

# **Measurements of the 4-12 GHz Cryogenic Amplifiers for 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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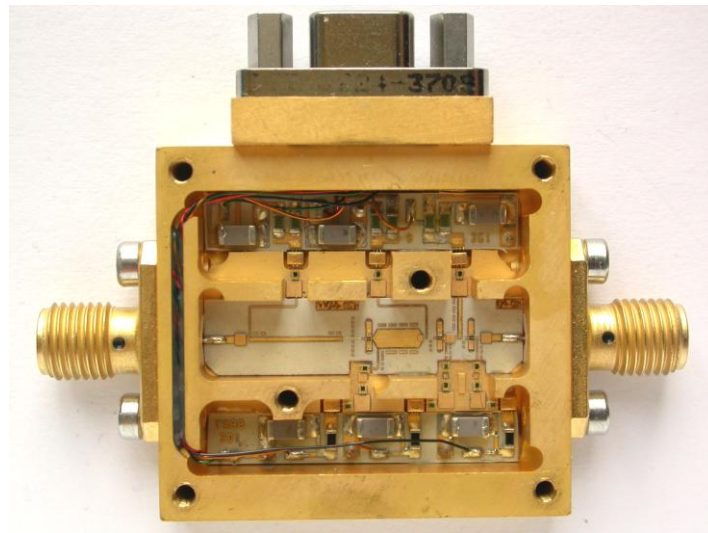
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## Introduction

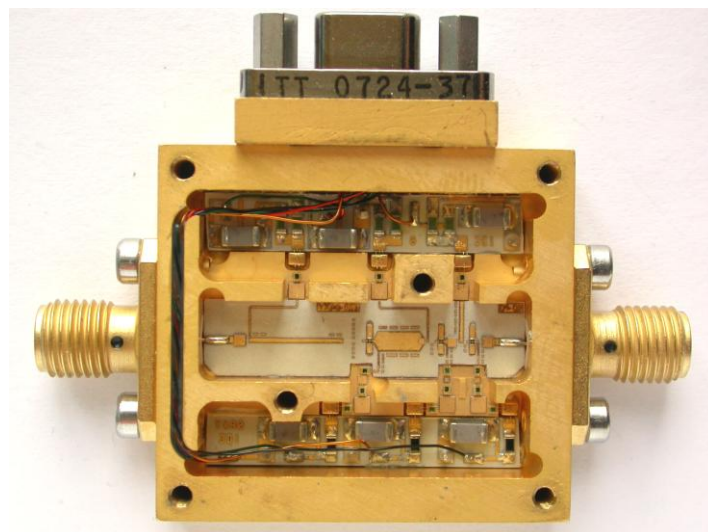
The initial tri-band receiver for the Santa María (Azores) RAEGE antenna should allow simultaneous operation (with the two orthogonal circular polarizations) in S, X and Ka band. This will be achieved with a cryogenic receiver built into a single cryostat. The minimum bandwidth required is 2.2-2.7 GHz in S band, 7.5-9 GHz in X band and 28-33 GHz in Ka band.

Yebes has developed and manufactured two cryogenic amplifiers for the X-band of the Santa María receiver based on the design of the LNAs developed for the ALMA band 9 and Plateau de Bure (IRAM) receivers. The original band of these designs is 4-12 GHz and although only a small part of this band is used in the X band VLBI receivers it was estimated that using this very well known and highly reliable design was a better option than a completely new design optimized for narrow band.

This report summarizes the measured performance of the two LNAs at ambient and cryogenic temperature, in the 4-12 GHz (wide) and in the 7.5-9 GHz (VLBI) bands. The serial numbers of these units are: YXA 1207 (*Figure 1*) and YXA 1208 (*Figure 2*).



