Wettzell S/X Bands Cryogenic Receiver

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1. Introduction

This report summarizes the new design and characteristics of the S and X band cryogenic receiver for the Geodetic Observatory Wettzell developed at the Yebes Technological Development Center.

The receiver is based on a two stages closed cycle cryocooler (CTI-22), the cold stage below 20 K and the intermediate stage, below 70 K.

Specifications

Frequency bands*	S Band: 2.2-2.37 GHz X Band: 8.15-9.0 GHz
Physical Temperature	< 70 K radiation shield < 20 K cold stage
Pressure	$< 10^{-6}$ mbar
Pressure Leaks	$< 5 \cdot 10^{-6}$ mbar·l/s
Gain	> 30 dB at S and X bands
Noise Temperature	S band: < 12 K X band: < 15 K
Input	S band: N connector X band: waveguide WR-112 S band calibration: SMA X band calibration: SMA
Output	S band: SMA X band: SMA
Output impedance	50 Ω

* IVS Frequency Bands for Geodetic Observations.

2. Cryostat Geometry

The next figures show the cryostat design:

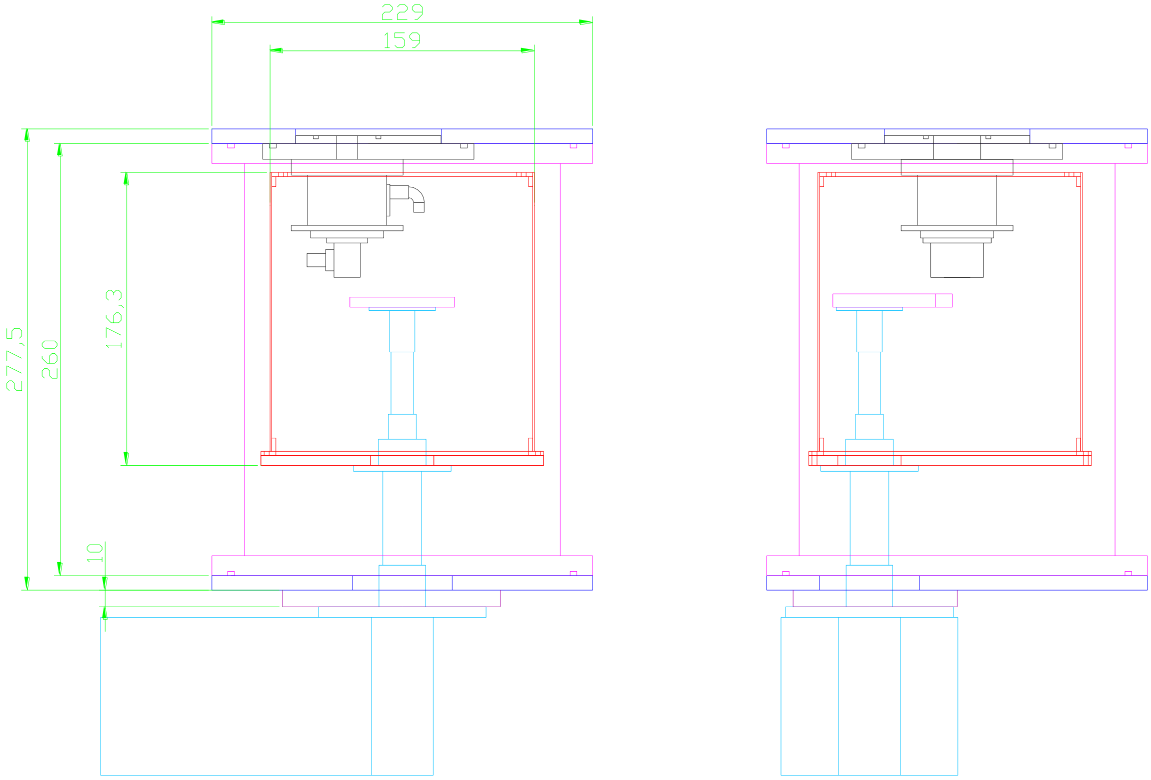


Figure 1. Cryostat overview (cold head (light blue), vacuum case (pink and dark blue), radiation shield (red), cold stage (pink) and directional coupler (black)).

The cryostat design is an upgrade of a previous one designed at Wettzell Observatory several years ago. This new design has been performed carefully due to the little free space inside the cryostat and also taking into account the space in the radio telescope at Wettzell.

The cryostat is built over a CTI Model-22 cold head in a cylindrical dewar made of steel. In the top cover a vacuum window (Wettzell supplied) lets the X band radiation goes through, for the S band, an N connector feedthrough is used and it is connected to an air line inside the cryostat. In the bottom cover there are all the RF connectors for S and X bands, vacuum flanges, pressure monitor, DC cabling and housekeeping connectors.

Inside the cryostat there is a cylindrical radiation shield made of aluminum and with multilayer isolator (MLI). The temperature of this stage is less than 70 K.

Removing the radiation shield, the entire receiver can be easily reached. It is the coldest part of the receiver at temperature of 17 K approximately. The cold stage is made of copper and is connected to both amplifiers and the directional coupler.

All the RF cabling is made of coaxial semi-rigid cable. The cables that connect the cold stage (amplifiers and coupler) with the room temperature stage (SMA connectors) are made of coaxial semi-rigid steel cable, UT-085. The cable from the air line output to the S band LNA input is a coaxial semi-rigid copper cable, UT-141.

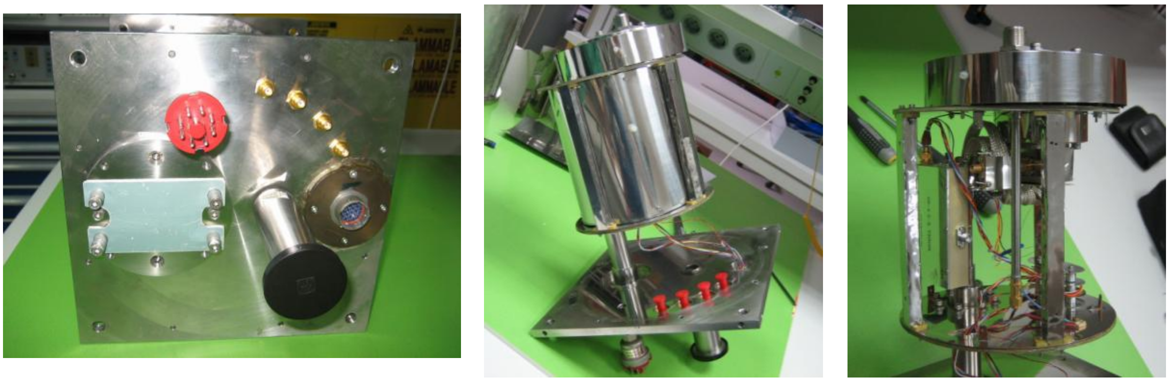


Figure 2. Previous dewar design.

Figure 3. Cryostat overview (current design).

2.1. Vacuum case

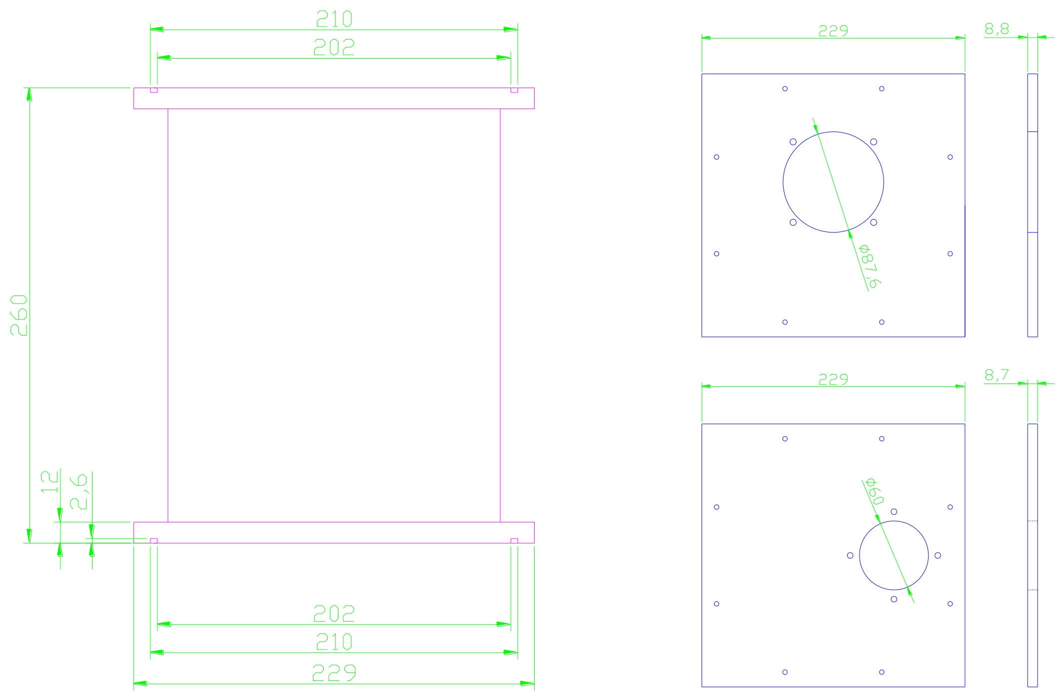


Figure 4. Dewar, vacuum seals and flanges dimensions.

The dewar consists of three main parts: stainless steel cylinder, top and bottom covers. At the top cover the inputs for the X and S bands are presented (vacuum window for X band and N connector adapter for S band).

The dewar lower flange has several outputs for different uses:

- Cold head connection: to place the cold head in the right position, taking into account the limited space in the 20 m radio telescope at Wettzell Observatory, a second flange was placed between the lower flange and the cold head. To get the desire vacuum two viton seals have been used.
- Two apertures with transitions for the vacuum control (pressure sensor and vacuum valve).
- Three Fisher hermetic connectors for the housekeeping control and monitoring, and amplifiers biasing.
- Four SMA hermetic connectors for the RF input/output signals (calibration and RF).

Inside the dewar, at the bottom cover, there is an aluminum plate to carry out the transition between room temperature DC wiring and the cryogenic wires, using DB connectors.

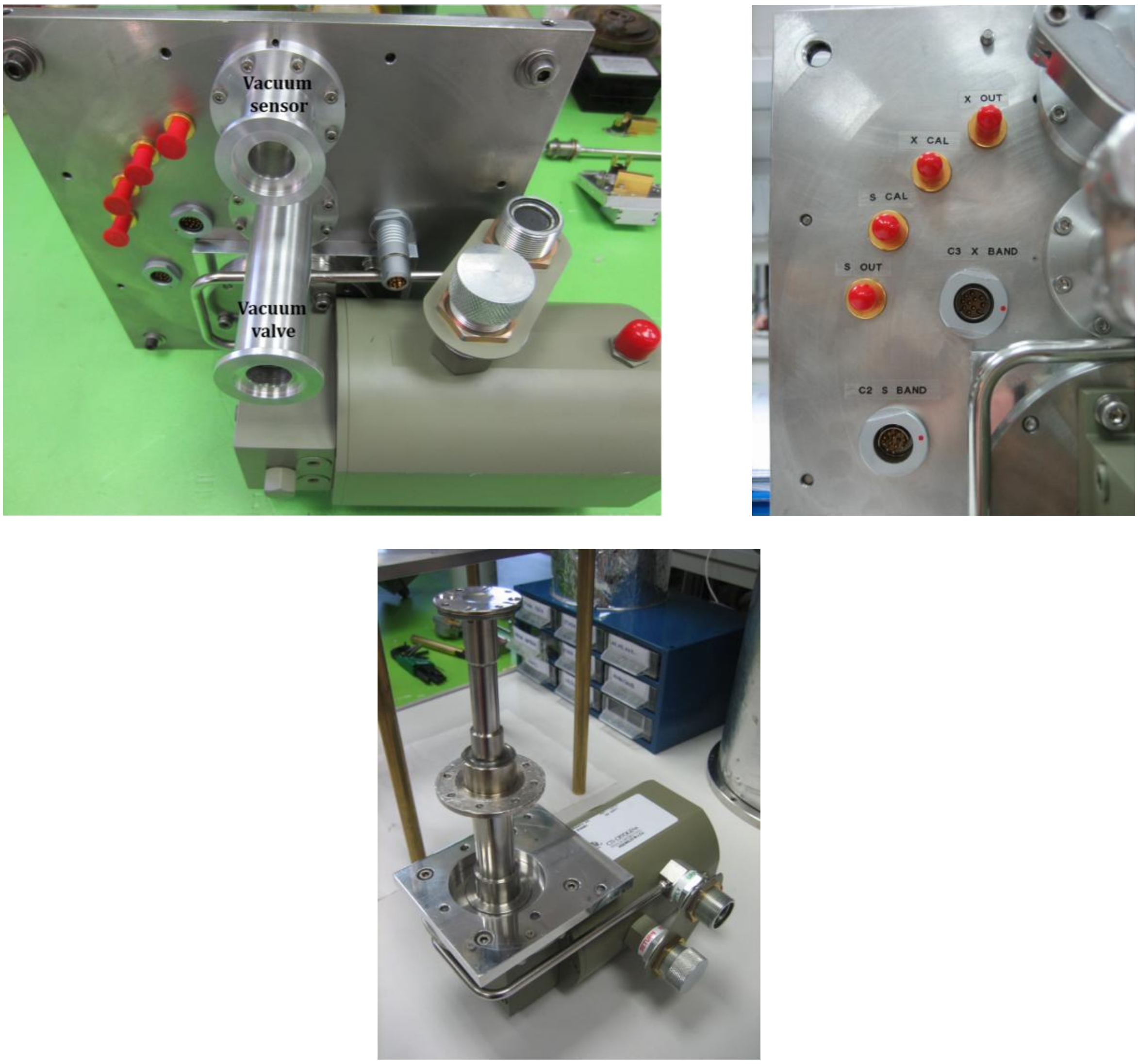


Figure 5. Bottom dewar cover and cold head flange.

