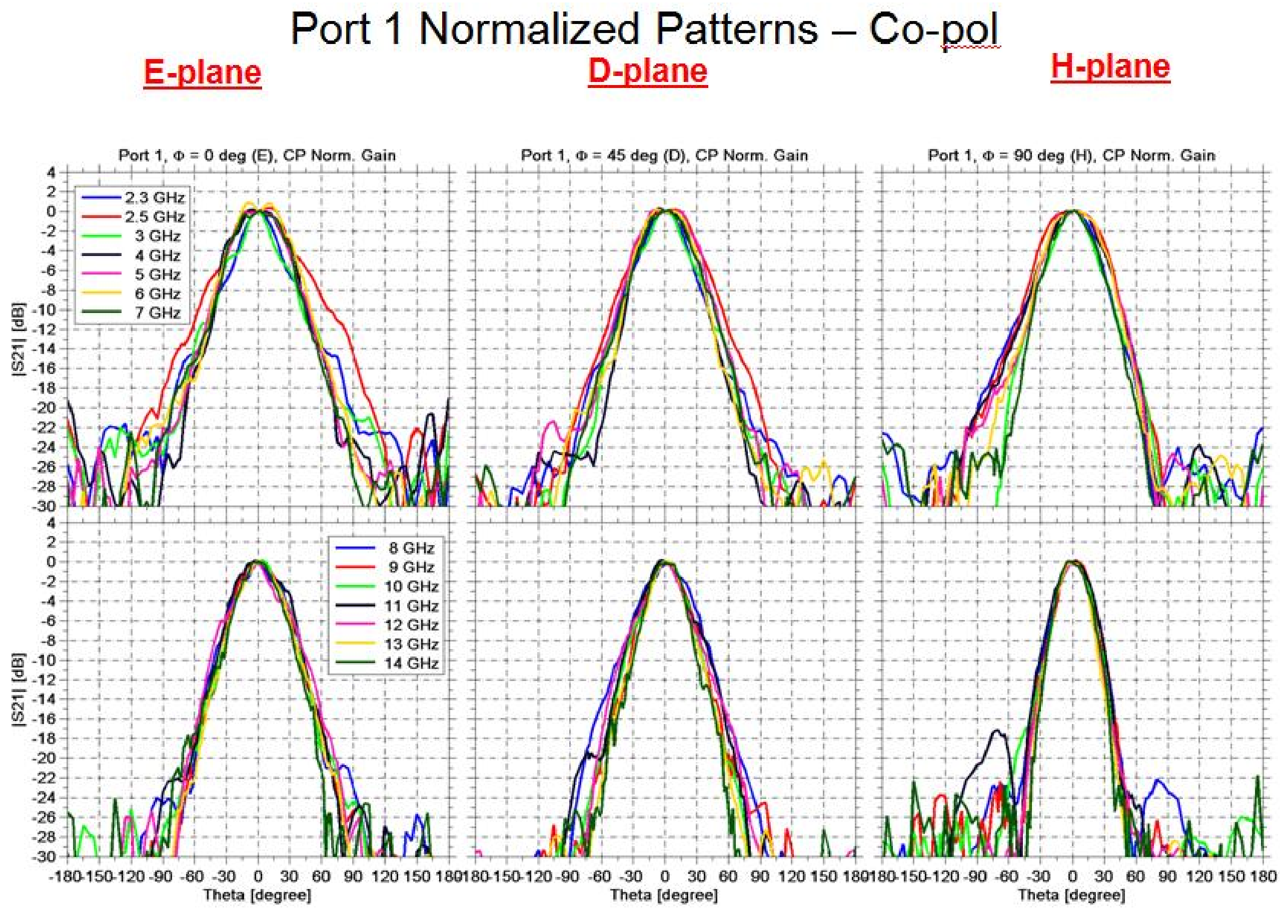
3.1 RF Signal Input.

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°.

Radiation patterns of the 2-14 GHz QRFH-45-6-2-2P3 feed alone (without receiver) are shown in the following plots (Source courtesy of CalTech S.Weinreb).

Pattern simulations and measurements of the entire receiver are available from Callisto on demand (RD 4).