*Figure 1. Photo of the YXA 1207 cryogenic amplifier.*



*Figure 2. Photo of the YXA 1208 cryogenic amplifier.*



# OBSERVATORIO DE YEBES

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### RAEGE CRYO-LNA REPORT

DATE: 30/07/14

BAND:	4 - 12	S/N:	YXA 1207
TRANSISTOR 1 <sup>st</sup> STAGE:	HRL 150x0.1 um (4851) T-78		
TRANSISTOR 2 <sup>nd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		
TRANSISTOR 3 <sup>rd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		

ROOM TEMPERATURE DATA		T = 307.0	
OPTIMUM BIAS	$V_{d1} = 1.5$	$I_{d1} = 10$	$V_{g1} = -3.58$
	$V_{d2} = 1.5$	$I_{d2} = 10$	$V_{g2} = -4.18$
	$V_{d3} = 1.5$	$I_{d3} = 10$	$V_{g3} = -2.99$
AVERAGE NOISE TEMP: 53.3		MIN. INPUT RETURN LOSS: -4.3	
AVERAGE GAIN: 33.4		MIN. OUTPUT RETURN LOSS: -13.2	

CRYOGENIC TEMPERATURE DATA		T = 13.5	
OPTIMUM BIAS  ( $P_{diss} = 9.03$ mW)	$V_{d1} = 1.00$	$I_{d1} = 4.5$	$V_{g1} = -1.38$
	$V_{d2} = 0.60$	$I_{d2} = 3.1$	$V_{g2} = -1.19$
	$V_{d3} = 0.90$	$I_{d3} = 3.0$	$V_{g3} = -1.14$
AVERAGE NOISE TEMP: 5.88		MAX. / MIN. NOISE TEMP: 7.29      4.77	
AVERAGE GAIN: 33.8		GAIN SPAN FULL BAND: 1.7	
MIN. INPUT RETURN LOSS: -3.8		MIN. OUTPUT RETURN LOSS: -13.6	

**REMARKS:**    Gain data from VNA measurements

$V_d$  in Volts,  $I_d$  in mA, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz



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### RAEGE CRYO-LNA REPORT

DATE: 30/07/14

BAND:	7.5 -9	S/N:	YXA 1207
TRANSISTOR 1 <sup>st</sup> STAGE:	HRL 150x0.1 um (4851) T-78		
TRANSISTOR 2 <sup>nd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		
TRANSISTOR 3 <sup>rd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		

ROOM TEMPERATURE DATA			
			T = 307.0
OPTIMUM BIAS	$V_{d1} = 1.5$	$I_{d1} = 10$	$V_{g1} = -3.58$
	$V_{d2} = 1.5$	$I_{d2} = 10$	$V_{g2} = -4.18$
	$V_{d3} = 1.5$	$I_{d3} = 10$	$V_{g3} = -2.99$
AVERAGE NOISE TEMP: 51.8		MIN. INPUT RETURN LOSS: -4.3	
AVERAGE GAIN: 33.0		MIN. OUTPUT RETURN LOSS: -21.8	

CRYOGENIC TEMPERATURE DATA			
			T = 13.5
OPTIMUM BIAS	$V_{d1} = 1.00$	$I_{d1} = 4.5$	$V_{g1} = -1.38$
	$V_{d2} = 0.60$	$I_{d2} = 3.1$	$V_{g2} = -1.19$
	$V_{d3} = 0.90$	$I_{d3} = 3.0$	$V_{g3} = -1.14$
(P <sub>diss</sub> = 9.03 mW)			
AVERAGE NOISE TEMP: 5.99		MAX. / MIN. NOISE TEMP: 6.35      5.74	
AVERAGE GAIN: 33.6		GAIN SPAN FULL BAND: 0.2	
MIN. INPUT RETURN LOSS: -3.8		MIN. OUTPUT RETURN LOSS: -18.8	