2.1.1. Vacuum Seals

O-rings with their main specifications and locations are presented in the table below:

Seal	Type	d_1 (mm)	d_2 (mm)	Reference	Qty
Vacuum case – top flange and lower flange	OR VI	202.8	3.53	571.943	2
Vacuum window – top flange	OR VI	34	2.5	461.979	1
Directional coupler – top flange	OR VI	110.72	3.53	305.643	1
Cold Head – ancillary flange – lower flange	OR VI	63,22	1,78	435.803	2
Vacuum system transitions – lower flange	OR VI	28	4	670.265	2

Table 1: Vacuum seals Epidor. [3]

2.1.2. Vacuum Window

The vacuum window goal is to allow transition (physical, electromagnetic and vacuum) between the X band horn, or the waveguide to the horn, that it is out of the cryostat, and the directional coupler.

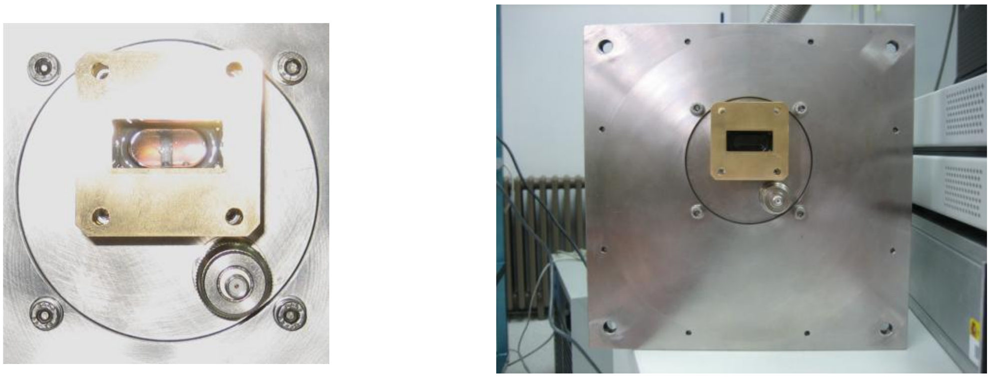


Figure 6. Vacuum window and transition.

2.2. Intermediate stage and radiation shield

The intermediate stage is an aluminum plate of 6 mm thickness and 170 mm diameter, screwed onto the first stage of the cold head. Attached to this plate there is an aluminum cylinder to cover the cold stage and reduce the radiation load. Both parts are covered with multilayer isolator, MLI (8 layers).

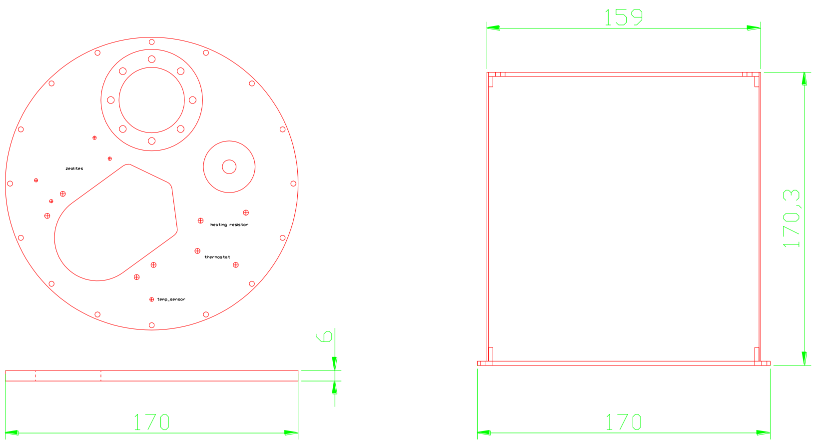


Figure 7. Intermediate stage design and radiation shield.

On the intermediate stage there are a temperature sensor, a heating resistor, a thermostat and a vacuum trap based on zeolites. These devices have the following characteristics:

- Heating resistor: 100 Ω, 25 W.
- Zeolites regeneration resistor: the vacuum trap includes a 100 Ω and 2.5 W regenerator resistor.
- Temperature sensor: DT-670 Lakeshore Si-diode.
- Thermostat: 70° ± 3°.

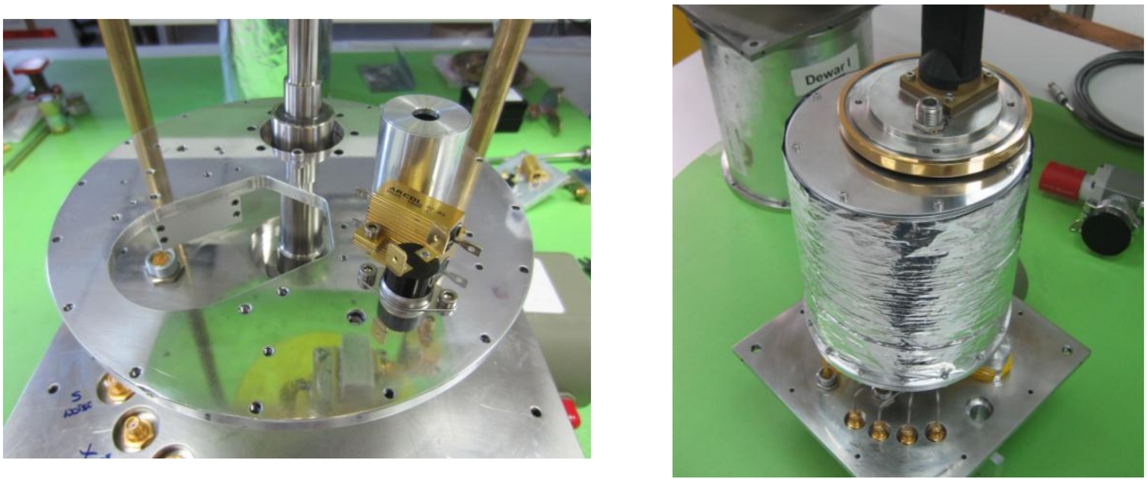


Figure 8. Intermediate stage installed in the cryostat (with the thermostat and the heating resistor). Radiation shield with the MLI.

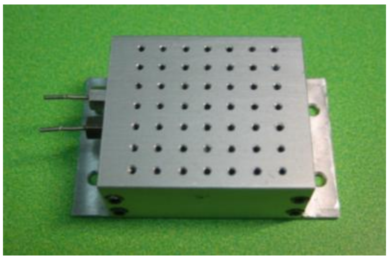


Figure 9. Vacuum trap.

2.3. Cold stage

The cold stage consists of a copper plate, 8 mm thickness and 63 x 72 mm size. Attached to this plate are placed the vacuum trap, the thermostat, heating resistor and the temperature sensor (same specifications than the used for the intermediate stage). The S and X LNAs and the X band directional coupler are directly attached to this stage.

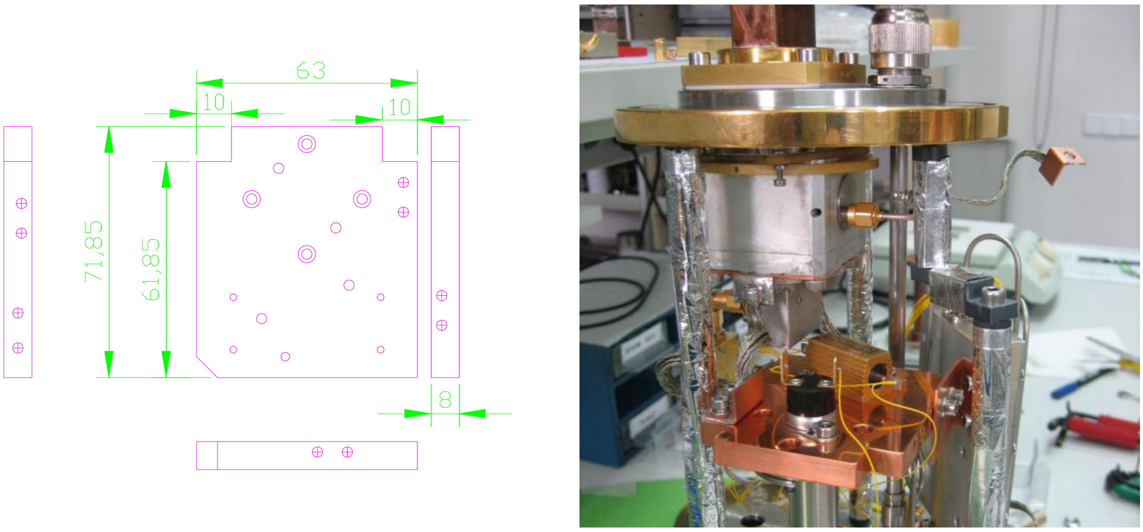


Figure 10. Cold Cu plate design and cold stage with the directional coupler.

2.4. Amplifier setting-up

The cryostat contains two low noise amplifiers:

- S Band LNA: Model S-2.3-30 Berkshire Technologies (Ser. 209).
- X Band LNA: CITCRYO1-12A.

Detailed specifications and biasing information can be found in the appendix.

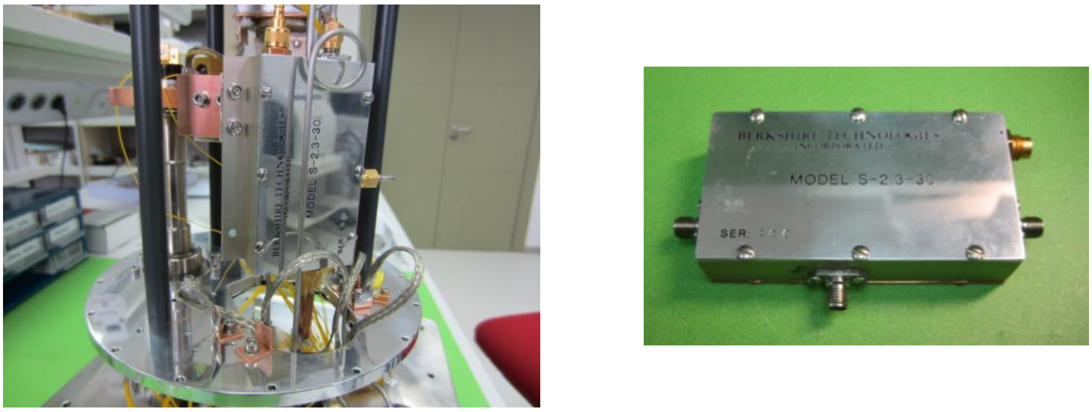


Figure 11. S band low noise amplifier.

