YSG 1001, 1002 and 1004 0.1-1.1 GHz cryogenic low noise amplifier report

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Y214G 1 AMPLIFIER REPORT

1. Introduction

YSG series 1 are 0.1 – 1.1 GHz low noise cryogenic amplifiers designed and built at the *Observatorio de Yebes* for the Purple Mountain Observatory SIS receivers. They are based on the wider band design YSG 0.

This document includes a description of the amplifier and how to operate it, details about the tests performed, the measurements techniques utilized and datasheets and plots with the relevant data collected.

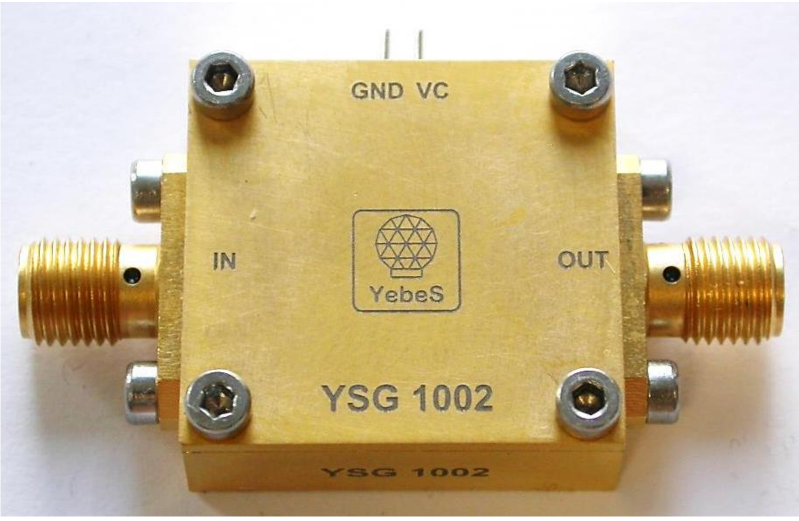


Figure 1: External view of a YSG 1 LNA. Dimensions excluding, connectors are 24.5×23×8.7 mm (X×Y×Z in the picture)

2. Description and operating procedures of the amplifier

2.1 Dimensions and mechanical interfaces

Figure 1 shows an outside view of an amplifier. The external dimensions and mechanical interfaces of the amplifier are shown in figure 2.

The amplifier chassis is made of gold plated aluminum. Four M2 threaded holes, which can be seen on the bottom side of the LNA chassis in figure 2, could be used for thermal anchoring. Take into account that the available thread length is 4.5 mm.

2.2 Electrical interfaces

Input and output ports are female SMA connectors.