**REMARKS:**    Gain data from VNA measurements

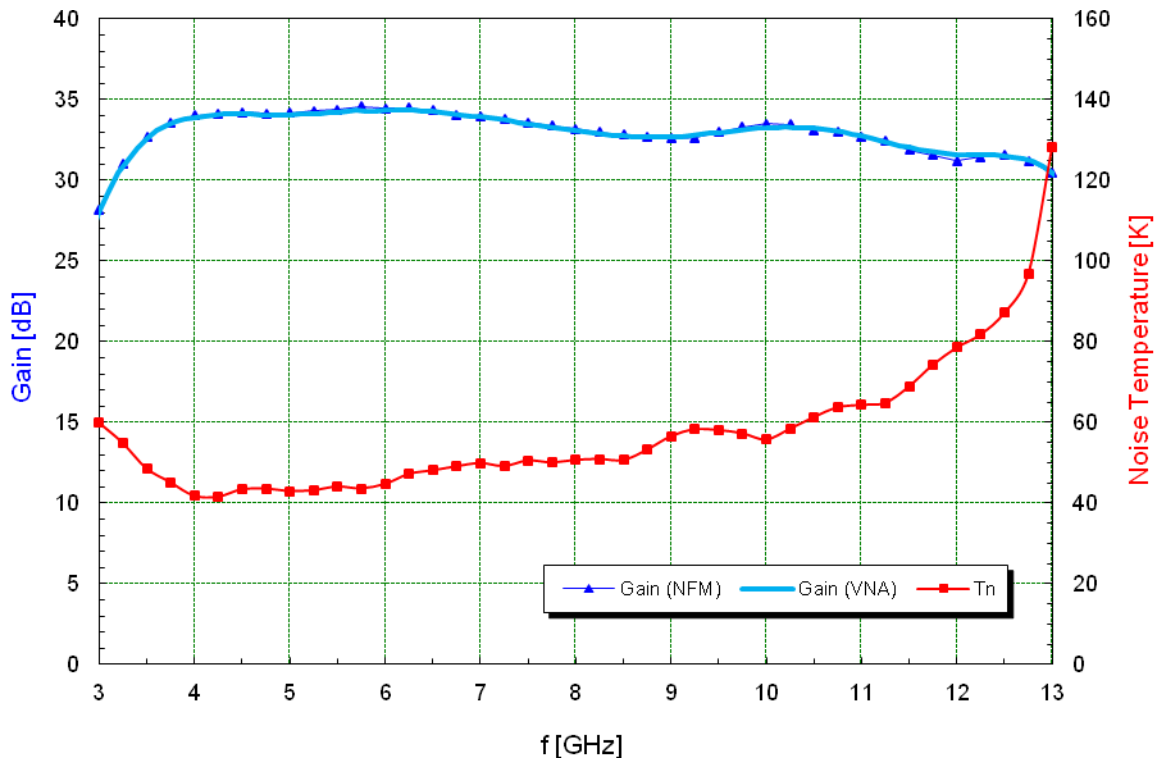
V<sub>d</sub> in Volts, I<sub>d</sub> in mA, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz