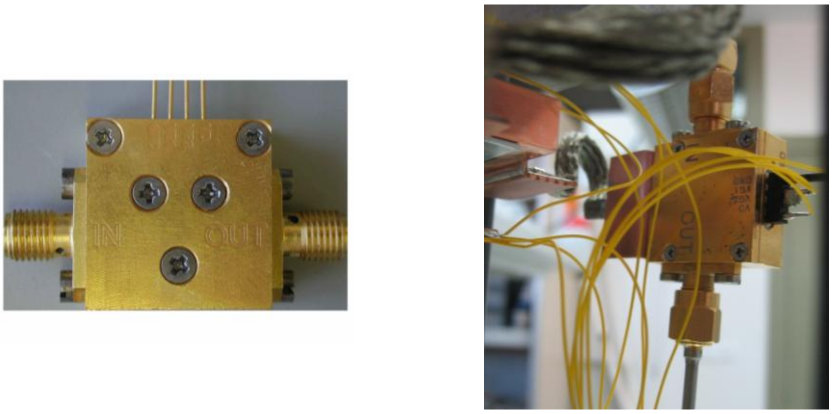


Figure 12. X band low noise amplifier.

2.5. Internal DC wiring

There are 3 hermetic Fischer connectors at the vacuum case:

- One of them with 16 pin for monitoring signals and housekeeping.
- Two of them with 11 pin for the amplifiers biasing signals.

Hermetic Fischer Connector	Function
C1	Housekeeping
C2	S band LNA
C3	X band LNA

The next figures show the Fischer connectors pin-out (11 and 16 pin):

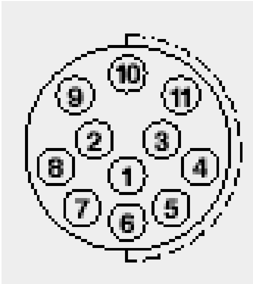


Figure 13: 11 pin Fischer
(connector view, red point up).

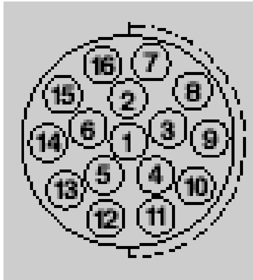


Figure 14: 16 pin Fischer
(connector view, red point up).

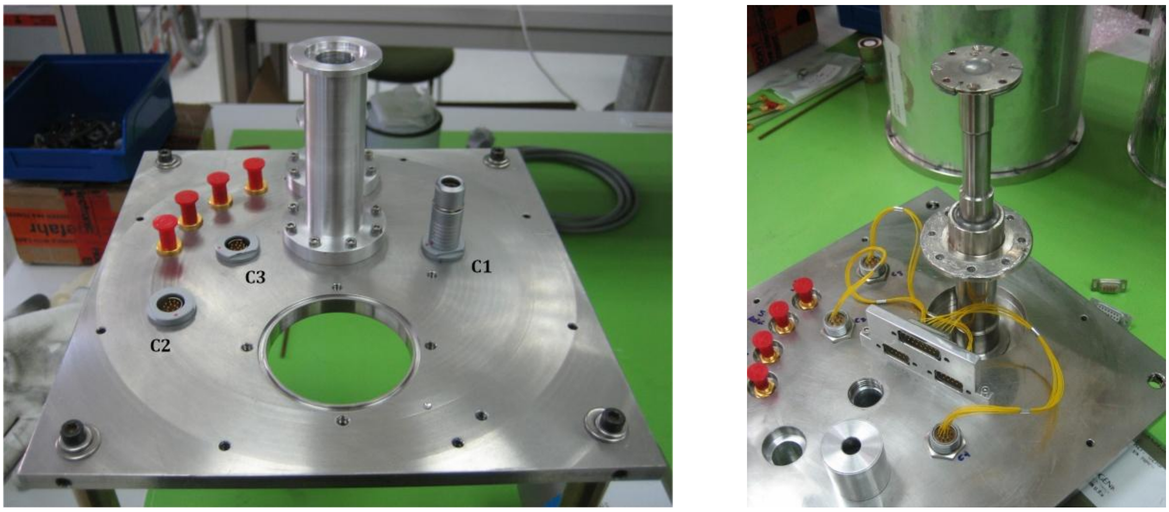


Figure 15: LNAs biasing connectors and housekeeping connector.

The DC wiring has been done using small section long cables to reduce the conduction load. The next table indicates the pin-out association between connectors.

Pin-Out DC connections Wettzell S/X receiver:

Fischer Pin	DB15 Pin	Signal
1	1	Tc_+
2	2	Tc_-
3	3	Ti_+
4	4	Ti_-
5	5	Calef_on
6	6	Regen_on
7	7	GND_res
8	8	(free)
9	9	(free)
10	10	(free)
11	11	(free)

Table 2: Fischer Connector (C1) 16 pin (housekeeping) correspondence with the DB15 connector.

Fischer Pin	DB9 Pin	Signal
1	1	Gnd
2	2	Vd1
3	3	Vg1
4	4	Vd2
5	5	Vg2
6	6	Vd3
7	7	Vg3

Table 3: Fischer Connector (C2) 11 pin (S band LNA) correspondence with the DB9 connector.

Fischer Pin	DB9 Pin	Signal
1	1	Gnd
2	2	Vd
3	3	Vg1
4	4	Vg2
5	5	(free)
6	6	(free)
7	7	(free)

Table 4: Fischer Connector (C3) 11 pin (X band LNA) correspondence with the DB9 connector.

Several pins and wires have been left free taking into account future upgrades (amplifiers changes).

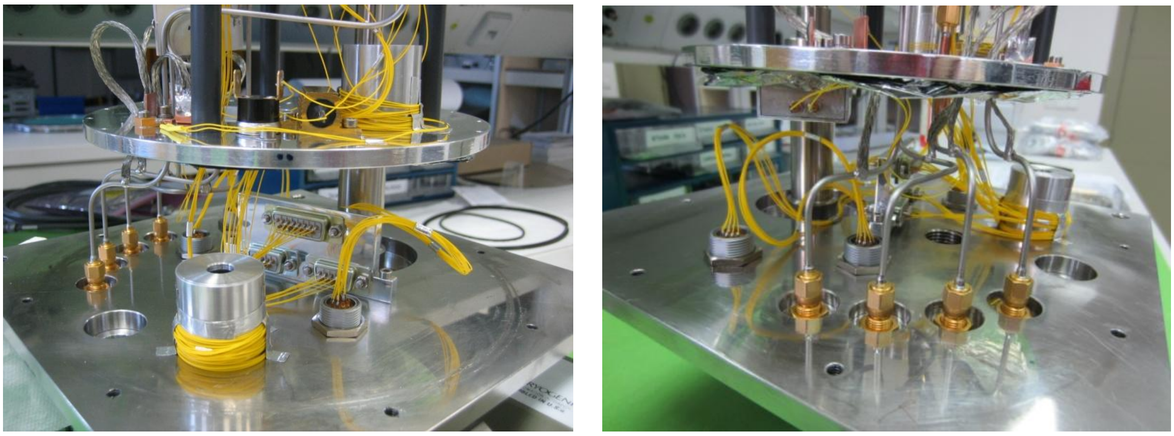


Figure 16: DC wiring.

2.5.1. Low Noise Amplifiers biasing wiring

Band	Amplifier frequency range (GHz)	IVS Frequencies (GHz)	Purpose
S	2.1-2.4	2.2-2.37	Geodetic VLBI
X	1-12	8.15-9.0	Geodetic VLBI

Next figures show the pin-out for the amplifier biasing connectors:

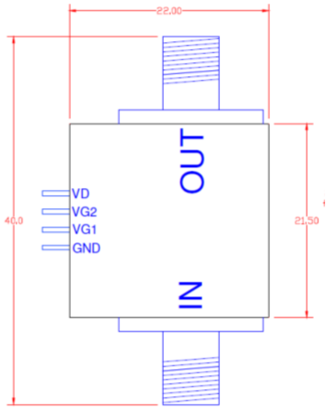


Figure 17. Pin-out biasing connector X band amplifier.

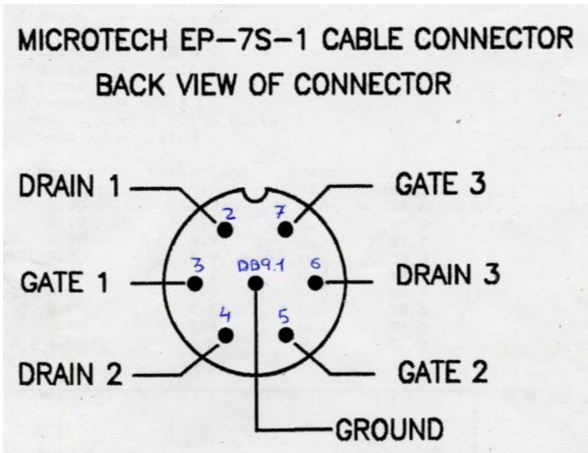


Figure 18. Pin-out biasing connector S band amplifier.

2.5.2. Housekeeping wiring

There is a 16 pin Fischer connector placed at the room temperature stage (300 K) for the cryostat internal monitoring signals: heating resistors, zeolites regenerators, temperature sensors and thermostats.

Fischer Pin	Signal	Description
1	Tc_+	Cold stage temperature sensor (+)
2	Tc_-	Cold stage temperature sensor (-)
3	Ti_+	Intermediate stage temperature sensor (+)
4	Ti_-	Intermediate stage temperature sensor (-)
5	Calef_on	Signal to activate the heaters after passing through the thermostat
6	Regen_on	Signal to activate the zeolites regeneration resistor after passing through the thermostat
7	GND_res	Ground

Table 5. Housekeeping signals description.

A five meters cable is supplied to connect the receiver with the different housekeeping signals. One end has the Fischer connector o be plugged to the receiver. The other end contains the following elements:

Fischer Pin	Signal	DB 25 pin	Banana Connectors
1	Tc_+	3, 4	
2	Tc_-	15, 16	
3	Ti_+	6, 7	
4	Ti_-	18, 19	
5	Calef_on		Red
6	Regen_on		Yellow
7	GND_res		Black

Table 6. Housekeeping 5 m cable description.

- DB-25 connector: to Lakeshore 218 system (positions one and two) DT 670 sensors.
- Banana connector: to power supply for the receiver heating and zeolites regenerating.

3. Cryogenic system

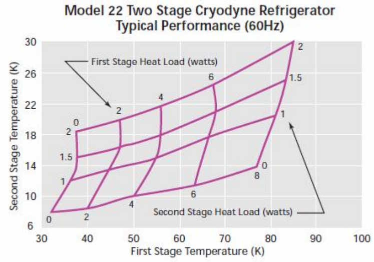
This receiver uses a CTI-Cryogenics Cold Head Model 22, with the following characteristics:

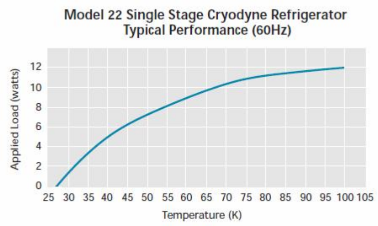
Model 22 Cryodyne Refrigeration System

The Model 22 is available in both single and two stage configurations to suit a variety of applications that require a compact cryocooler.

The single stage M-22 is designed to provide up to 11 watts of heat lift at 77K for cooling of high temperature superconductors, detectors and optical devices.

The two stage M-22 is designed to provide useable heat lift under 10K and up to 1 watt at 20K and 8 watts at 77K simultaneously. Applications include spectroscopy, low temperature thermometry, amplifier cooling and LASER frequency tuning.





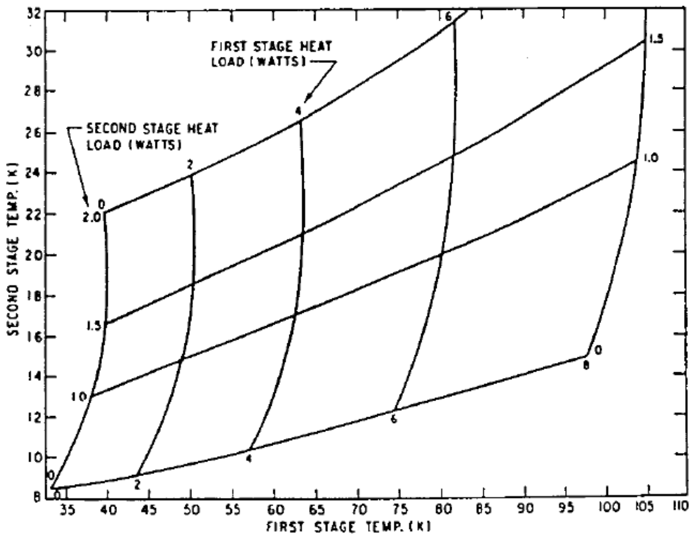


Figure 19. Typical refrigeration capacity of the model 22C cryodyne cryocooler (50 Hz).