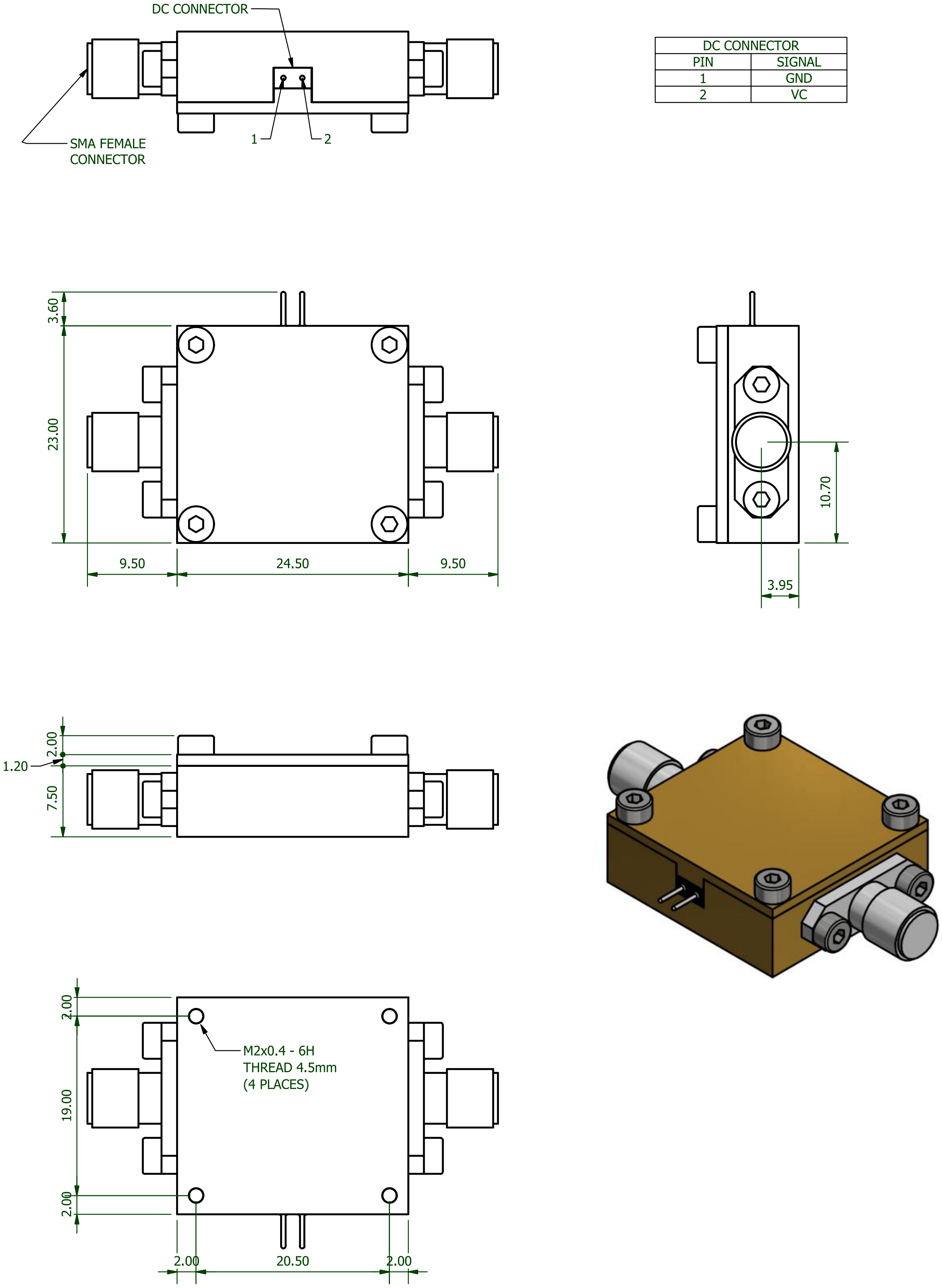
The **DC bias connector** is a 2 pin PCB socket connector with 2 mm pitch. It is recommended to solder the bias pins to the power supply cables for a reliable cryogenic operation. Compatible female connectors for field tests could be provided if needed.

2.3 Bias and ESD

This unit has two stages of SiGe HBT transistors sensitive to ESD. Cautions must be taken during the manipulation and operation of the unit. The amplifier incorporates internal protection elements (diodes, resistors and capacitors) in the bias circuitry.

To bias the amplifier, a single voltage has to be supplied between the pins labeled 'VC' and 'GND'. The common ground 'GND' pin is connected to the chassis of the LNA. Never exceed the maximum values indicated in the table below. The nominal voltage for each unit at room and cryogenic temperatures is indicated in the corresponding data sheet. The cryogenic bias condition optimizes the device for noise, gain, ripple and reflection. The data sheet reflects also the typical current consumption of the amplifier. A significant deviation from this value could indicate a malfunction of the unit.

MAXIMUM RATINGS	
VC	4.5 V
IC	50 mA
Power dissipation	225 mW
RF Input level	0 dBm



DC CONNECTOR	
PIN	SIGNAL
1	GND
2	VC

Figure 2: *YSG 1 mechanical and electrical interface, external dimensions and DC connector pinout.*

3. Measurements

Noise temperature (and gain) was measured with a system based on a computer controlled Agilent N8975A Noise Figure Meter described in detail in [1], [2]. Room temperature data were obtained with an Agilent N4000A noise diode. The DUT is cooled in a Dewar with a CTI 1020 refrigerator. Cryogenic measurements were taken with the "cold attenuator" method, using an Agilent N4002A noise diode (at room temperature) plus a 15 dB attenuator and a Heat-Block device cooled at cryogenic temperature. Temperature is carefully monitored in the attenuator body using a Lake Shore sensor diode. An absolute accuracy (@ 2 σ) of 14 K at T_{amb}=297 K and 1.7 K at T_{amb}=14 K can be estimated with methods presented in [3]. Repeatability is better than these values by an order of magnitude.

S parameters were measured in the same Dewar with an Agilent E8364B Vector Network Analyzer from 0.1 to 20.1 GHz. A detailed description of the measurement procedure used at cryogenic temperature can be found in [1], [2]. The amplifier output is connected to one of the stainless steel Dewar transitions and its input to the other through a semi-flexible Cu cable. A full two port calibration is done at room temperature with the electronic calibration kit Agilent N4693-60001 inside the Dewar in place of the amplifier, with the same semi-flexible cable. The stainless steel lines are supposed to be invariant with temperature. The Cu cable is measured at cryogenic temperature independently and its loss is taken into account to correct S11 and S21. Time domain gating is used to correct for the residual reflection changes in the lines.