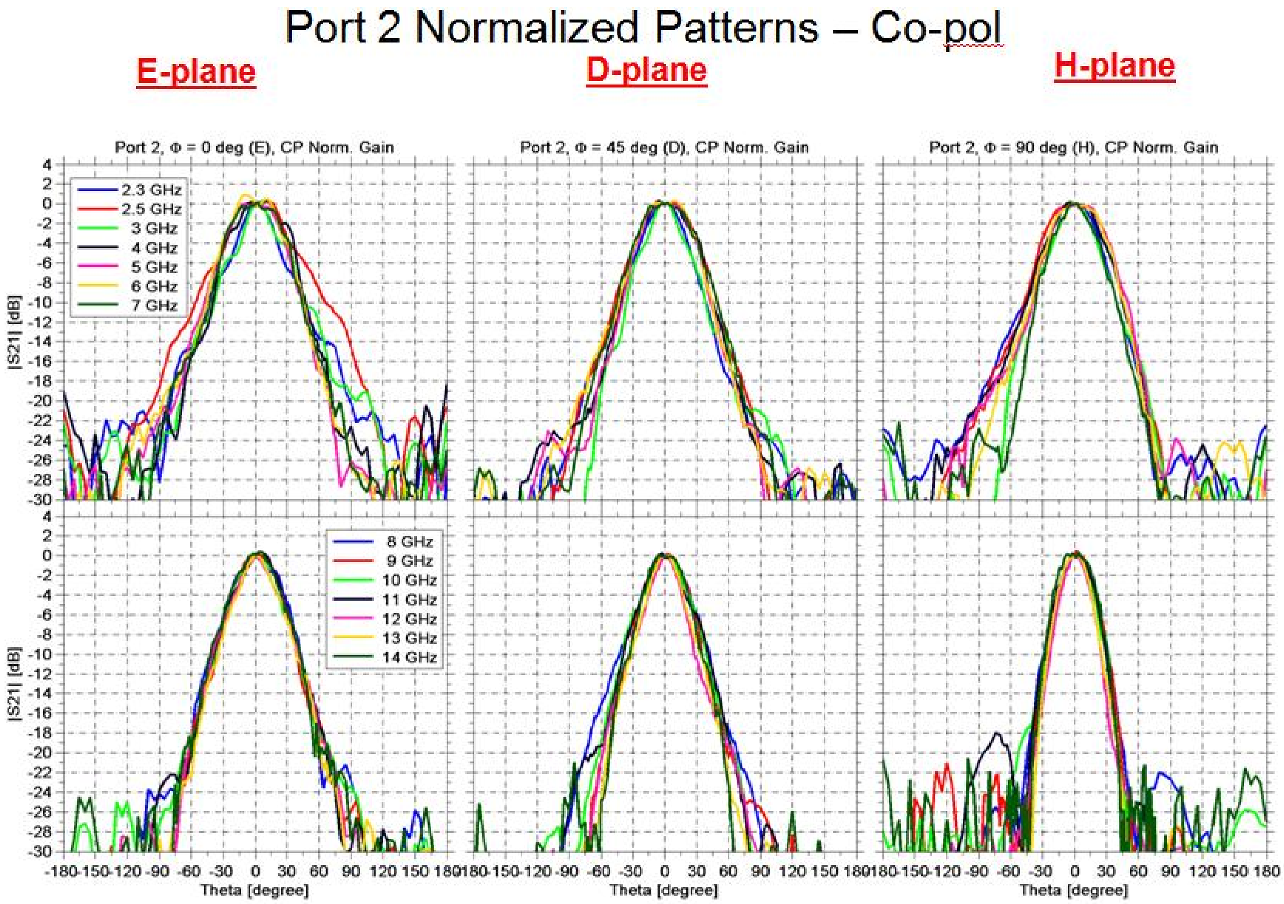


Figure 3-1 QRFH-45 Radiation Measured Radiation Pattern

3.2 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

3.3 Phase Calibration (Optional –CalBox)

3.3.1 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.2]
2	GND Att phase	Digital attenuator grounding. For more information see the Hittite HMC-C018 datasheet [RD.2]
3	Shift Clock Att phase	TTL Clock signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
4	Serial Input Att phase	TTL Serial signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
5	Reset Att phase	TTL Reset signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
6	Latch enable Att phase	TTL Latch Enable signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
7	+15VDC	Comb generator supply voltage (70mA typical current consumption).
8	GND	Comb generator ground.

