Krytar 30 dB coupler for the injection of the calibration signal to the 2-14 GHz wideband VGOS receiver

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Change Record

Revision	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks

Outline

1. Introduction

Radio Astronomy receivers, specifically those to be used in the VLBI observations, incorporate subsystems for calibration. This is particularly the case of the 2-14 GHz receiver of the 13-m Radio Telescope of the *Observatorio de Yebes*.

There are two types of calibration needed for VLBI: amplitude and phase. Amplitude and phase calibration signals are injected to the receiver RF front-end by a directional coupler, right after the horn and before the LNA, inside the cryostat (see Figure 1).

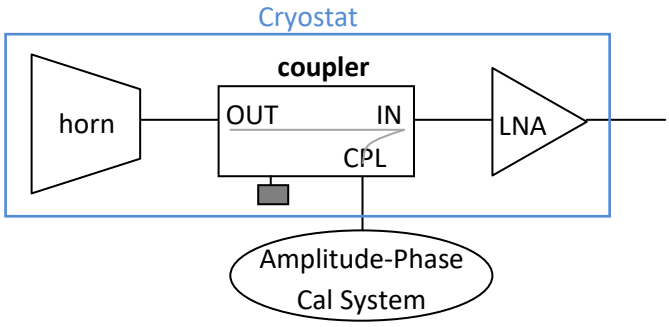


***Figure 1**: Coupler for the injection of the amplitude and phase calibration system.*

In a previous report [1] a description of the characteristics of a good coupler for the injection of the amplitude and phase calibration signals was presented. Two couplers of 20 and 30 dB respectively, from Pulsar supplier, were measured and compared. The present report is a natural extension of [1] searching for commercial couplers that work properly at cryogenic temperature despite the fact that they are designed just to operate at room temperature. The 30 dB couplers made by Krytar for the 2-18 GHz band were measured at room and 20 K temperature.

2. 30 dB Couplers Measurements.

Results of two Krytar 2-18 GHz 30 dB couplers, with part number 1825 and serial numbers 204046 and 204047 are presented in Table 1 at room and cryogenic temperature (20 K). Full measurements can be found in the Annex I.

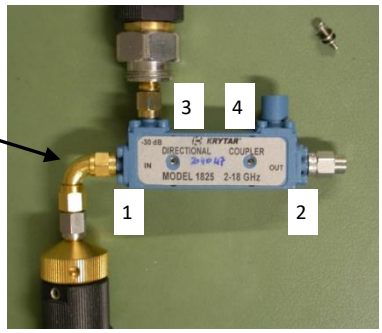
Serial Number	**Krytar 1825 (2-18GHz 30dB) #SN 204046**	
Nominal Coupling	30 dB	
Connector	SMA female	
Frequency Band	2 – 18 GHz	
Temperature	*297 K*	*20 K*
Return Loss (dB, max. any port)	-15 (*)	-13
Coupling (dB): mean	-30 (*)	-29.6
Δ_{pp}	0.59	2.42
Group delay IN-CPL (Δ_{pp}) [*ps*]	69	197
Insertion Loss dB (max.)	0.53 (**)	0.32

Serial Number	**Krytar 1825 (2-18GHz 30dB) #SN 204047**	
Nominal Coupling	30 dB	
Connector	SMA female	
Frequency Band	2 – 18 GHz	
Temperature	*297 K*	*20 K*
Return Loss (dB, max. any port)	-17 (*)	-15
Coupling (dB): mean	-29.9 (*)	-29.3
Δ_{pp}	1	2
Group delay IN-CPL (Δ_{pp}) [*ps*]	38	148
Insertion Loss dB (max.)	0.53 (**)	0.15

Table 1. *Yebes measurements of two Krytar 30 dB couplers (part number 1825).*

(*) Ambient measurements are taken outside of the cryostat. For the measurement of the IN-OUT path, the coupler was attached directly to the VNA cables; these are the S(1,1) and S(2,2) showed in the graph. For the measurement of the coupled-IN path, there was an elbow SMA M-F transition attached to the IN port, which is not de-embedded (see photo below), but it doesn't disturb the S(3,3) measurement.

