Measurements of the 3dB 90º cryogenic coaxial hybrid couplers for the S and X bands of the tri-band receiver for Santa María (Azores) RAEGE station.

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Change Record

Revision	Date	Affected Paragraphs(s)	Reason/Initiation/Remarks
A	2014-08-04	All	First Issue

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1 Introduction

The initial receivers built for the RAEGE VLBI 2010 antennas should allow simultaneous operation (with the two orthogonal circular polarizations) in S, X and Ka band. This will be achieved using three in-focus coaxial horns. The present design is based on using a septum polarizer for Ka band in the inner horn, and two outer coaxial horns with four probes each for X and S band. Achieving the adequate field configuration to generate the circular polarization will involve the use of a combination of 180º and 90º coaxial 3 dB hybrid couplers. The minimum bandwidth required is 2.2-2.7 GHz in S band, 7.5-9 GHz in X band and 28-33 GHz in Ka band.

Modern cryogenic amplifiers obtain noise temperatures below 5 K in S and X band. Taking full advantage of this extreme sensitivity requires a very careful design of the feed. In particular, losses in horns, probes, input cables and hybrids couplers can severely degrade the performance and could very easily become the dominant contribution to the total receiver noise. In order to minimize the noise, the design of the receivers assumes that the hybrids will be cooled to cryogenic temperature.

Yebes has developed[1] special designs for 3 dB 90º hybrids in several bands optimized for cryogenic operation. There are devices commercially available covering these bands with good ambient temperature characteristics, but their cryogenic performance degrades to unacceptable levels. Thereby, two designs have been made for the bands 2-8 GHz and 4-12 GHz, to cover the S and X bands of the receiver, specially conceived to operate when cooled to 20 K. Its coupling and reflection characteristics show very little temperature dependence. The units are a very compact, low-loss, reliable, repetitive and low thermal mass devices, capable to withstand extreme thermal cycling.

This report summarizes the measured performance of the units YH90X1023 (X-Band) and YH90SC1002 (S-Band) that will be used in the tri-band Santa María (Azores) receiver, at ambient and cryogenic temperature.

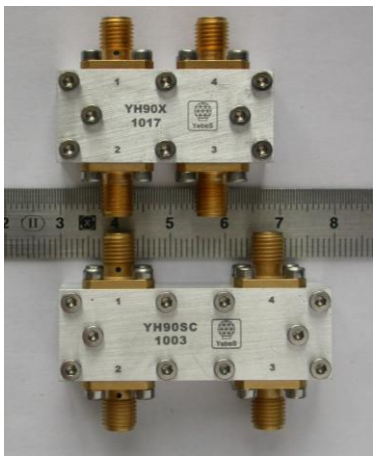


Figure 1. This photo shows one hybrid of each type for easy comparison of their relative sizes. Top: 4-12 GHz, bottom: 2-8 GHz

[1] *Cryogenic Hybrid Coupler for Ultra Low Noise Radio Astronomy Balanced Amplifiers,* Inmaculada Malo-Gómez, J. Daniel Gallego-Puyol, Carmen Diez-González, Isaac López-Fernández, and César Briso-Rodríguez, IEEE Transactions on Microwave Theory and Techniques, vol. 57, no. 12, December 2009.