For all other interface specifications and serial data protocols see RD.2

3.3.2 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 minimum.

3.4 Noise Calibration Control

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.2]
4	GND Att noise	Digital attenuator grounding. For more information see the Hittite HMC-C018 datasheet [RD.2]
5	Shift Clock Att noise	TTL Clock signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
6	Serial Input Att noise	TTL Serial signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
7	Reset Att noise	TTL Reset signal. For more information see the Hittite HMC-C018 datasheet [RD.2]
8	Latch enable Att noise	TTL Latch Enable signal. For more information see the Hittite HMC-C018 datasheet [RD.2]

For all other interface specifications and serial data protocols see RD.2

3.5 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 TBD.

3.6 Mains Power Interfaces (mains power is provided by the antenna)

Electrical Service:	Input voltage: 90VAC-132VAC **or** 191VAC-264VAC. The input voltage has to be specified by the final customer. Input frequency: 47Hz to 63Hz
Power required:	350Wmax. (300W typical during normal operation)
Connector:	IEC 3 pin mains socket
Location:	Wall mount enclosure bottom panel
Label:	J1

3.7 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 3-1.
Control:	Details in the following Table 3-2.
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 the following tables.

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

Table 3-1 : 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 3-2 : Functions Implemented– Part 2

3.7.1.1 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 3-2.

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*

Type	Byte n°	Bits								Description
		7	6	5	4	3	2	1	0	
		0	0	1	1	0	0	0/1	X	0 = False ; 1 = True
	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

Type	Byte n°	Bits								Description
		7	6	5	4	3	2	1	0	
	10	Y (ASCII string)								Tens K ; "0" ≤ Y Value ≤ "9" ; ex. 7
	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 3-3 : Monitored Parameters List

3.7.1.2 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 3-4**Erreur ! Source du renvoi introuvable.**.

Note: 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" (<u>C</u>ryocooler)
	2/7	0	1	0	0	0	0	1	1	ASCII "C" (<u>C</u>ooling)
	3/8	0	1	0	0	0	0	1	1	ASCII "C" (<u>C</u>ommand)
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 3-4 : Remote Commands

* <u>**Note :**</u>

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.

<u>Examples of remote commands sent by a client in ASCII:</u>

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. MECHANICAL

4.1 Cryogenic Dewar Assembly

4.1.1 Overview

Overall Dimensions: L618.15mm x Ø311mm at RF Input Window (Ø381mm at base plate for mechanical mounting interface) See also Figure 4-2.

