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- TECHNOLOGY DEVELOPMENT -

IASF-BO copper strap thermal conductance test report

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1 Change Record

Version	**Date**	**Affected sections**	**Reason**
0	05/01/2017	All	Draft version

2 Applicable and reference Documents

2.1 Applicable documents

AD-1.	B2+3 Warm Test Baseplate ICD	iALMA-TEC-ICD-IAB-001-G	28/10/2015
AD-2.			
AD-3.			
AD-4.			
AD-5.			

2.2 Reference documents

REF1.	ALMA Band 2(+3) Cryogenic Design Report	Report	2013
REF2.			
REF3.			
REF4.			

3 Table of content

4 Introduction and Scope

The 20K stage of the Band2+3 cartridge prototype is designed in such a way that the whole unit has an optimized thermal homogeneity. For this reason the Low Noise Amplifier chain assembly is linked to the copper supporting structure through dedicated high conductivity copper thermal straps. The preliminary design considered a thermal braid with effective conductance of 0.44 W/K at 20 K. This document reports about the thermal conductance measurement of the thermal strap manufactured at the CryoWaves Lab to be integrated in the cartridge assembly during the preliminary verification tests.

5 Experimental Setup

The measurement is run in the Blue Barrel cryogenic facility at the CryoWaves Lab at INAF-IASF Bologna. Such facility is equipped for this test with:

- a 2-stage 4K cooler by Sumitomo Heavy Industries, cold head model RDK415, capable to lift 1.5 W at the colder stage of 4.2 K and about 40 W at the 50K stage;
- a scroll pump by Agilent Technologies, model TriScroll PTS300.

The test setup (Figure 1) allows the estimation of the conductance from the measurement of the steady state temperature difference ΔT between the ends of the copper strap when a known power W is applied to it, according to the relation:

$$W = K(T) \cdot \Delta T_{st}$$

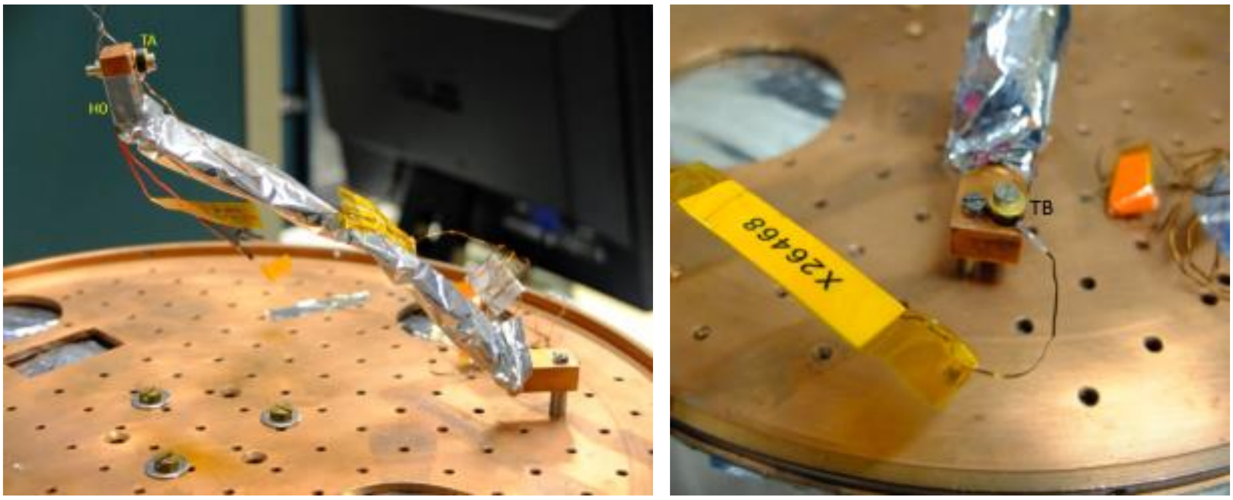

Figure 1 Left panel: Overview of the sample under test and location of the TA and H0. Right panel: location of TB sensor.

In order to perform the measurements, two calibrated LakeShore Cryotronics Cernox temperature sensors are located on the ends of the thermal strap and a Minco film heater is taped on the upper end to provide power at low temperatures. The upper end of the strap is hold suspended on the cold stage of the facility through a thin stainless steel wire connected with an Aluminum support structure. The lower end of the strap is connected to the facility 4K flange through a low conductance stainless steel link, so that measurements at different temperatures are easily got. A further silicon diode temperature sensor is used to monitor the cold flange temperature. The whole set of sensors and the heater are read and biased by a temperature control instrument by LakeShore Cryotronics, model 340.

Id	Sensor	Location
TA	CX1050 – X34088	Thermal strap upper warm end
TB	CX1050 – X26468	Thermal strap lower cold end
TC	DT670 - D60196	4K flange
H0	Minco HK5572R26.5	Thermal strap upper warm end

Table 1 The table reports the type and ID code of the sensors and heaters, together with their location in the test setup.

6 Test data and results

After setting up the facility as described in the previous section, it was closed and sealed in the afternoon of December, 19th 2016, and pumped down starting at 15:00 CET up to 16:35, when the inner pressure reached the value of $2.5 \cdot 10^{-2}$ mBar and the cooler was activated so that the cooldown started.