4. Cryostat thermal and vacuum behavior

Several tests have been performed to determine the cryostat thermal and vacuum behavior. The systems used for cooling and pumping are the following:

- Cold head CTI 22.
- Compressor CTI model 8200, 220 V, 50 Hz.
- Vacuum system:
  - Rotary pump and turbomolecular pump Alcatel.
  - Vacuum sensors: Pirani sensor (pressure from atmospheric to 10^{-4} mbar) and cold cathode (pressure from 10^{-4} mbar to 10^{-8} mbar).

The final results are:

- Intermediate stage temperature: ≤ 63 K.
- Cold stage temperature: ≤ 17 K.
- Vacuum <10^{-8} mbar (cryogenic vacuum).
  - Leakage rate $3.5 \cdot 10^{-6}$ mbar·l/s ($4,8 \cdot 10^{-7}$ mbar/s).
- Cooling down time: < 8 h
- Warming up time: < 15 h (or < 2 with zeolites regenerators and heating resistors on)

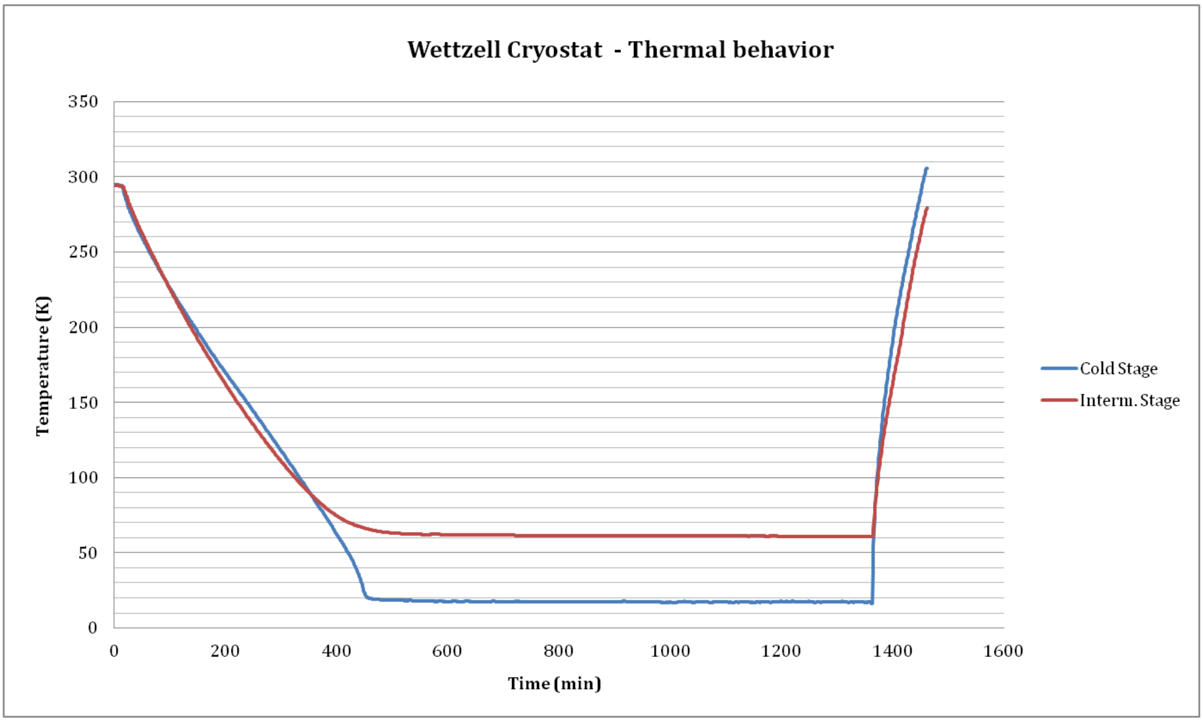


Figure 20. **Cooling test 1** (zeolites regenerators and heating resistors on).

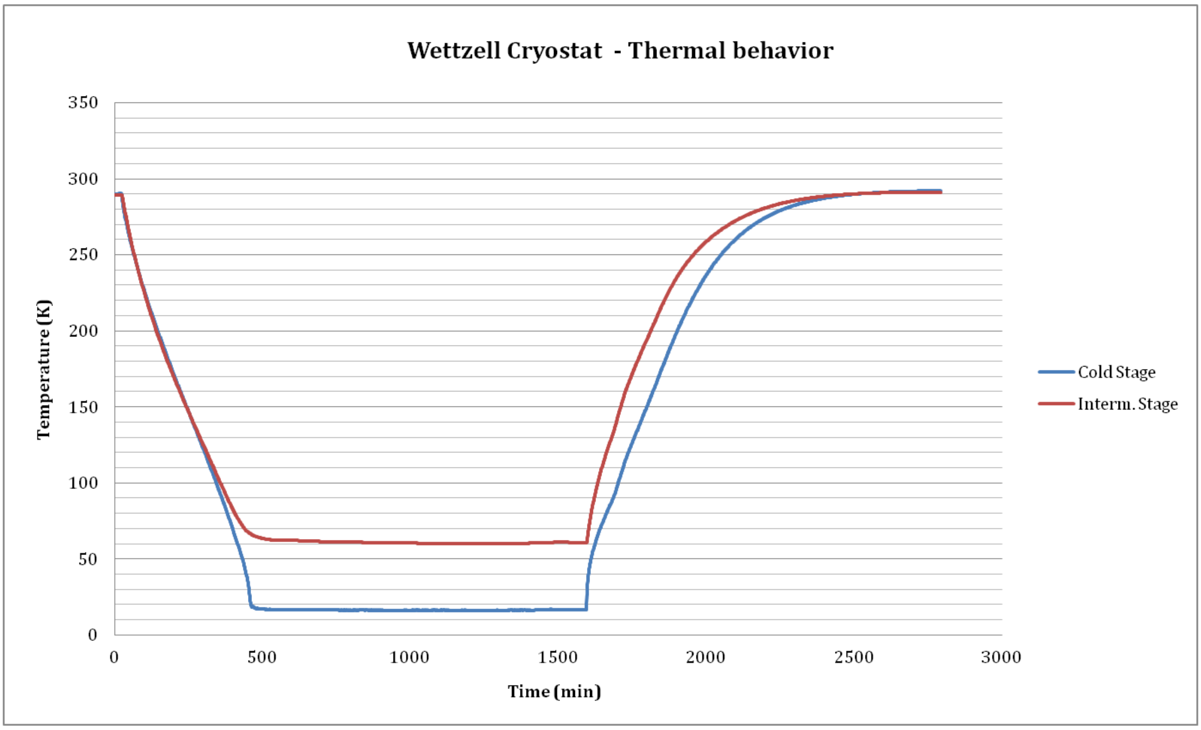


Figure 21. **Cooling test 2**.

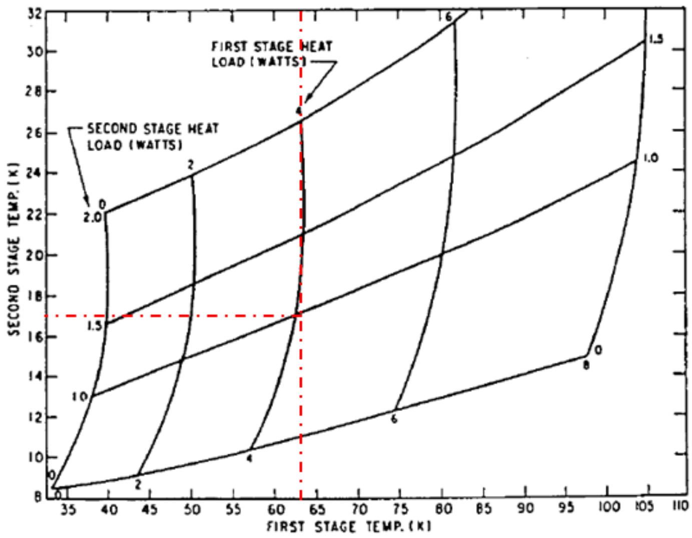
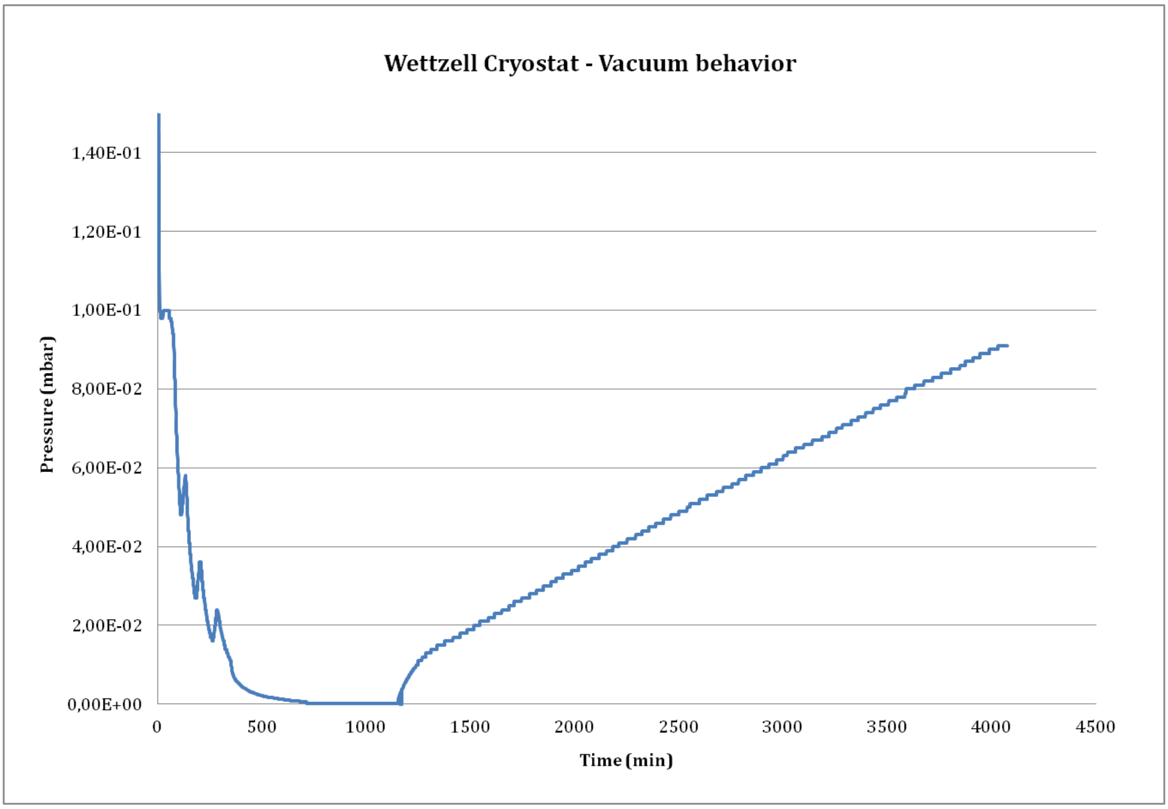


Figure 22. Intermediate stage load ≈4 W, cold stage load ≈1 W.