Weight: ~27kg

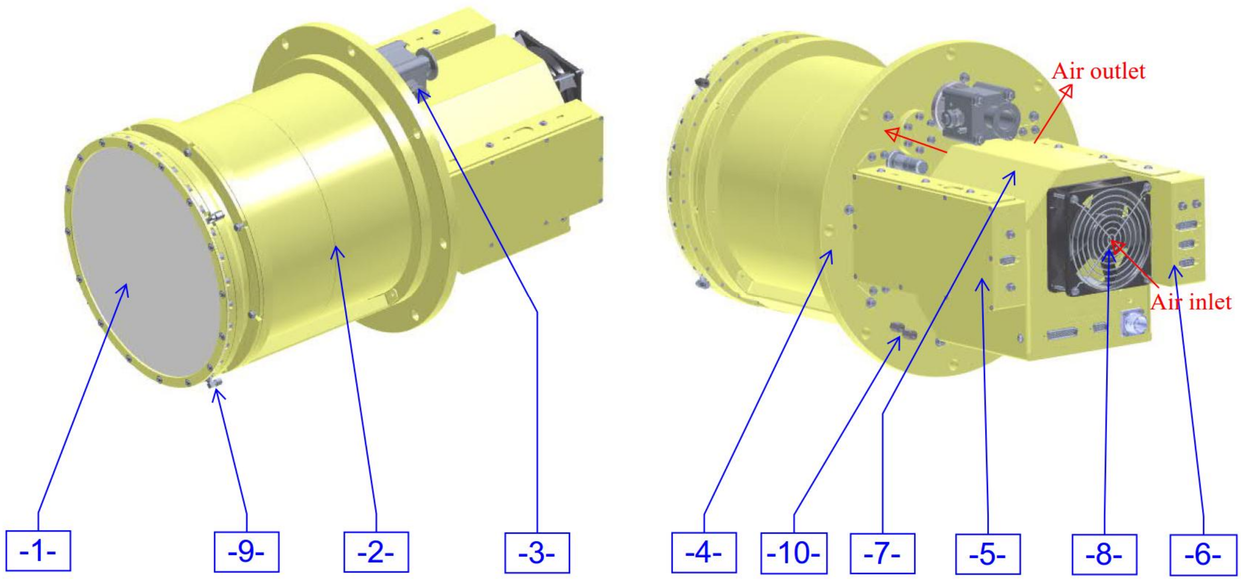


Figure 4-1: Receiver Mechanical Overview

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 5.2
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)

4.1.2 Receiver mounting recommendations

The base plate is equipped with 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.

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 4-1: 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 weather aggressions (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.

4.2 Interfaces with Antenna System

4.2.1 Location of phase centre of feed

The QRFH feed phase centre installed into the Dewar is as shown in the drawing below and is aligned along the geometrical axis of symmetry of the assembly (RD **1**). The variation of location of the phase centre in the Z axis is in the range indicated and is related to the frequency.

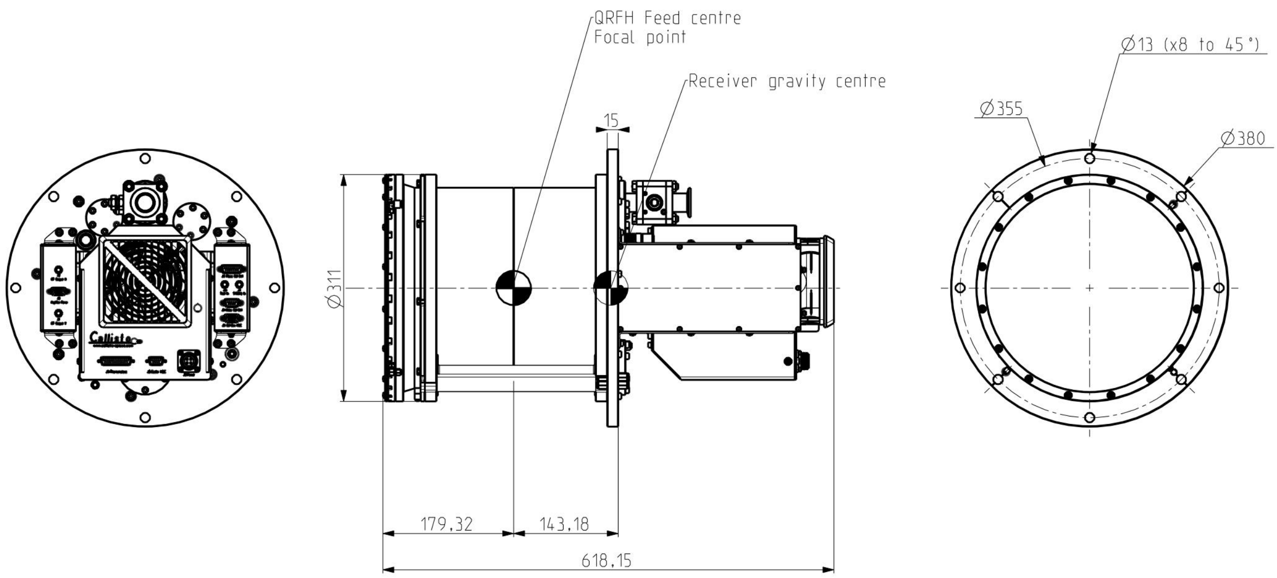


Figure 4-2: Receiver dimensions and feed phase centre location

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 4-2) indicates the position of the feed phase centre in Z axis. There are two 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.

4.2.2 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 4-2). These holes must be used to attach the receiver to a mechanical support in lab or in antenna.