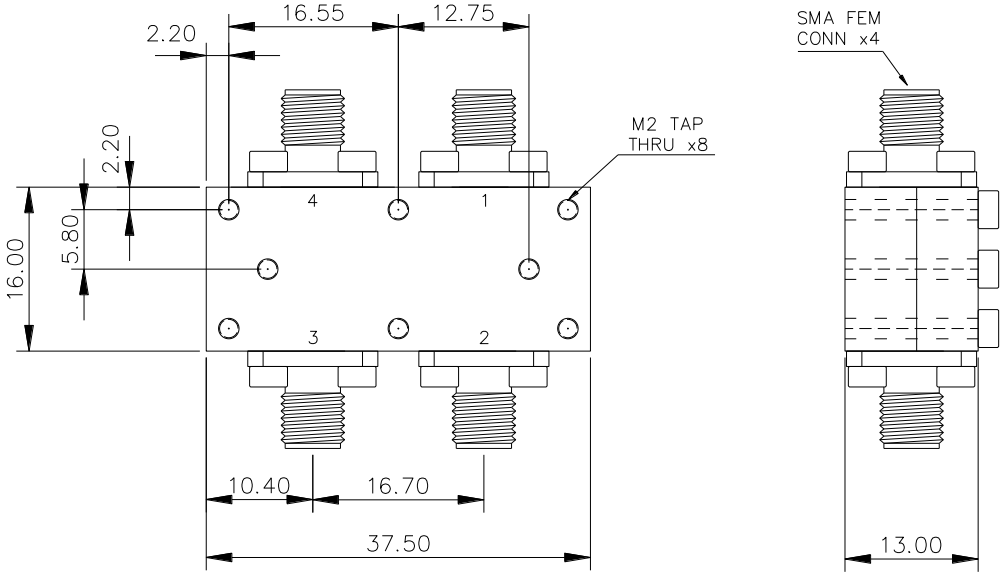
MEASURED PERFORMANCE

Serial Number	**YH90X 1023**			
Description	**3dB 90º cryogenic hybrid**			
Frequency Band	4 - 12 GHz		7.5 - 9 GHz	
Nominal Coupling	3 dB			
Connector	SMA female, sliding pin			
Weight (typ.)	36 g (1.27 oz)			
Temperature	*297 K*	*20 K*	*297 K*	*20 K*
A. E. Insertion Loss dB (max.)[*1]	0.52 dB	0.15 dB	0.44	0.13 dB
Return Loss (max. any port)	-23 dB	-23 dB	-23.3	-26.7 dB
Amplitude Unbalance (max.)	± 0.3 dB	± 0.37 dB	± 0.13 dB	± 0.13 dB
Phase Unbalance (max.)	± 1º	± 1.5º	± 0.5º	± 0.6º

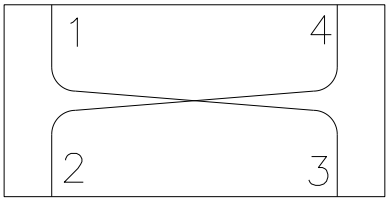
**1: Average Equivalent Insertion Loss (dB),* $L_{eq}=10\ log_{10}\ (|s_{11}|^2+|s_{12}|^2+|s_{13}|^2+|s_{14}|^2)$

OUTLINE DRAWING

Dimensions in mm.