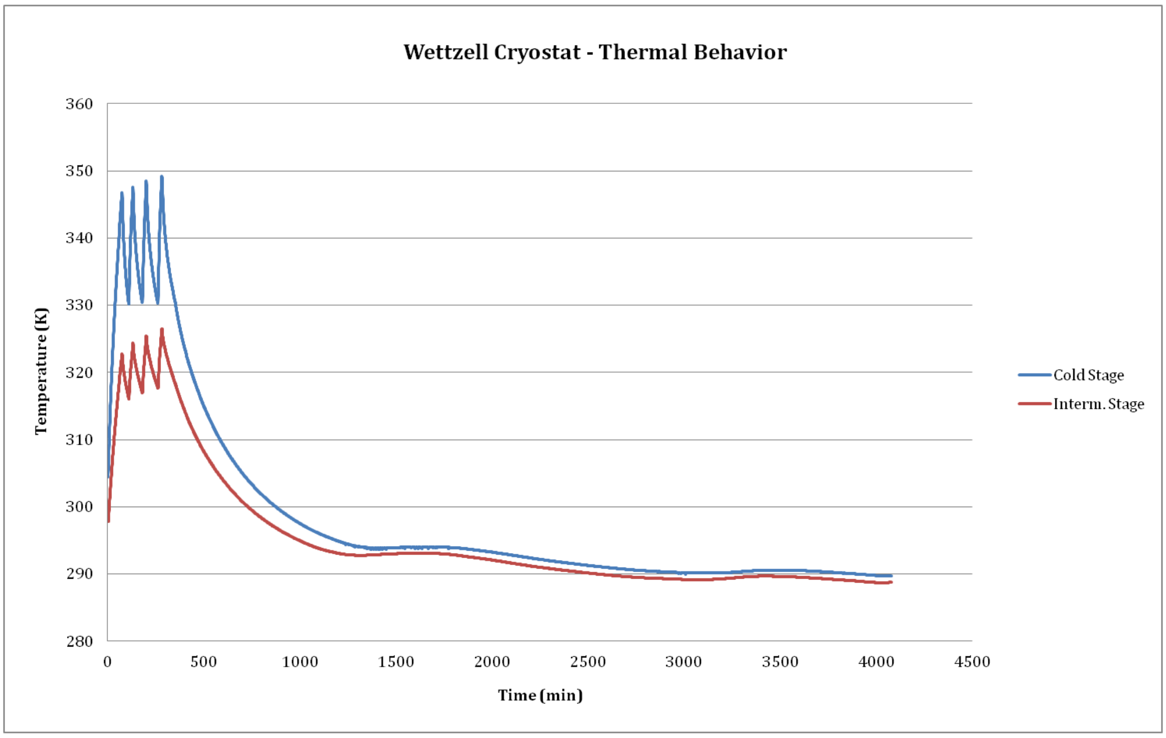


Figure 23. Vacuum test (Pirani sensor) and thermal behavior during the vacuum test, (zeolites regenerators and heating resistors on during the first 5 hours).

5. Receiver calibration: noise temperature and gain

The Y factor method has been used to calibrate the receiver (measure the noise temperature). The noise temperature measurement is carried out connecting the receiver input to different adapted loads with known temperatures.

When the load at the input has a temperature, T_H, the power at the output is P_H, hot load. If a second measure is done with a load with a different temperature, T_C, the power will be different, P_C, cold load. Then, the receiver noise temperature can be calculated by the following expressions:

$$T_{RX} = \frac{T_H - Y \cdot T_C}{Y - 1} \qquad \text{where} \qquad Y = \frac{P_H}{P_C}$$

This method is based on the hypothesis that the receiver behavior is linear between P_H and P_C.

The thermal loads used are:

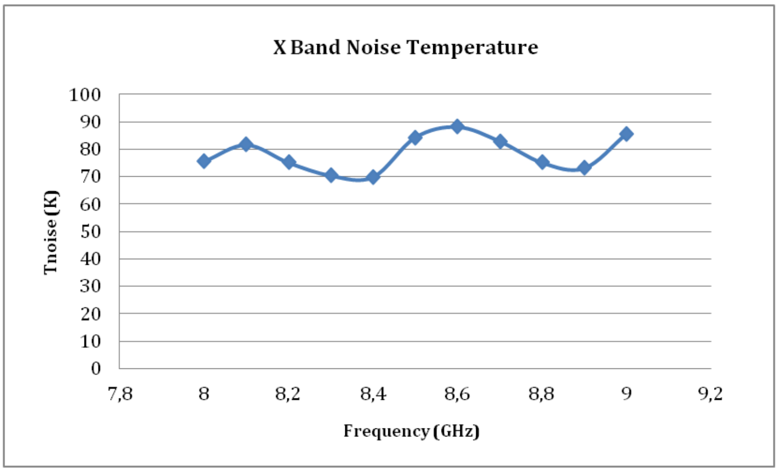
- Hot load: coaxial SMA 50 Ω load at room temperature, ≈ 298 K.
- Cold load: coaxial SMA 50 Ω load submerged in liquid nitrogen, ≈ 77 K.

Results without taking into account the losses due to the cables, SMA connectors, waveguide transition, etc.:

LNAs Noise Temperature measured at room temperature

X band	
T_H= = 295.5 K	T_C = 77.3 K
Freq. (GHz)	**Noise Temp. (K)**
8	75.555
8.1	81.57
8.2	75.155
8.3	70.435
8.4	69.92
8.5	84.28
8.6	88.075
8.7	82.895
8.8	75.165
8.9	73.14
9	85.595

S band	
T_H= = 296 K	T_C = 77.3 K
Freq. (GHz)	**Noise Temp. (K)**
2	59.98
2.1	59.785
2.2	52.645
2.3	52.105
2.4	61.635
2.5	49.15
2.6	57.965
2.7	58.16
2.8	79.855
2.9	77.945
3	80.375



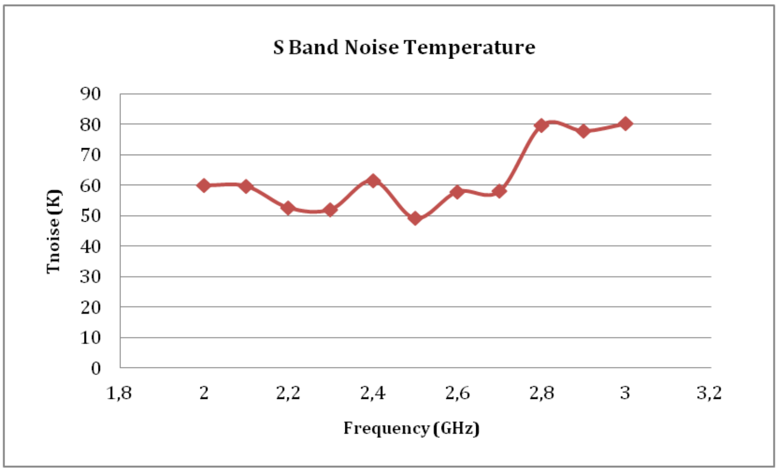


Figure 24. T_{RX} at room temperature (≈ 295 K).

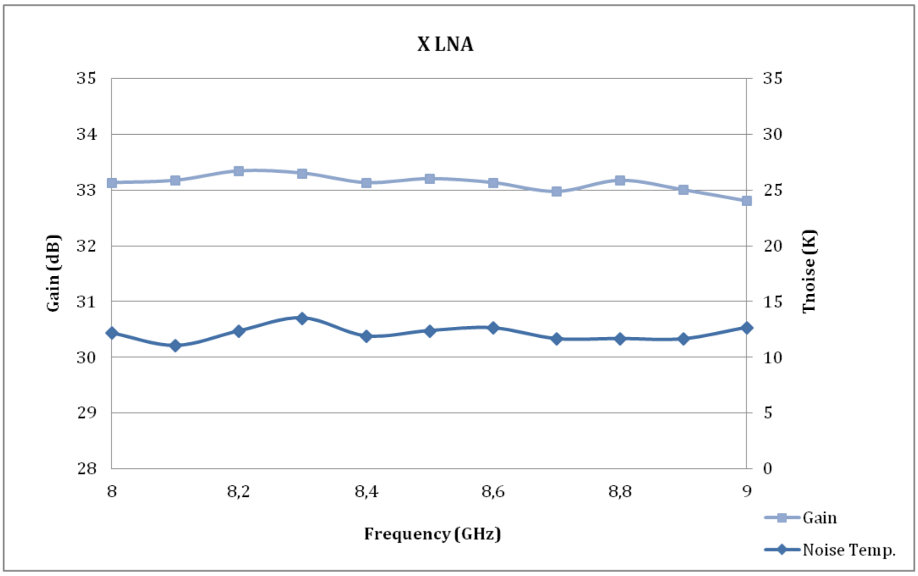
LNAs Noise Temperature and Gain measured at cold temperature

X band	
T_H = 295 K	T_C = 77.3 K
Freq. (GHz)	**Noise Temp. (K)**
8	12.155
8.1	11.045
8.2	12.35
8.3	13.515
8.4	11.9
8.5	12.375
8.6	12.62
8.7	11.65
8.8	11.66
8.9	11.64
9	12.67

S band	
T_H= = 296 K	T_C = 77.3 K
Freq. (GHz)	**Noise Temp. (K)**
2.2	7.95
2.3	9.78
2.4	10.71
2.5	5.835

X band	
Freq. (GHz)	**Gain (dB)**
8	33.13
8.1	33.17
8.2	33.34
8.3	33.3
8.4	33.13
8.5	33.2
8.6	33.13
8.7	32.97
8.8	33.17
8.9	33
9	32.8

S band	
Freq. (GHz)	**Gain (dB)**
2.2	31.63
2.3	30.97
2.4	31.03
2.5	30.63



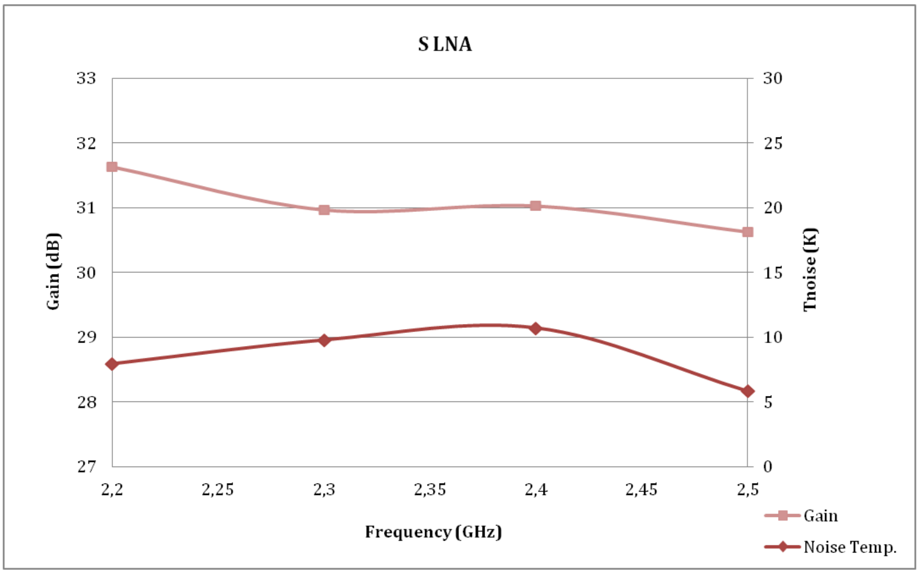


Figure 25. T_{RX} and gain at cold temperature (≈ 16.5 K).

6. Low Noise Amplifiers Biasing Module

With the receiver, a biasing module for the low noise amplifiers is supplied. Next its basic characteristics are presented.

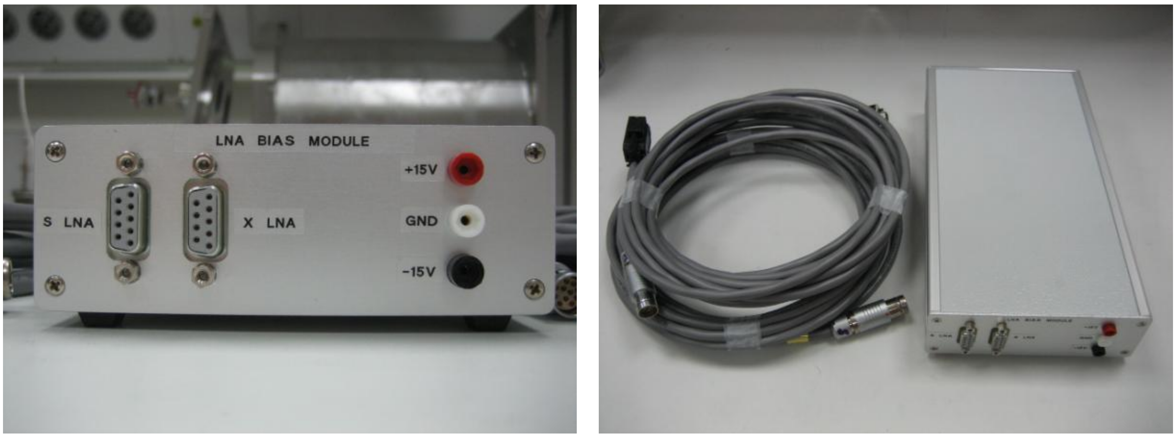


Figure 26. Low noise Amplifiers Biasing Module and 5 m cables for X and S band amplifiers.