5. RECEIVER ENVIRONMENT

5.1 General Parameters

Operating Temperature:	-10° to +40°C[1] (+25°C recommended in order to increase the cooler lifetime see footnote [1])
	+40°C to +55°C[1] (Degraded Performance, see section 4.1.2 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 5.3). 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)

5.2 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 4-1) 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.

[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 5.2.

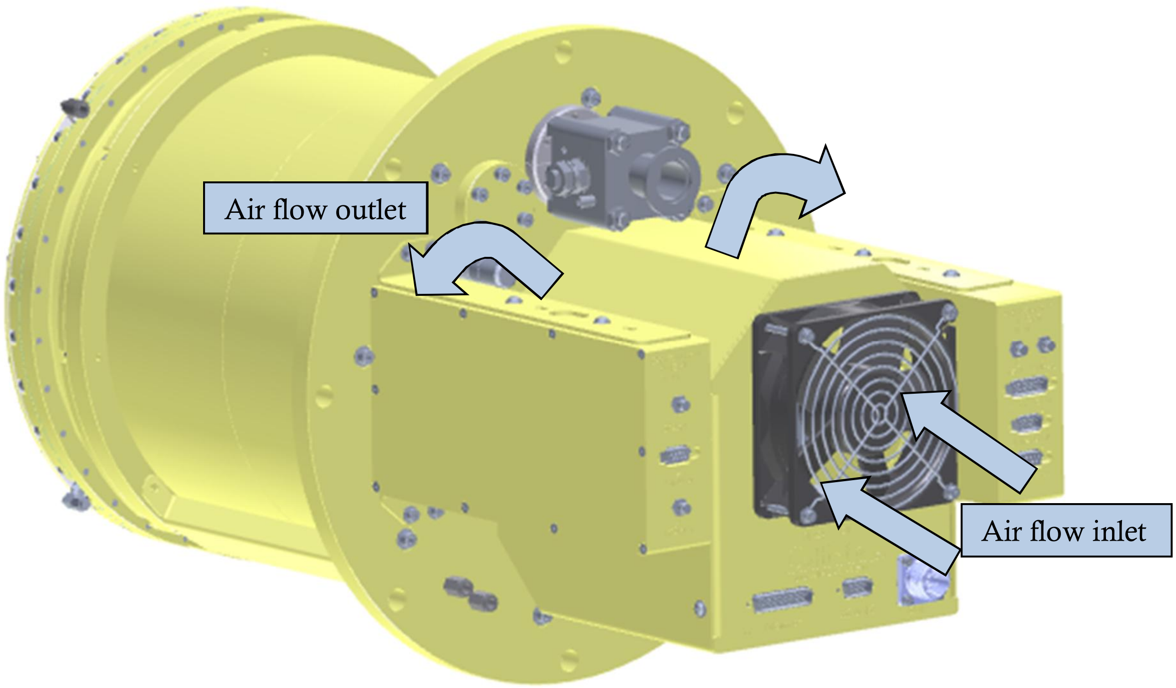


Figure 5-1: Direction of the air flow

5.3 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.

6. M&C UNITS

6.1 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 6-1: DAQ-PSU Enclosure - Cables routing space