### YXA 1207 (8)

$V_{D(1,2,3)} = (1.5, 1.5, 1.5)$

$I_{D(1,2,3)} = (10, 10, 10)$

$T=307$

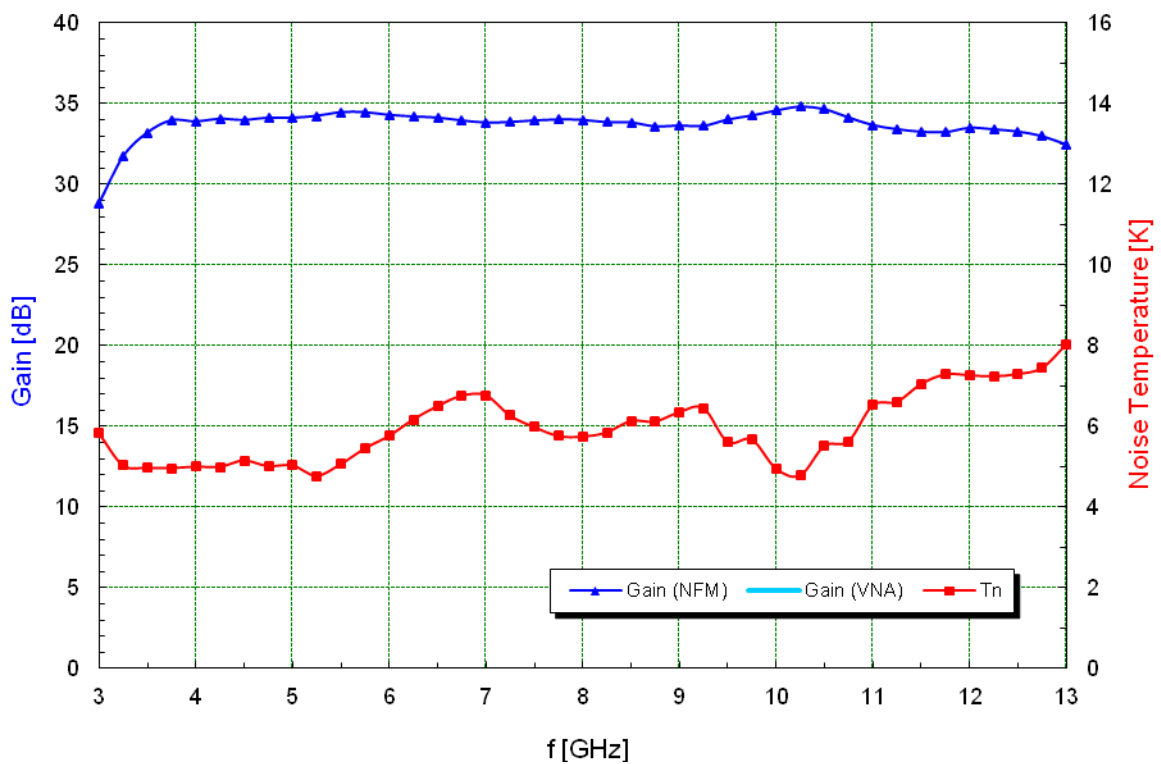


### YXA 1207 (8)

$V_{D(1,2,3)} = (1, 0.6, 0.9)$

$I_{D(1,2,3)} = (4.5, 3, 3)$

$T=13.5$

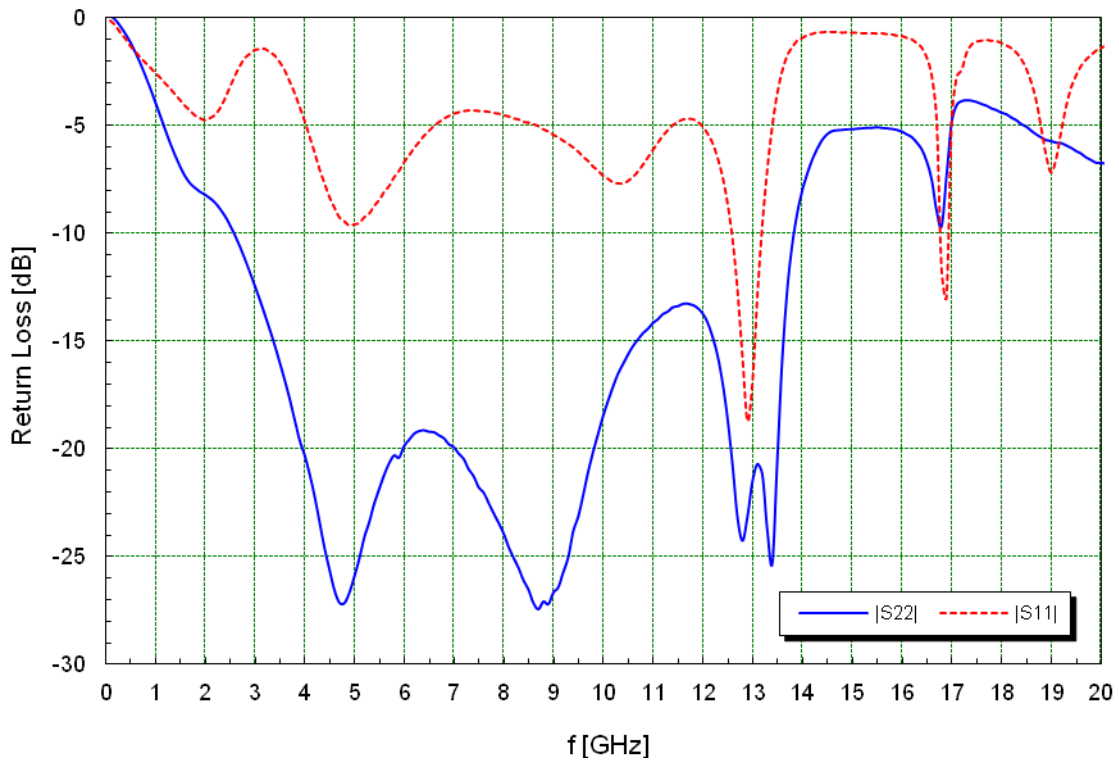


### YXA 1207 (8)

VD=(1.5,1.5,1.5)