Not de-embedded elbow SMA M-F transition



(**) The Average Effective Insertion Loss of the coupler is a measurement of its dissipative loss, directly related to the noise added by the coupler. It is slightly overestimated in this report:

a. At 300K, because a) the measurement adds the loss of the elbow transition and b) because the power coupled to the isolated port (S-par S_{14}) has not been taken into account.
b. At 20 K, the transition is not used and the overestimation is caused by the power coupled to the isolated port (S-par S14) which was not taken into account.

CONCLUSION:

- At cryogenic temperature, return loss of all measured ports get worse about 2-4 dB.
- At cryogenic temperature, the pn 204046 coupler shows an anomalous behavior of the transmission of the IN-OUT path at low frequency that is not understood.
- The contact of the SMA connectors to the lines is not soldered neither glued, just held by pressure. At cryogenic temperature the different contraction of the materials could reduces the pressure causing a worse connector-line contact. A possible solution to improve the contact at cryogenic temperatures is the substitution of the SMA connectors by a type similar to the

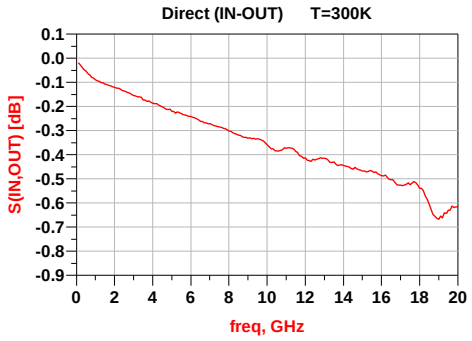
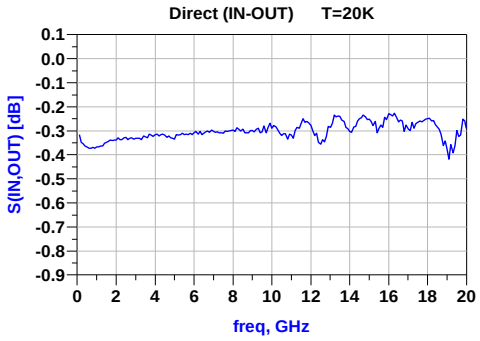
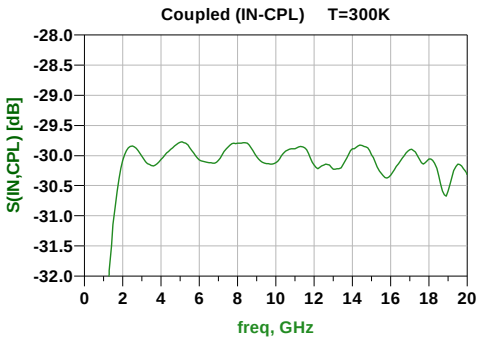