Low Noise Amplifiers biasing procedure:

- Connect Fischer connectors to the corresponding connectors (S and X) on the dewar.
- Connect DB9 connectors to the S and X inputs.
- Connect a power supply to the +15 V and -15 V inputs.
- Turn on power supply.

The biasing module is already adjusted for the indicated S and X LNAs biasing points.

S LNA	
V_{d1}	2.3 V
I_{d1}	6 mA
V_{g1}	-0.28 V
V_{d2}	2.5 V
I_{d2}	8 mA
V_{g2}	-0.9 V
V_{d3}	3 V
I_{d3}	10 mA
V_{g3}	-0.78 V

X LNA	
V_{d4}	0.9 V
I_{d4}	17 mA
V_{g4}	1.42 V

LNAs Biasing Module Consume	
+15 V	-15 V
73 mA	33 mA V

Table 7. LNAs Biasing (cold temperature).

However, the back cover of the biasing module can be removed for accessing to the biasing power supply card. The schematics of this card are shown in the next figure. This card allows adjusting four stages (three for the S LNA and one for the X LNA). V_d and I_d can be adjust for each stage by means of the corresponding potentiometer.

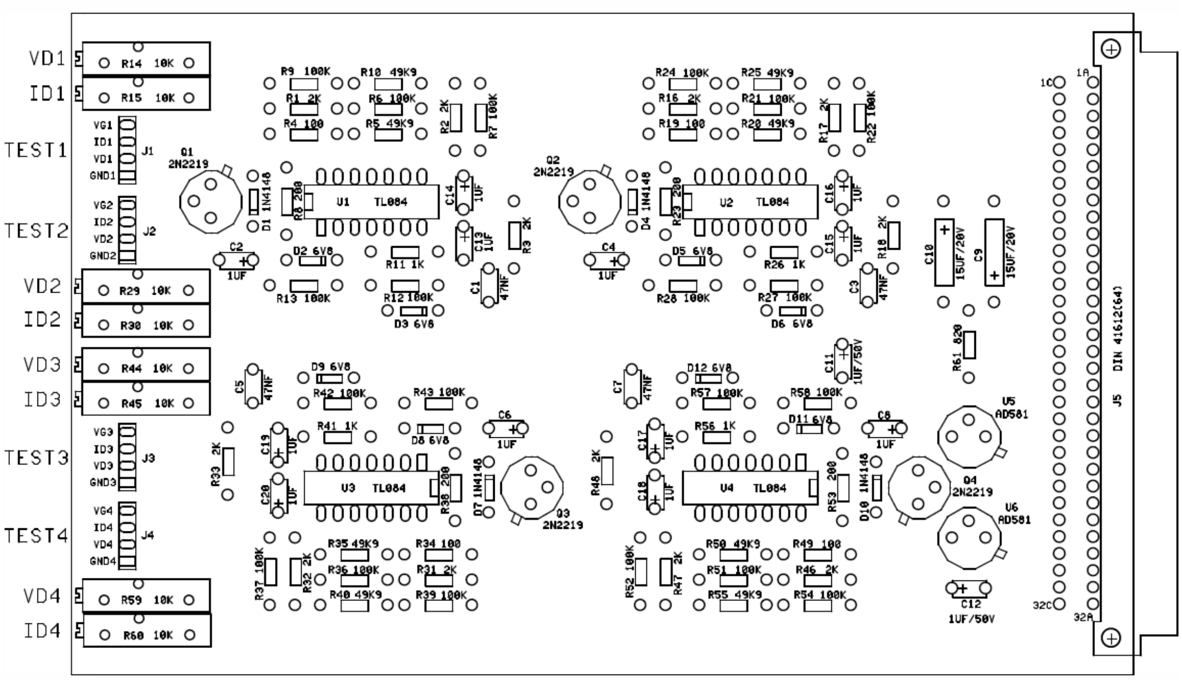


Figure 27. PC Board Components.

7. Installation, first use and switch off

Proceed as follow to install de receiver:

- The vacuum controller, the temperature monitor, the LNAs biasing module and the RF module must be switch off.

- **Making Vacuum**
  - Connect the housekeeping cable to the rear side Fischer connector of the cryostat (C1) (figure 15).
  - Connect the vacuum controller to the vacuum sensor Quadmag.
  - Connect the vacuum valve to the corresponding vacuum flange (the valve must be closed).
  - Switch on the vacuum controller. The vacuum sensor will start the set up and a green led will light continuously when ready. The vacuum controller will show atmospheric pressure.
  - Switch on the temperature monitor (housekeeping cable has a DB25 connector for the Lakeshore connector input). The temperature of the first 2 channels will be around room temperature.
  - Connect a vacuum system (rotary pump and turbomolecular) to the DN25 output of the vacuum valve.
  - Start running the rotary pump for at least ten minutes.
  - Slowly open the valve. The vacuum level will start to decrease. If the decreasing of the pressure inside the cryostat stops then open slowly the valve. Repeat this procedure until you open completely the valve. During this procedure avoid any abrupt opening of the valve. When the vacuum is about 10^{-1} mbar, start turbomolecular operation.
  - Connect the zeolites regenerator banana connector to a power supply.
    - Black: GND
    - Red:+6.17 V, 113 mA
  - Connect the heating resistor banana connectors to a power supply.
    - Black: GND
    - Yellow: +25.7 V, 493 mA
  - Leave the system running in the above conditions for 12 hours. Then, the resistor can be turned off. The vacuum system should be pumping at least for 12 hours more.

- **Connecting the helium compressor**
  - Remove all dust plugs and caps from the helium supply and return lines, compressor and cold head. Check all fittings.
  - Connect the helium return line between the compressor and the cold head.
  - Connect the helium supply line between the compressor and the cold head.
  - Verify proper helium supply static pressure (245 psi for CTI 8200 compressor). If the indicated pressure is not the specified by the compressor manufacturer follow the instructions supplied by the manufacturer.
  - Connect the cold head cable between the compressor and the cold head.


Figure 28. Wettzell cryostat vacuum and cold test.

- **Connecting the LNAs Biasing Unit**
  - Connect the LNAs Biasing Module to a power supply (+15 V, -15 V, GND). Power supply off.
  - Plug the 2 DC supply cables between the LNAs Biasing Module and the Cryostat connector plate (figure 15).

Cryostat Connector	LNA Biasing Module
C2	S band LNA
C3	X band LNA

  - The LNAs biasing point is already set up. In case a verification or change is needed go to chapter 6.
  - Turn on the power supply (verify table 7 values).

- **First use**

After 24 hours pumping the system is ready to start the cooling down process.

- The pressure inside should be at $5 \cdot 10^{-3}$ mbar or lower.
- Close the vacuum valve. The pressure inside the cryostat will increase slightly at 10^{-6} mbar/s rate or lower (faster just when closing the vacuum valve). The pressure inside must be maintained always below $5 \cdot 10^{-2}$ mbar.
- Switch on the compressor. The temperatures will start decreasing and also the pressure level.
- After 8-9 hours the cryostat will reach its operational cryogenic temperature and pressure.

Temperature radiation shield	< 70 K
Temperature cold stage	< 20 K
Pressure	< 10^{-6} mbar

- **Switch off**

For switching off the system (for example if the system will be stored for long periods or for maintenance) proceed as follows:

- Be sure that the pumping valve is closed.
- Switch off the compressor.
- Switch off the LNAs Biasing Module.
- Leave the cryostat warming to room temperature. This can be verified at the temperature monitor. This process can be accelerated by turning on the heating resistors (+25 V) and the zeolites regenerators (+6 V).
- Once the system is at room temperature, open slowly the vacuum valve to achieve atmospheric pressure inside the cryostat.

8. References

[1] Behrens, G., Campbell, W., Williams, D., White, S.. *Guidelines for de Design of Cryogenic Systems*. National Radio Astronomy Observatory (NRAO), Green Bank, West Virginia. 1997.

[2] *CTI-Cryogenics cryodyne refrigeration systems*. Helix Techonology Corporation, 2002, USA.

[3] *DT-670 Sensor Catalog.* Lakeshore. (http://www.lakeshore.com/Documents/LSTC_DT670_l.pdf)

[4] *Juntas tóricas*. Epidor Catalog (O-rings).

[5] López, J.A., Gallego, J.D., de Vicente, P., Abad, J.A., Almendros, C. *Criostato del receptor S/X de VLBI del CAY*. Informe técnico IT OAN 1994-6.

[6] Malo, I., López Fernández, J. A., Tercero, F., Abad, J.A., Almendros, C., Fernández, J., Yagüe, J.M.. *Criostato del receptor de GHz del CAY*. Informe técnico IT OAN 2005-12.

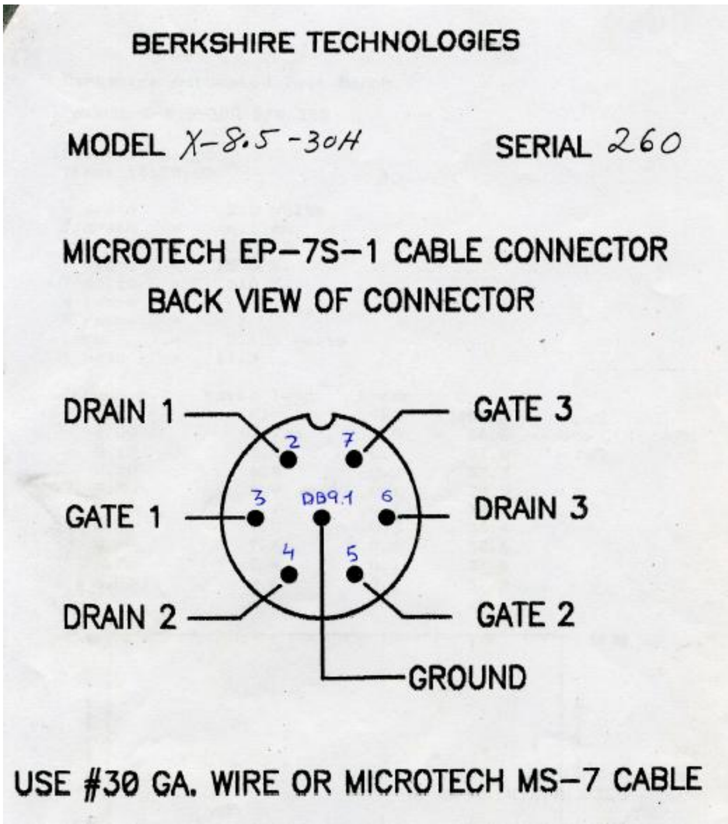
[7] *Multiple Uses of Model 22C/350C Cryodyne® Refrigerators Installation, Operation andServicing Instructions*. Brooks. USA.

[8] Serna Puente, J. M., López Fernández, J. A., López Pérez, J. A., Tercero, F., et al. *Nuevo receptor banda C de la antena Aries del Observatorio de Yebes*. Informe técnico IT OAN 2010-14.

[9] Serna Puente, J. M., López Fernández, J. A., Tercero, F., et al. *Receptor criogénico bandas K/Q de la Antena Aries del Centro de Desarrollos Tecnológicos de Yebes*. Informe técnico IT OAN 2013.