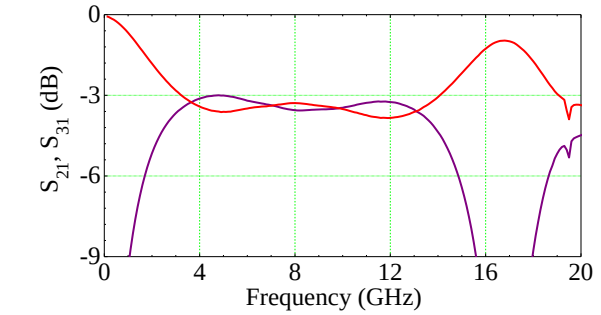


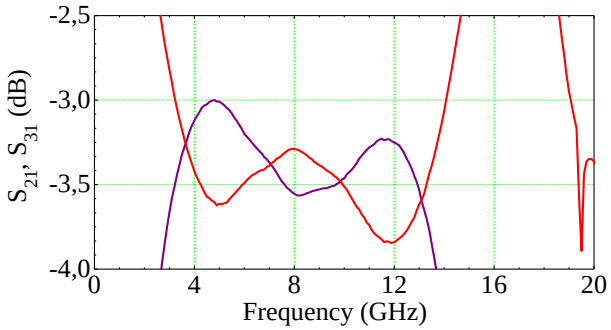
ELECTRICAL SCHEMATIC

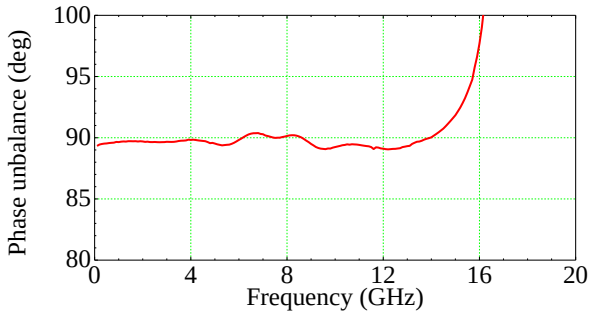


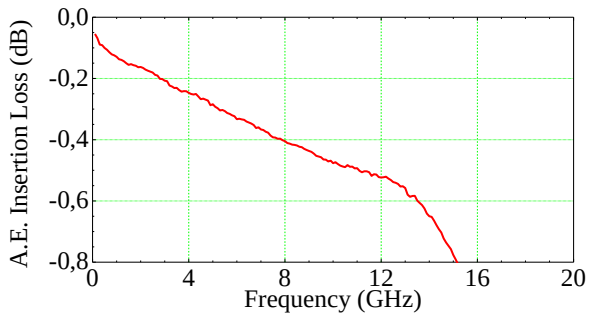
MEASUREMENTS

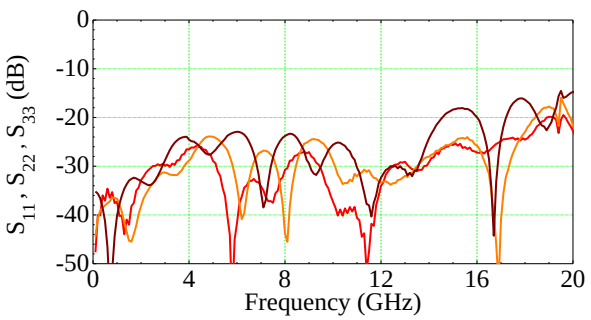
Temperature 297 K



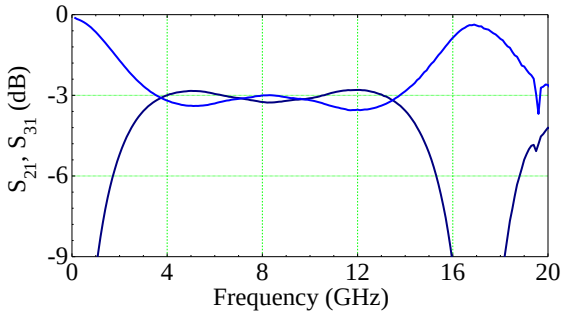


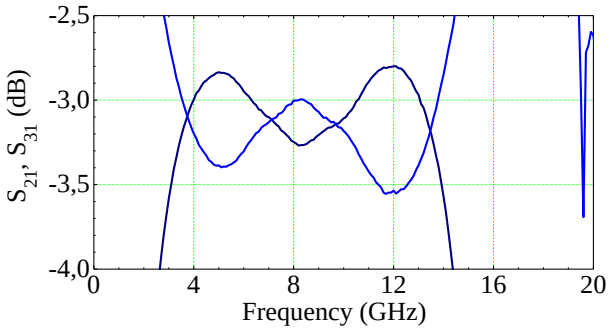


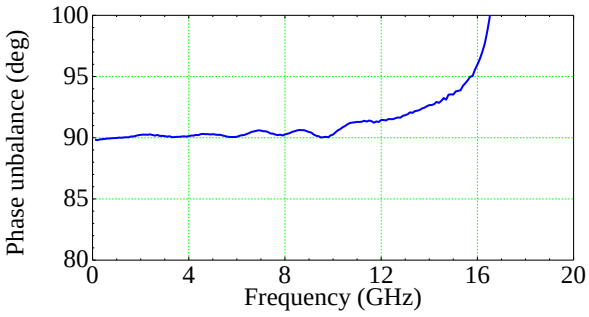


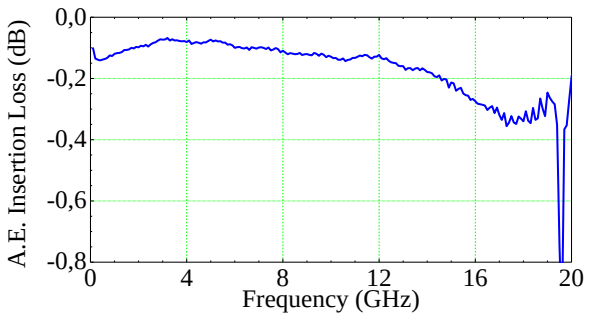


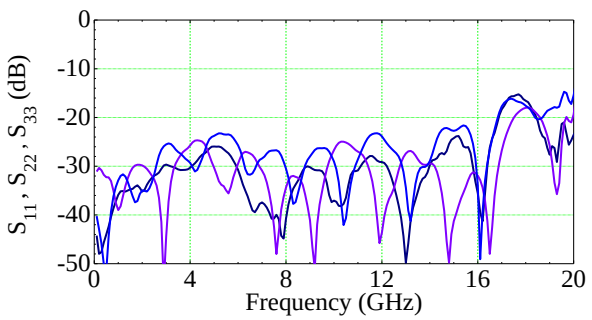
Temperature 20 K











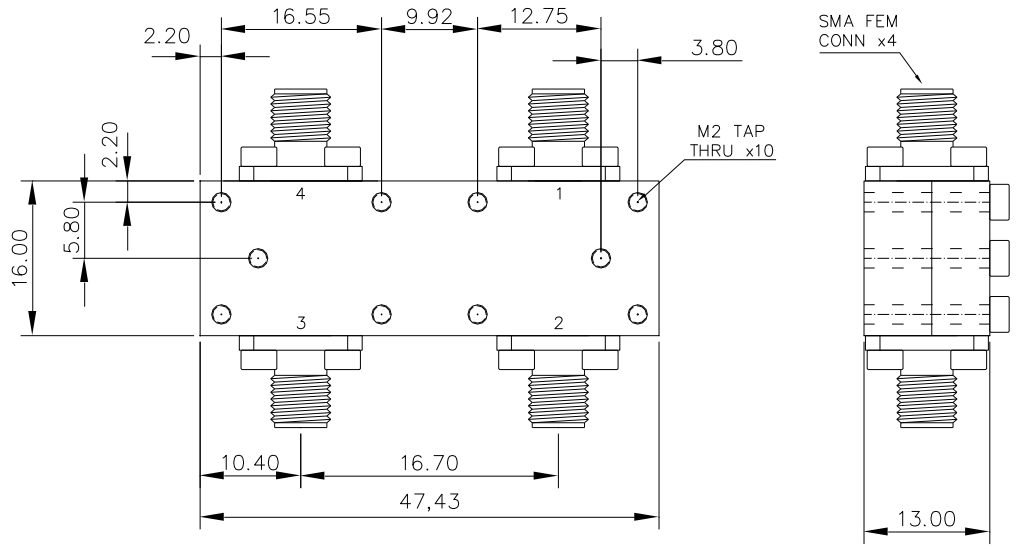
MEASURED PERFORMANCE

Serial Number	**YH90SC 1002**			
Description	**3dB 90º**			
Frequency Band	2 - 8 GHz		2.2 – 2.7 GHz	
Nominal Coupling	3 dB			
Connector	SMA female, sliding pin			
Weight (typ.)	40.5 g (1.43 oz)			
Temperature	*297 K*	*20 K*	*297 K*	*20 K*
A. E. Insertion Loss dB (max.)[*1]	0.54 dB	0.18 dB	0.23 dB	0.08 dB
Return Loss (max. any port)	-22.2 dB	-25.3 dB	-28.8 dB	-28.1 dB
Amplitude Unbalance (max.)	± 0.28 dB	± 0.28 dB	± 0.23 dB	± 0.22 dB
Phase Unbalance (max.)	± 1.3º	± 1º	± 0.2º	± 0.5º