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

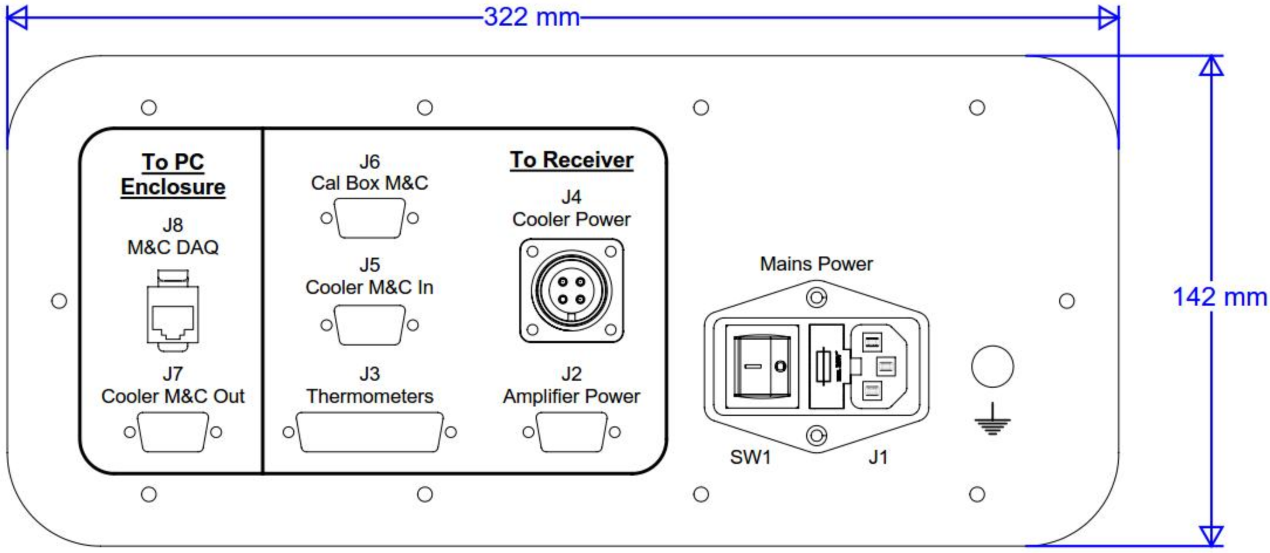


Figure 6-3: DAQ-PSU Enclosure – Bottom interface panel

6.1.1 Environmental

Operating Temperature: -10° to +40°C

Storage Temperature: -40° to +60°C

Relative Humidity: To 90% non-condensing

6.2 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 6-4: PC Enclosure - Front Panel Door

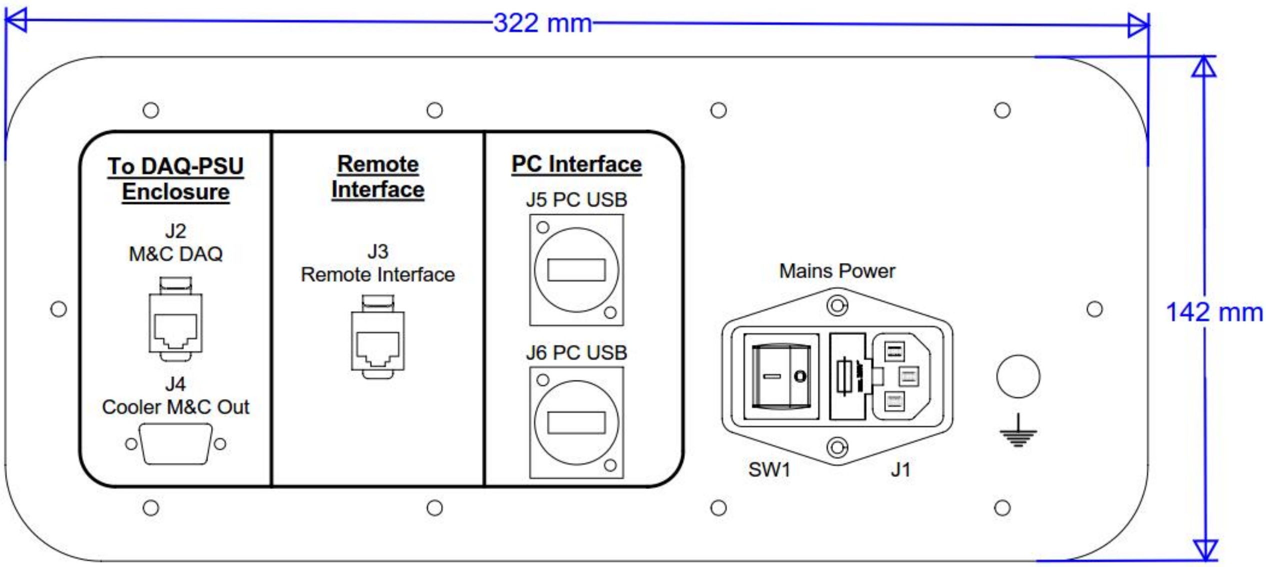


Figure 6-5: PC Enclosure – Bottom interface panel

6.2.1 Environmental

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

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**