Additional measurements to ensure the absence of oscillations were performed at room and cryogenic temperatures.

The amplifier reports which follows this page contains:

1) Data-sheet:
   Amplifier identification, nominal bias and a summary of the measurements performed at room and cryogenic temperature.
2) Noise and gain plots: Noise temperature and available gain at room and cryogenic temperature. Gain curves are taken with the Vector Network Analyzer and with the Noise Figure Meter during noise measurements.
3) Return loss plots: |S11| and |S22| at room and cryogenic temperature

References

[1] J. D. Gallego, I. López-Fernández, C. Diez, "*A Measurement Test Set for ALMA Band 9 Amplifiers*", 1st Radionet Engineering Forum Workshop, 23-24/06/2009, Gothenburg (available at http://www.radionet-eu.org/fp7wiki/lib/exe/fetch.php?media=na:engineering:ew:lopez-fernandez_final.pdf)

[2] I. López-Fernández, J. D. Gallego, C. Diez, A. Barcia, "*Development of Cryogenic IF Low Noise 4-12 GHz Amplifiers for ALMA Radio Astronomy Receivers*", 2006 IEEE MTT-S Int. Microwave Symp. Dig, pp. 1907-1910, 2006.

[3] J. D. Gallego, J. L. Cano, "*Estimation of Uncertainty in Noise Measurements Using Monte Carlo Analysis*", 1st Radionet Engineering Forum Workshop, 23-24/06/2009, Gothenburg (available at http://www.radionet-eu.org/fp7wiki/lib/exe/fetch.php?media=na:engineering:ew:gallego_final.pdf)

OBSERVATORIO DE YEBES

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CRYOGENIC LNA DATA SHEET

DATE: 09/11/17

BAND:	0.1- 1.1 GHz	S/N:	**YSG 1001**
TRANSISTORS: ST1:	SiGe HBT	ST2:	SiGe HBT

ROOM TEMPERATURE DATA T = 300.0

NOMINAL BIAS	**V_c = 2.0**	I_c = 16.5	P_{diss} = 33.00

	FREQUENCY BAND:	0.1-1.1
MEASUREMENTS	AVERAGE NOISE TEMP:	80.9
	AVERAGE GAIN:	38.5
	MIN. INPUT RETURN LOSS:	-11.9
	MIN. OUTPUT RETURN LOSS:	-17.9

CRYOGENIC TEMPERATURE DATA T = 13.6

NOMINAL BIAS	**V_c = 1.70**	I_c = 8.7	P_{diss} = 14.79

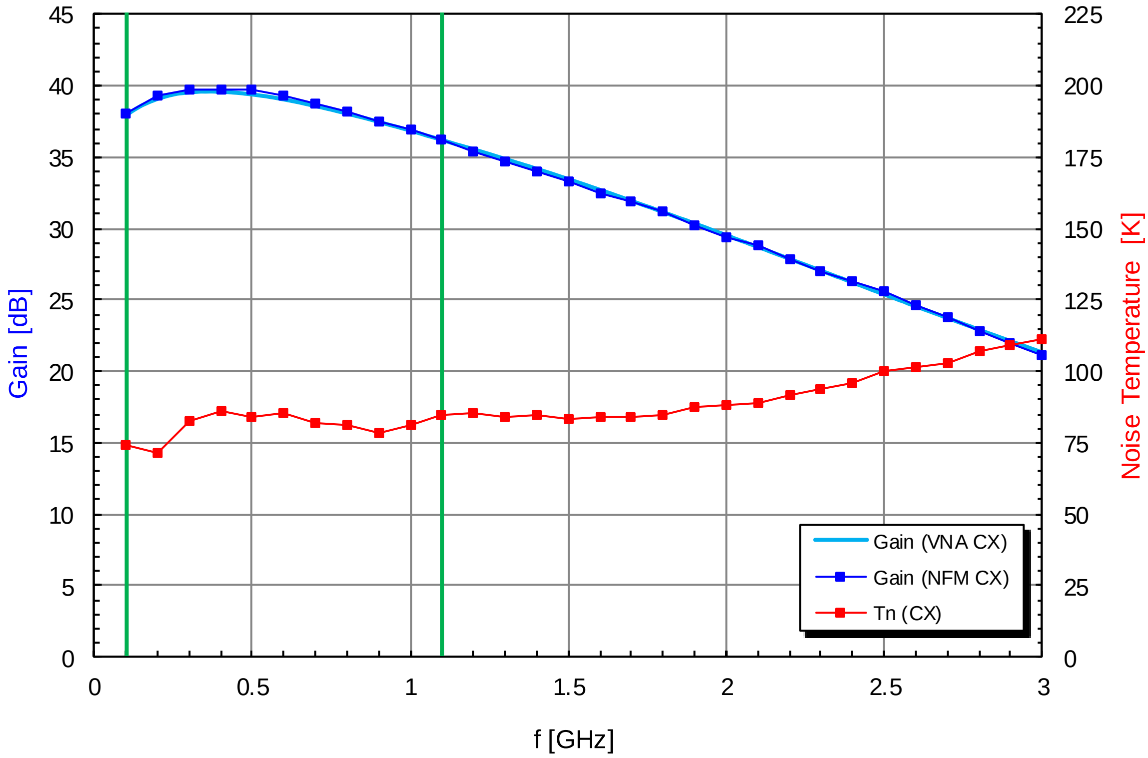
	FREQUENCY BAND:	0.1-1.1
MEASUREMENTS	AVERAGE NOISE TEMP:	7.1
	MIN. - MAX. NOISE TEMP:	6.2 - 7.8
	AVERAGE GAIN:	42.6
	MIN. INPUT RETURN LOSS:	-14.4
	MIN. OUTPUT RETURN LOSS:	-16.2