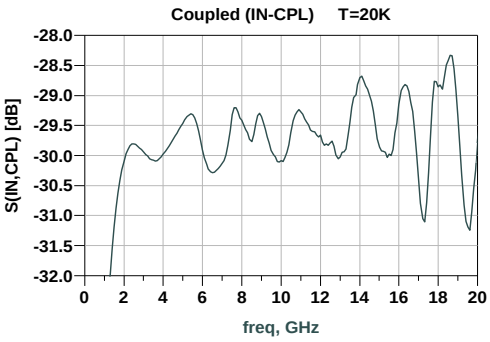
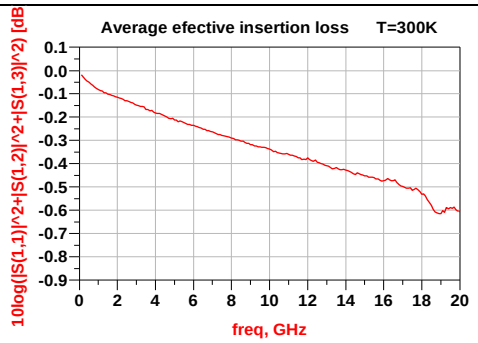
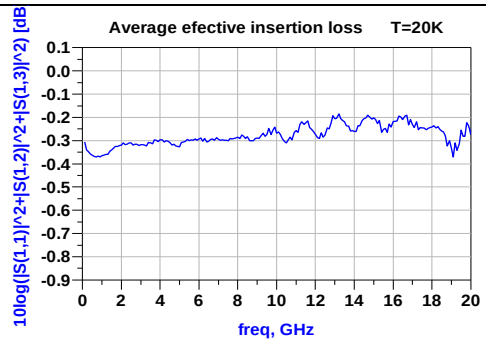
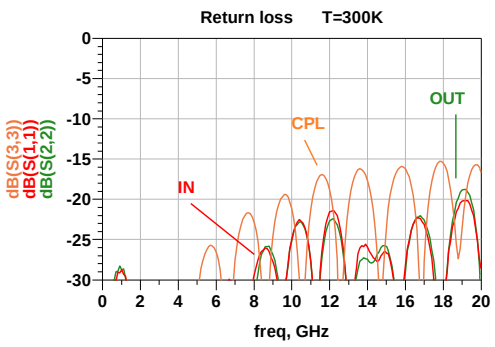
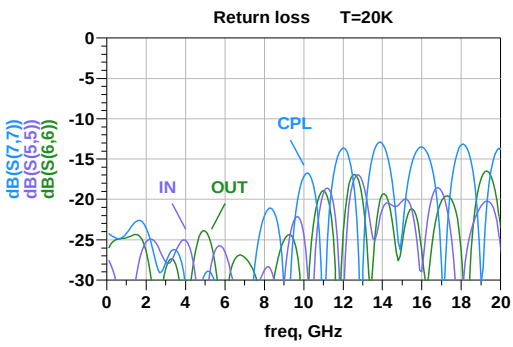
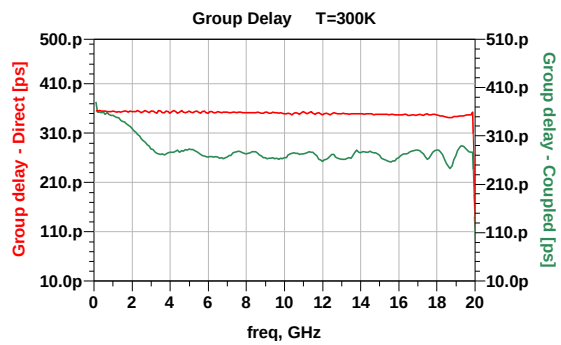
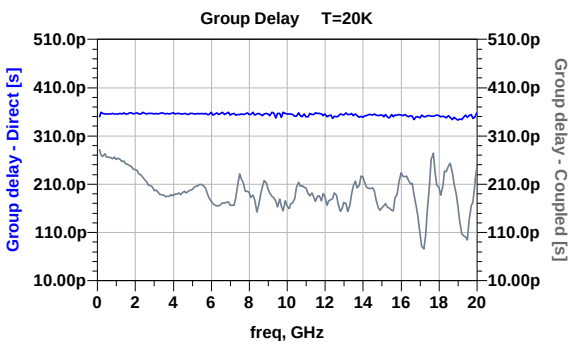
"universal field-replaceable receptacle" attached to a suitable sliding center-pin soldered to the line that would allow absorbing the different expansion coefficient of the materials.

- Coupling measurements at cryogenic temperature show sharp changes which also appear in the group delay. These could be caused by resonances of the housing. Note that the sharp changes of the group delay appear at almost the same frequencies in the two couplers measured. It is important to remark that group delay variation over frequency could be calibrated (if they remain constant in time) but the resonances present sharp variations of the performance and may change with time or aging.

3. References

[1] I. Malo, J.D. Gallego, J. González, I. López-Fernández, C. Diez, R. Amils, "New 30 dB coupler for the injection of the calibration signal to the 2-14 GHz wideband VGOS receiver", IT-CDT-2019-16, BRAND project.

4. Annex I: Ambient and cold measurements.

Krytar 1825 (2-18GHz, 30dB) #SN 204046	
300 K	20 K
	
	
	
	
	

Krytar 1825 (2-18GHz, 30dB) #SN 204047

300 K	20 K