9. Appendix

9.1. S band amplifier specifications



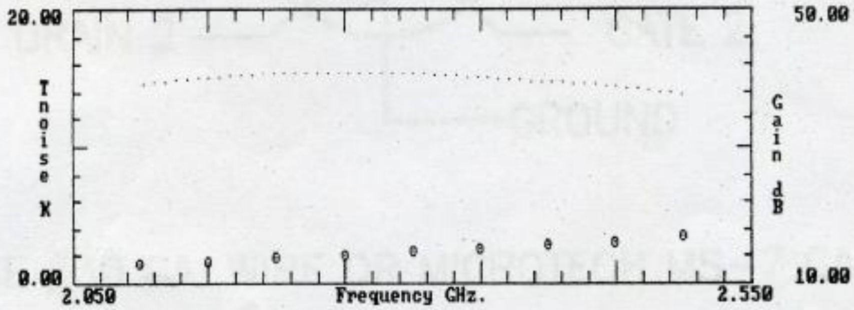
Berkshire Automated Test Bench

MODEL S-2.3-30H #240 AT 15K

Date: 07/23/97
Time: 09:41:12

V drain	=	2.5 Volts
I drain	=	5.7 mA.
Pad	=	25.0 dB
T start	=	15.3 K.
T delta	=	5.0 K.
N temps	=	5
N repeats	=	3
Zero	=	0.124 Volts
T head	=	13.2

Frequency (GHz.)	Noise Temp. (K)	Error (K)	Gain (dB.)
2.10	1.4	0.1	39.0
2.15	1.6	0.1	40.0
2.20	1.8	0.1	40.5
2.25	2.0	0.1	40.6
2.30	2.3	0.1	40.6
2.35	2.5	0.1	40.0
2.40	2.8	0.1	39.4
2.45	3.0	0.1	38.8
2.50	3.4	0.1	37.6



Bias conditions:

Stage	Drain V	Drain mA
1	2.3V	6.0 mA
2	2.5V	8.0 mA
3	3.0V	10.0 mA

9.2. X band amplifier specifications

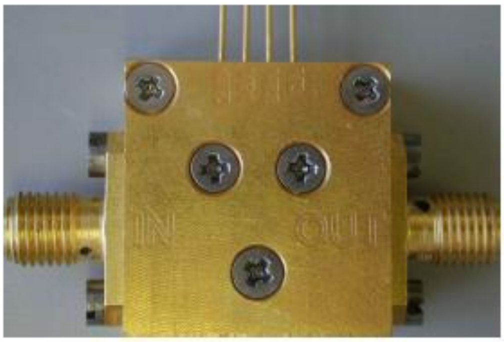
CIICRYO1-12A
Cryogenic HEMT Low Noise Amplifier
Jan 26, 2010

Features

RF Frequency:	1-12 GHz
Gain @ 11K:	32 dB ±2 dB (2-12 GHz), typical
Noise temperature @ 11 K:	< 6 K, typical average
Noise figure @ 11 K:	< 0.09 dB, typical average
IRL:	> 15 dB (4.5-12 GHz), typical
ORL:	> 20 dB (2.5-12 GHz), typical
Operating temperature:	4.2 K- 320 K
DC power @ 11 K:	1.0 Vdc at 22 mA, typical

Description

The CITCRYO1-12A is a cryogenic, low noise, broadband amplifier. In its standard configuration it comes with female SMA connectors on the RF-input and output and a 4-pin 2 mm pitch header for the DC. The amplifier requires three separate DC-voltages.



Performance Characteristics (T_a=15K)

Parameter	Min	Typ	Max	Unit
Linear Gain				
1 GHz	28.0	30		dB
7 GHz	30.0	32		dB
12 GHz	29.0	32		dB
Noise Temp				
1 GHz		8.0	12.0	K
7 GHz		4.0	6.0	K
12 GHz		8.0	11.0	K

Parameter	Min	Typ	Max	Unit
IRL				
1 GHz	0.3	0.5		dB
7 GHz	15.0	20.0		dB
12 GHz	9.0	14.0		dB
ORL				
1 GHz	4	9		dB
7 GHz	15.0	25.0		dB
12 GHz	15.0	24.0		dB

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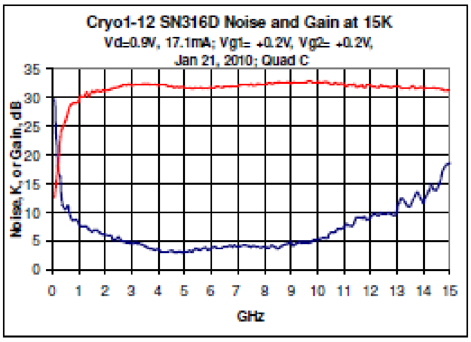
MS 136-93
Pasadena, CA 91125

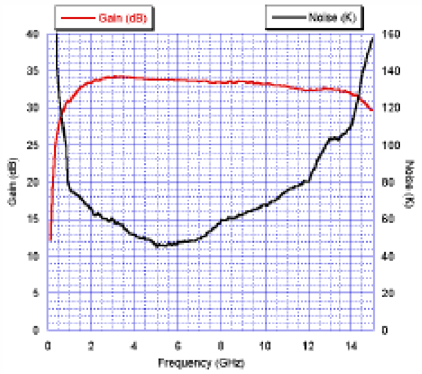
CITCRYO1-12A
Cryogenic HEMT Low Noise Amplifier

Measured typical performance characteristics (T_a=297K unless otherwise indicated)

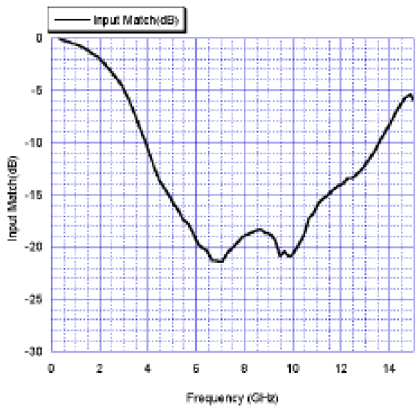
Gain and Noise versus Frequency (T_a=15K)



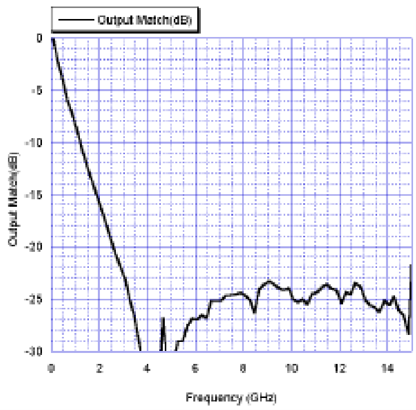
Gain and Noise versus Frequency



Input Match

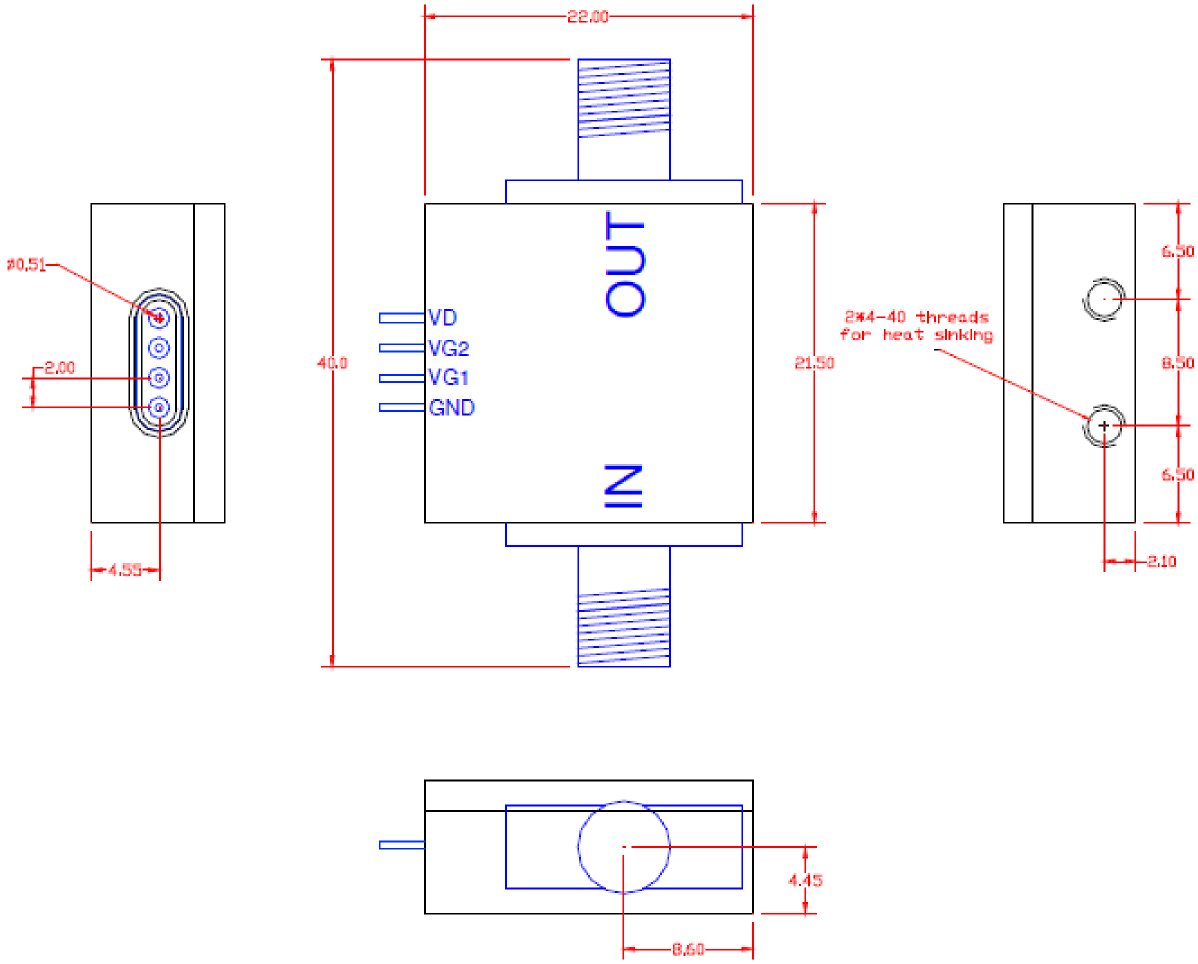


Output Match



CITCRYO1-12A
Cryogenic HEMT Low Noise Amplifier

Module drawing



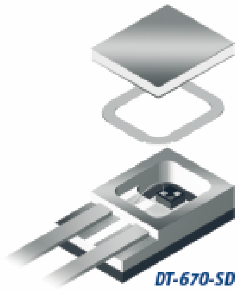
Part number: CITCRYO1-12A-XY

X= F for female input connector Y= F for female output connector
X= M for male input connector Y= M for male output connector

CITCRYO1-12A-FF for a module with female SMA connectors on input and output.

9.3. Temperature sensors specifications

Silicon Diodes



DT-670-SD

DT-670 Silicon Diodes

DT-670-SD Features

- Best accuracy across the widest useful temperature range—1.4 K to 500 K—of any silicon diode in the industry
- Tightest tolerances for 30 K to 500 K applications of any silicon diode to date
- Rugged, reliable Lake Shore SD package designed to withstand repeated thermal cycling and minimize sensor self-heating
- Conformance to standard DT-670 temperature response curve
- Variety of packaging options

DT-670E-BR Features

- Temperature range: 1.4 K to 500 K
- Bare die sensors with the smallest size and fastest thermal response time of any silicon diode on the market today
- Non-magnetic sensor

DT-621-HR Features

- Temperature range: 1.4 K to 325 K*
- Non-magnetic package
- Exposed flat substrate for surface mounting

** Calibrated down to 1.4 K, uncalibrated (Curve DT-670) to 20 K*

***CAUTION:** These sensors are sensitive to electrostatic discharge (ESD). Use ESD precautionary procedures when handling, or making mechanical or electrical connections to these devices in order to avoid performance degradation or loss of functionality.*

DT-670 Series Silicon Diodes offer better accuracy over a wider temperature range than any previously marketed silicon diodes. Conforming to the Curve DT-670 standard voltage versus temperature response curve, sensors within the DT-670 series are interchangeable, and for many applications do not require individual calibration. DT-670 sensors in the SD package are available in four tolerance bands – three for general cryogenic use across the 1.4 K to 500 K temperature range, and one that offers superior accuracy for applications from 30 K to room temperature. DT-670 sensors also come in a seventh tolerance band, Band E, which are available only as bare die. For applications requiring greater accuracy, DT-670-SD diodes are available with calibration across the full 1.4 K to 500 K temperature range.

The bare die sensor, the DT-670E, provides the smallest physical size and fastest thermal response time of any silicon diode on the market today. This is an important advantage for applications where size and thermal response time are critical, including focal plane arrays and high temperature superconducting filters for cellular communication.

PACKAGING OPTIONS BO, BR, CO, CU, CY, ET, LR, MT

The Lake Shore SD Package – The Most Rugged, Versatile Package in the Industry

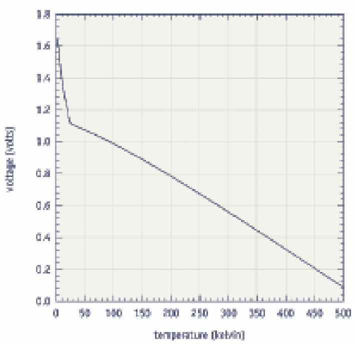
The SD package, with direct sensor-to-sapphire base mounting, hermetic seal, and brazed Kovar leads, provides the industry's most rugged, versatile sensors with the best sample to chip connection. Designed so heat coming down the leads bypasses the chip, it can survive several thousand hours at 500 K (depending on model) and is compatible with most ultra high vacuum applications. It can be indium soldered to samples without shift in sensor calibration. If desired, the SD package is also available without Kovar leads.