ID=(10,10,10)

T=307

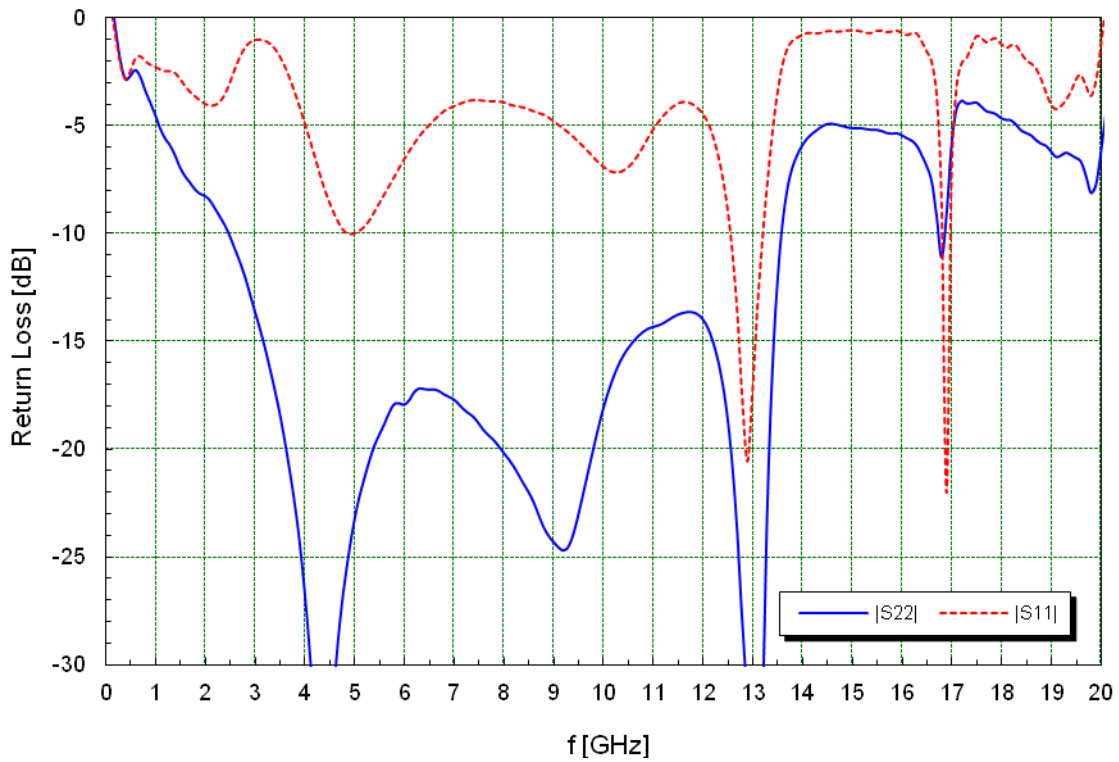


### YXA 1207 (8)

VD=(1,.6,.9)

ID=(4.5,3,3)

T=17K







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### RAEGE CRYO-LNA REPORT

DATE: 30/07/14

BAND:	4 - 12	S/N:	YXA 1208
TRANSISTOR 1 <sup>st</sup> STAGE:	HRL 150x0.1 um (4851) T-78		
TRANSISTOR 2 <sup>nd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		
TRANSISTOR 3 <sup>rd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		

ROOM TEMPERATURE DATA		T = 307.0	
OPTIMUM BIAS	$V_{d1} = 1.5$	$I_{d1} = 10$	$V_{g1} = -4.32$
	$V_{d2} = 1.5$	$I_{d2} = 10$	$V_{g2} = -3.01$
	$V_{d3} = 1.5$	$I_{d3} = 10$	$V_{g3} = -2.79$
AVERAGE NOISE TEMP: 55.3		MIN. INPUT RETURN LOSS: -3.9	
AVERAGE GAIN: 33.2		MIN. OUTPUT RETURN LOSS: -16.1	