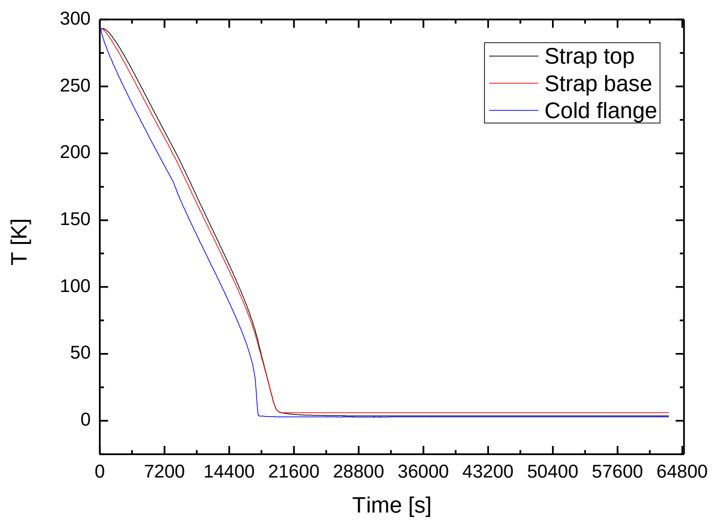

Figure 2 Temperature curves during the cooldown of the test setup.

At 17:15 CET when pressure has dropped down to $2.1 \cdot 10^{-3}$ mBar, the vacuum valve was closed and the cooldown proceeded without external pumping. As evident from Figure 2, the whole system reached its minimum steady temperature in about six hours.

The strap was then given a set of input power and the corresponding temperature difference between the top and the base sensors was recorded.

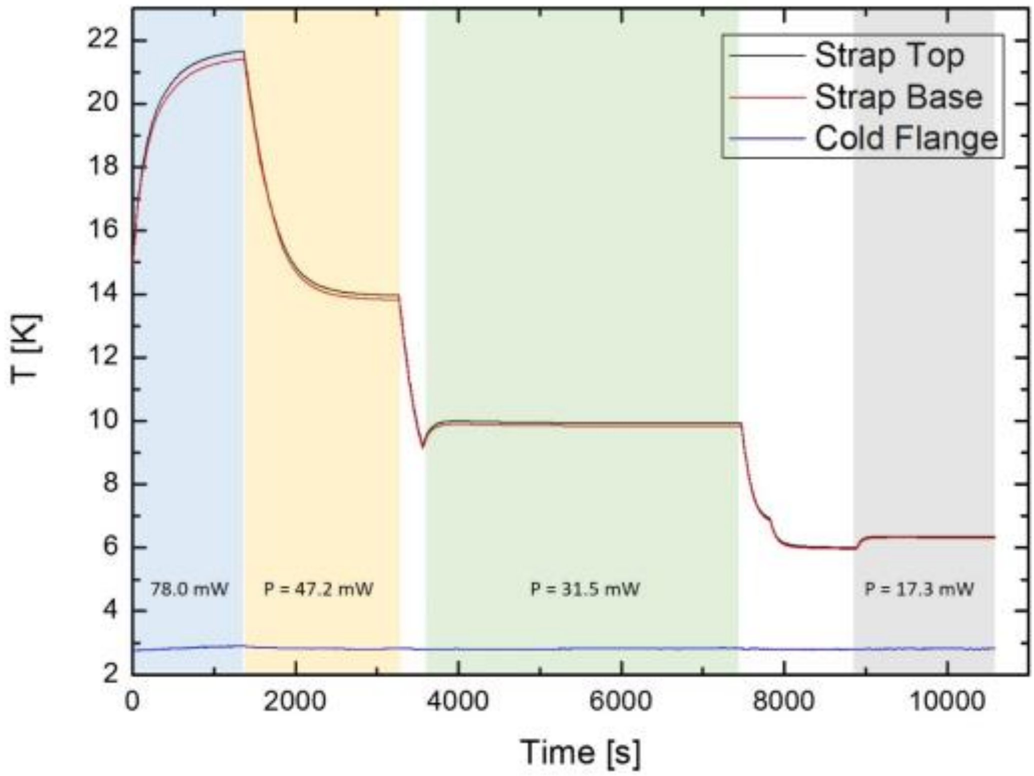

Figure 3 The system temperature curves during the whole thermal conductance measurement test. The different heat load provided to the top of the strap is written inside the color band identifying the time range it was applied during the test.

The whole temperature curve behaviour is shown in Figure 3, while the data used to evaluate the thermal conductance in the different points are reported in Table 2.

Strap Mean steady T [K]	**Power [mW]**	**ΔT_{meas} [K]**	**Conductance [W/K]**
21.538	78.0	0.245	0.32±0.08
13.892	47.2	0.137	0.34±0.10
9.883	31.5	0.091	0.35±0.15
6.338	17.3	0.044	0.39±0.35

Table 2 Mean temperature and standard deviation measured during cold steady state

The heat injected by the temperature controller is very stable and accurate so that the main uncertainty in the measurement is related to the temperature sensor accuracy of about 20 mK, which is the main contributor to the error associated to the thermal conductance measured.

7 Summary and Conclusion

The ALMA Band2+3 prototype detector chain is tested at the CryoWaves Lab inside the NAOJ ALMA cryostat. The thermalization of the Low Noise Amplifiers is provided through a high conductance link between them and the copper supporting structure mounted on the 20 K cryostat flange.

Such a link was manufactured at the CryoWaves Lab using thermal braids available on site. The thermal conductance measurements reported in this note demonstrate that the thermal link performance is comparable to the design link property.