DT-621-HR Miniature Silicon Diode

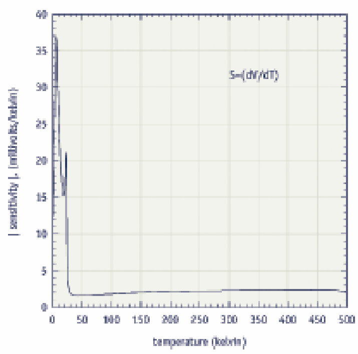
The DT-621 miniature silicon diode temperature sensor is configured for installation on flat surfaces. The DT-621 sensor package exhibits precise, monotonic temperature response over its useful range. The sensor chip is in direct contact with the epoxy dome, which causes increased voltage below 20 K and prevents full range Curve DT-670 conformity. For use below 20 K, calibration is required.

DT-621-HR

Typical DT-670 Diode Voltage Values



Typical DT-670 Diode Sensitivity Values

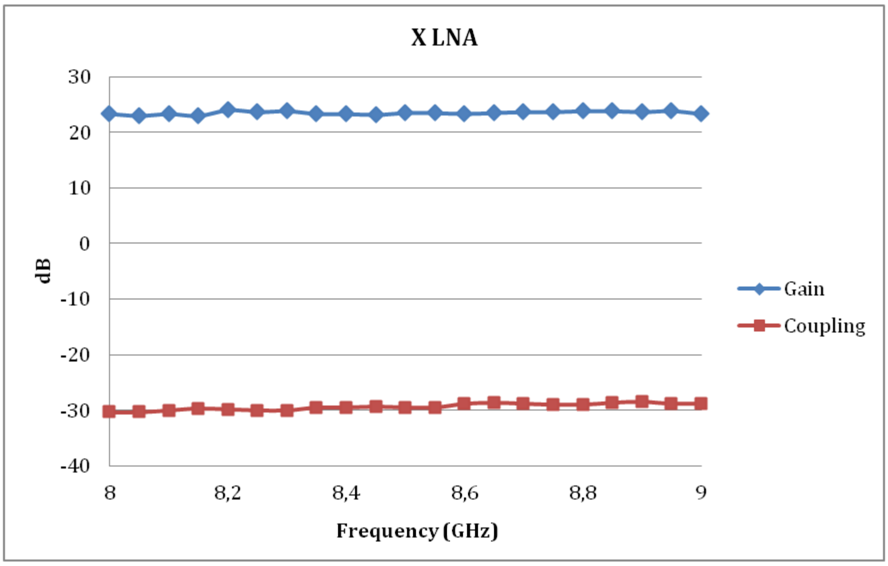


www.lakeshore.com Lake Shore Cryotronics, Inc. (614) 891-2244 fax: (614) 818-1600 e-mail: info@lakeshore.com

9.4. Gain and Coupling RF Measurements

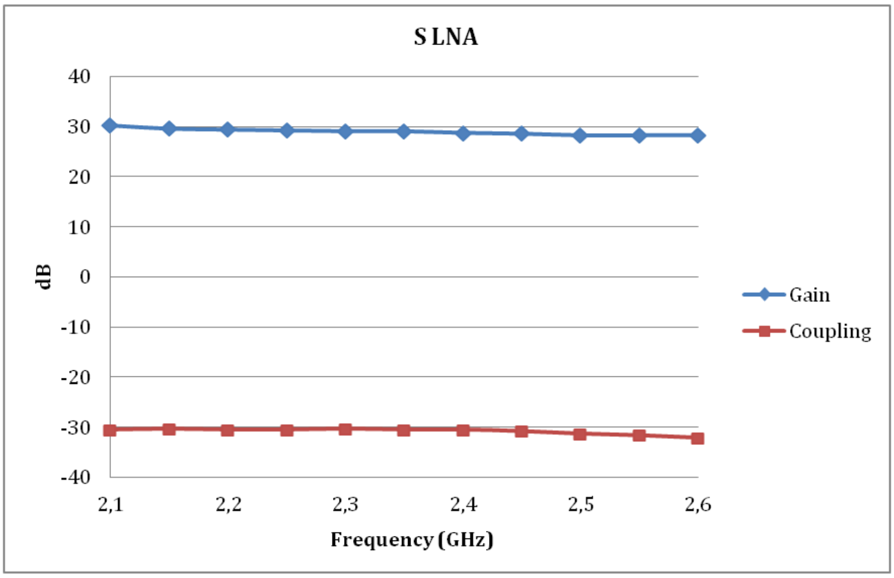
Measurements carried out at room temperature.

X Band LNA



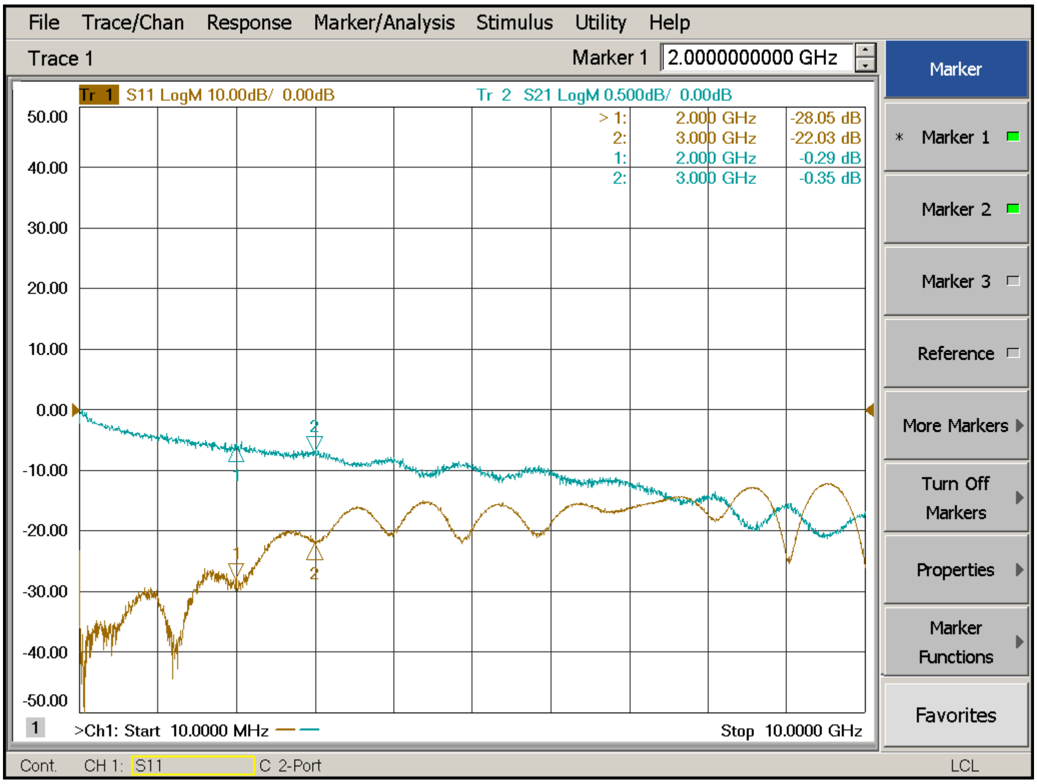
Frequency (Ghz)	Pout_cable (dBm)	Pout_ampli (dBm)	Pout_coupling (dBm)	Gain (dB)	Coupling (dB)
8	-40.17	-16.83	-47.17	**23.34**	-30.34
8.05	-40	-17	-47.33	**23**	-30.33
8.1	-40.33	-17	-47	**23.33**	-30
8.15	-40.17	-17.17	-46.83	**23**	-29.66
8.2	-41	-17	-46.83	**24**	-29.83
8.25	-40.33	-16.67	-46.67	**23.66**	-30
8.3	-40.33	-16.5	-46.5	**23.83**	-30
8.35	-40.17	-16.83	-46.33	**23.34**	-29.5
8.4	-40	-16.67	-46.17	**23.33**	-29.5
8.45	-40	-16.83	-46.17	**23.17**	-29.34
8.5	-40.17	-16.67	-46.17	**23.5**	-29.5
8.55	-40.17	-16.67	-46.17	**23.5**	-29.5
8.6	-40.17	-16.83	-45.67	**23.34**	-28.84
8.65	-40.33	-16.83	-45.5	**23.5**	-28.67
8.7	-40.17	-16.5	-45.33	**23.67**	-28.83
8.75	-40.33	-16.67	-45.67	**23.66**	-29
8.8	-40.33	-16.5	-45.5	**23.83**	-29
8.85	-40.5	-16.67	-45.33	**23.83**	-28.66
8.9	-40.5	-16.83	-45.33	**23.67**	-28.5
8.95	-40.67	-16.83	-45.67	**23.84**	-28.84
9	-40.5	-17.17	-46	**23.33**	-28.83

S Band LNA

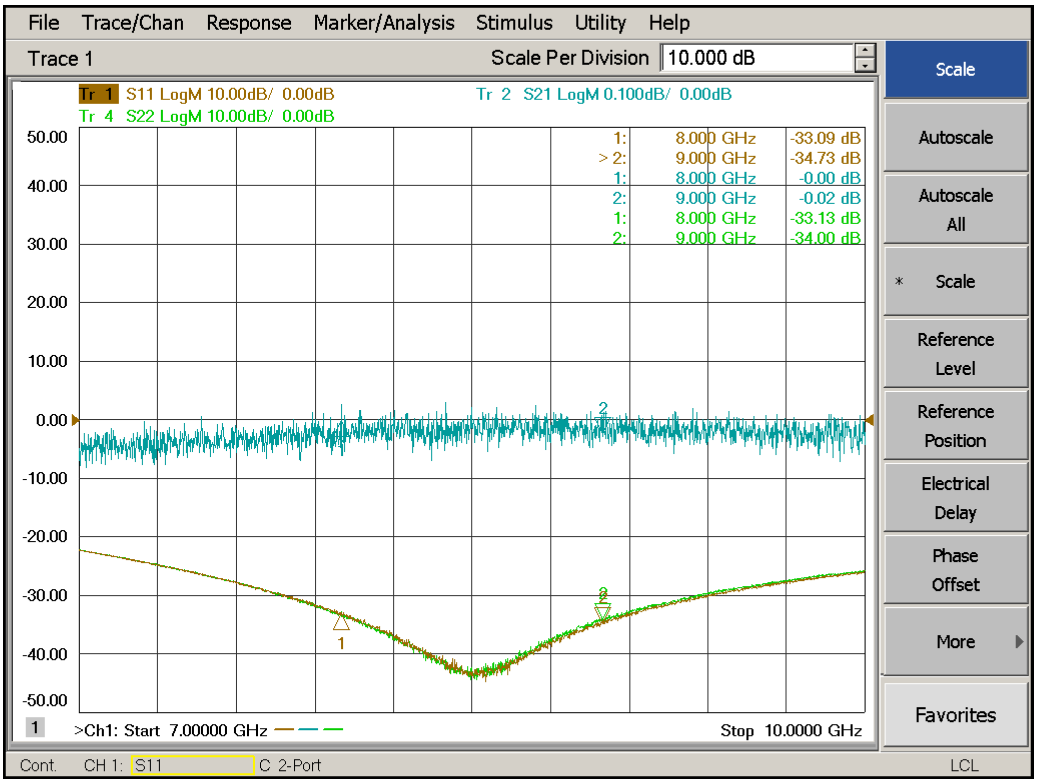


Frequency (Ghz)	Pout_cable (dBm)	Pout_ampli (dBm)	Pout_coupling (dBm)	Gain (dB)	Coupling (dB)
2.1	-40.67	-10.33	-40.83	30.34	-30.5
2.15	-40.5	-10.83	-41.17	29.67	-30.34
2.2	-40.5	-11	-41.5	29.5	-30.5
2.25	-40.5	-11.17	-41.67	29.33	-30.5
2.3	-40.67	-11.5	-41.83	29.17	-30.33
2.35	-40.33	-11.17	-41.67	29.16	-30.5
2.4	-40.33	-11.5	-42	28.83	-30.5
2.45	-40.33	-11.67	-42.5	28.66	-30.83
2.5	-40.33	-12	-43.33	28.33	-31.33
2.55	-40.5	-12.17	-43.83	28.33	-31.66

9.5. RF Measurements



Airline S parameters.



Vacuum window S parameters.