CRYOGENIC TEMPERATURE DATA		T = 13.6	
OPTIMUM BIAS  ( $P_{diss} = 9.44$ mW)	$V_{d1} = 1.00$	$I_{d1} = 4.5$	$V_{g1} = -1.78$
	$V_{d2} = 0.70$	$I_{d2} = 3.1$	$V_{g2} = -0.73$
	$V_{d3} = 0.80$	$I_{d3} = 3.5$	$V_{g3} = -0.64$
AVERAGE NOISE TEMP: 5.77		MAX. / MIN. NOISE TEMP: 6.59      4.52	
AVERAGE GAIN: 33.7		GAIN SPAN FULL BAND: 1.8	
MIN. INPUT RETURN LOSS: -3.6		MIN. OUTPUT RETURN LOSS: -14.8	

**REMARKS:**    Gain data from VNA measurements

$V_d$  in Volts,  $I_d$  in mA, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz



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### RAEGE CRYO-LNA REPORT

DATE: 30/07/14

BAND:	7.5 -9	S/N:	YXA 1208
TRANSISTOR 1 <sup>st</sup> STAGE:	HRL 150x0.1 um (4851) T-78		
TRANSISTOR 2 <sup>nd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		
TRANSISTOR 3 <sup>rd</sup> STAGE:	HRL 150x0.1 um (4948) T-78		

ROOM TEMPERATURE DATA		T = 307.0	
OPTIMUM BIAS	$V_{d1} = 1.5$	$I_{d1} = 10$	$V_{g1} = -4.32$
	$V_{d2} = 1.5$	$I_{d2} = 10$	$V_{g2} = -3.01$
	$V_{d3} = 1.5$	$I_{d3} = 10$	$V_{g3} = -2.79$
AVERAGE NOISE TEMP:	52.4	MIN. INPUT RETURN LOSS:	-4.1
AVERAGE GAIN:	32.9	MIN. OUTPUT RETURN LOSS:	-18.9

CRYOGENIC TEMPERATURE DATA		T = 13.6	
OPTIMUM BIAS  ( $P_{diss} = 9.44$ mW)	$V_{d1} = 1.00$	$I_{d1} = 4.5$	$V_{g1} = -1.78$
	$V_{d2} = 0.70$	$I_{d2} = 3.1$	$V_{g2} = -0.73$
	$V_{d3} = 0.80$	$I_{d3} = 3.5$	$V_{g3} = -0.64$
AVERAGE NOISE TEMP:	5.97	MAX. / MIN. NOISE TEMP:	6.39      5.56
AVERAGE GAIN:	33.3	GAIN SPAN FULL BAND:	0.5
MIN. INPUT RETURN LOSS:	-3.6	MIN. OUTPUT RETURN LOSS:	-16.4