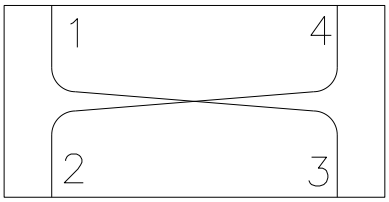
**1: Average Equivalent Insertion Loss (dB),* $L_{eq}=10\ log_{10}\ (|s_{11}|^2+|s_{12}|^2+|s_{13}|^2+|s_{14}|^2)$

OUTLINE DRAWING

Dimensions in mm.

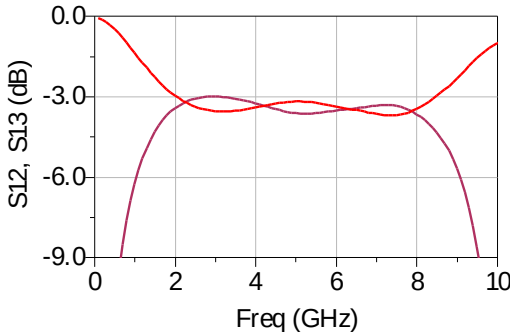


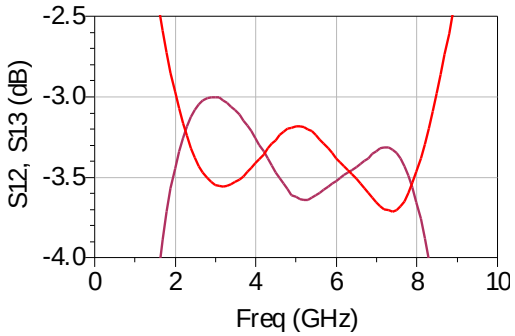
ELECTRICAL SCHEMATIC

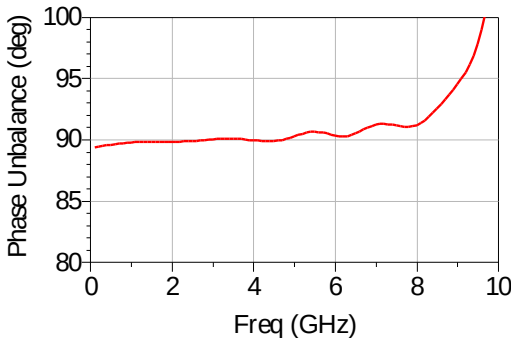


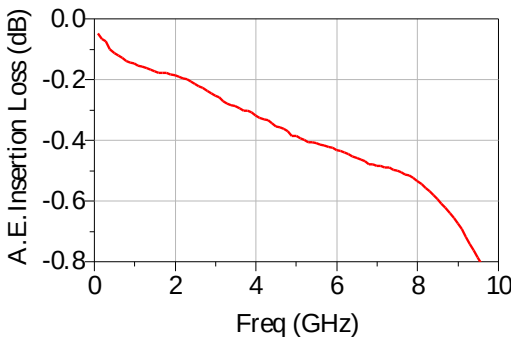
MEASUREMENTS

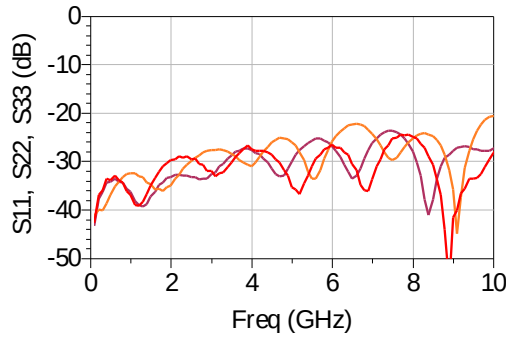
Temperature 297 K











Temperature 20 K