**REMARKS:**    Gain data from VNA measurements

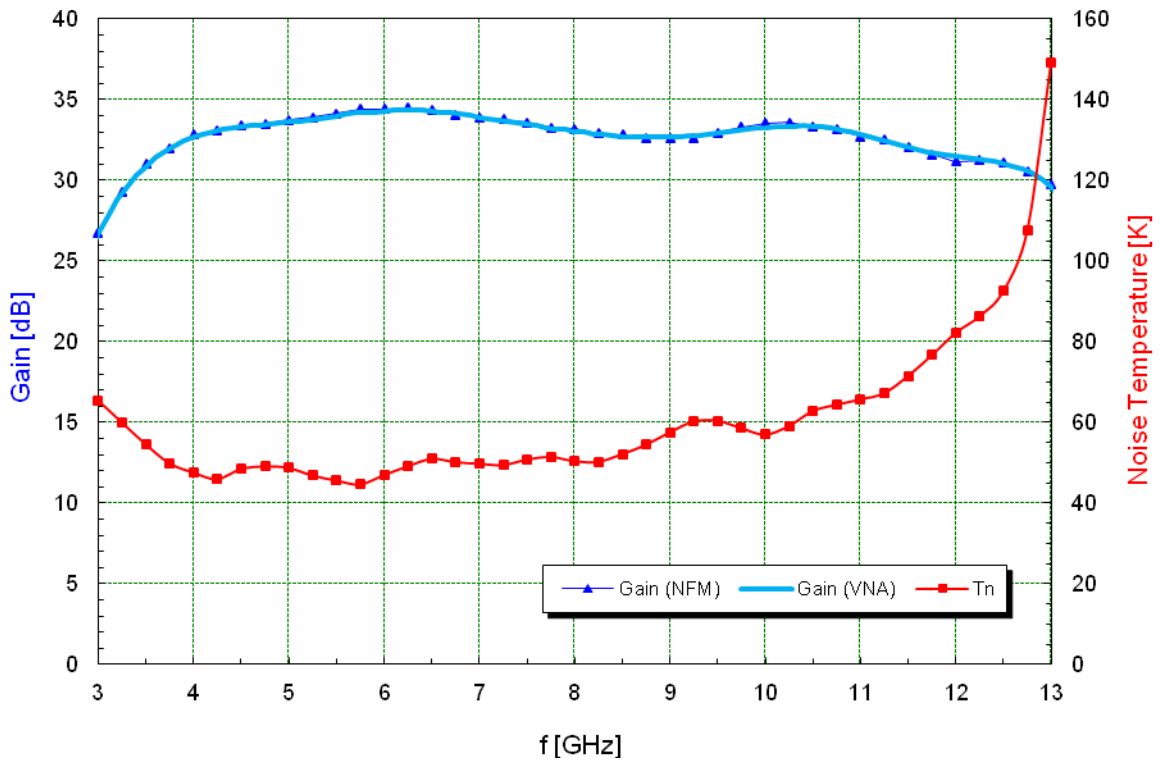
$V_d$  in Volts,  $I_d$  in mA, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz

### YXA 1208 (10)

$V_{D(1,2,3)} = (1.5, 1.5, 1.5)$

$I_{D(1,2,3)} = (10, 10, 10)$

$T=307$

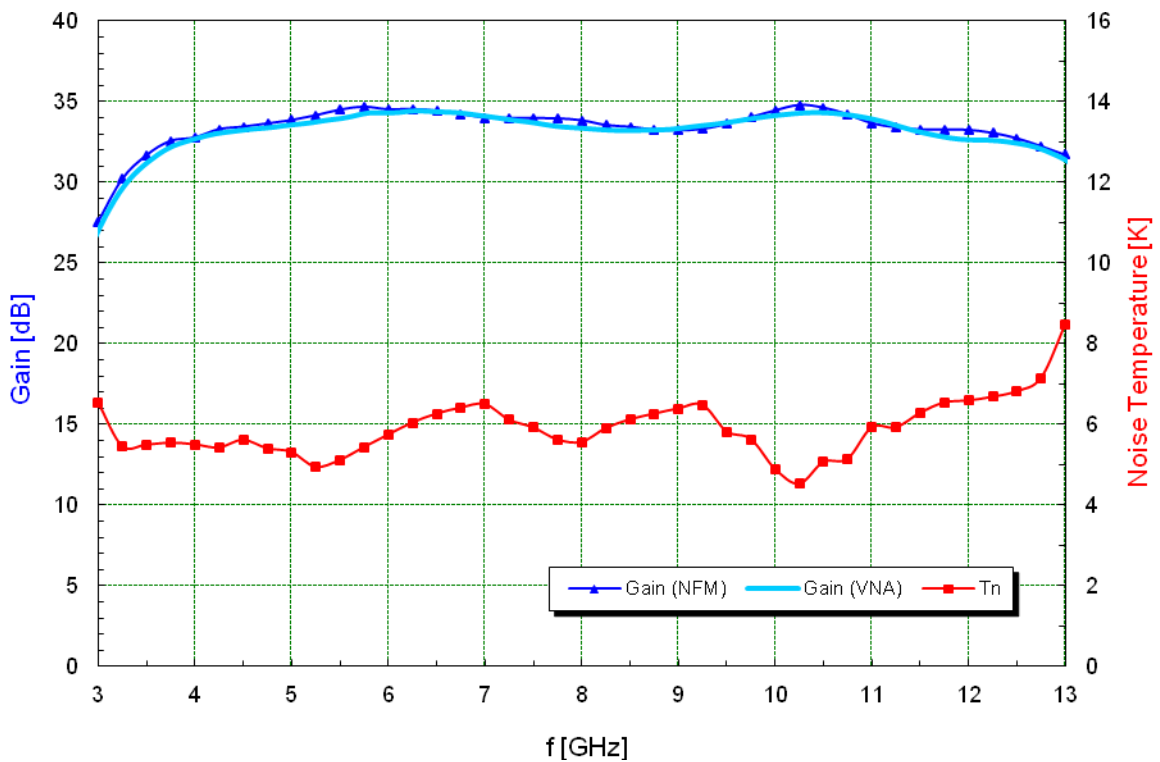


### YXA 1208 (10)

$V_{D(1,2,3)} = (1, 0.7, 0.8)$

$I_{D(1,2,3)} = (4.5, 3, 3.5)$

$T=13.6$

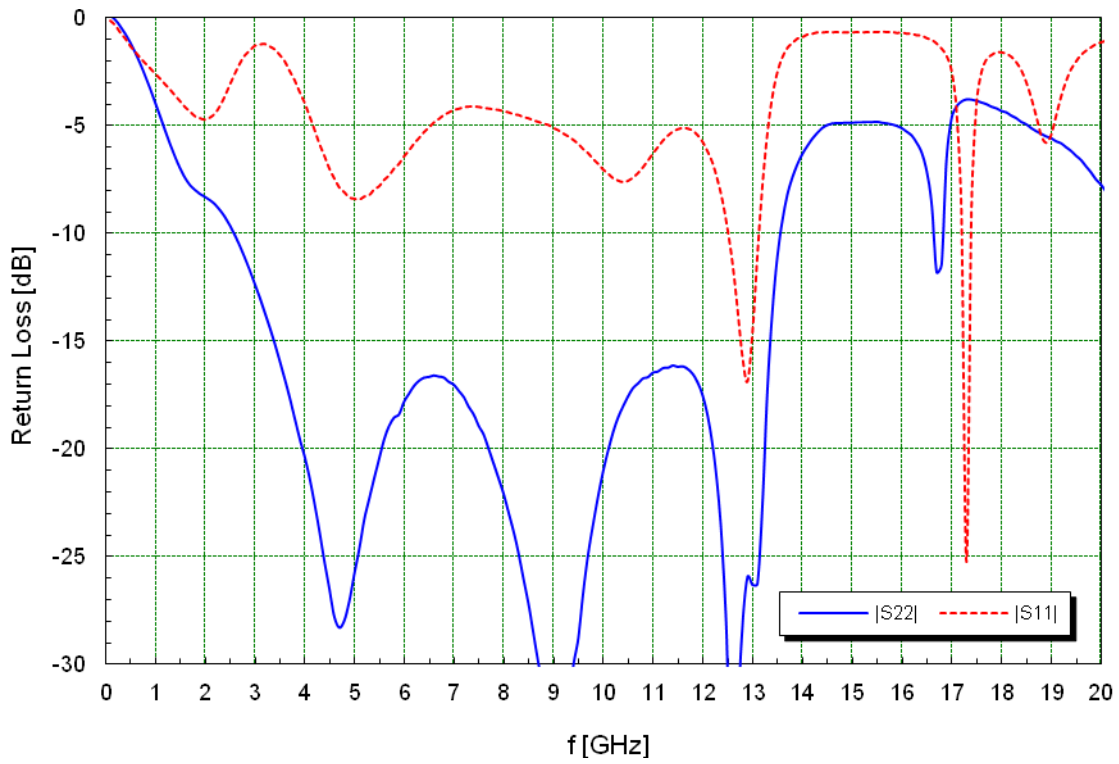


# YXA 1208 (10)

VD=(1.5,1.5,1.5)

ID=(10,10,10)

T=307



# YXA 1208 (10)

VD=(1,.7,.8)

ID=(4.5,3,3.5)

T=17K