REMARKS: Gain data from VNA measurements
Coaxial noise measurements according to cold att. method

V_c in Volts, I_c in mA, P_{diss} in mW, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz

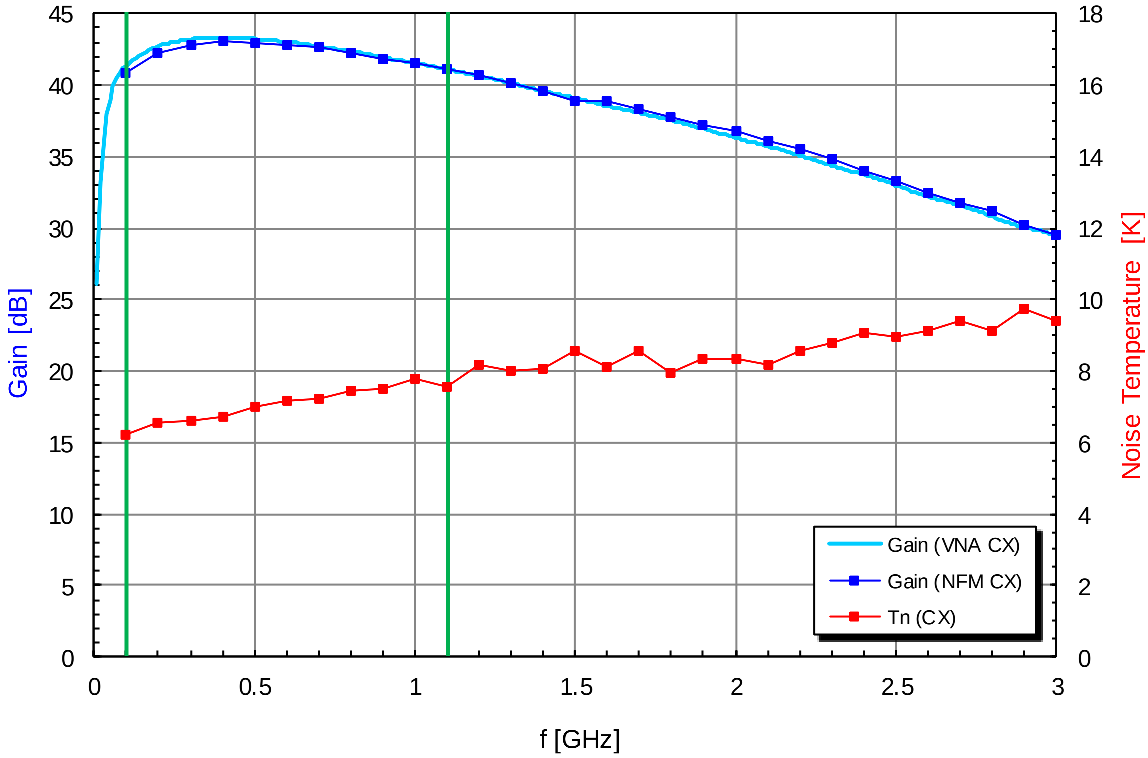
YSG 1001 15

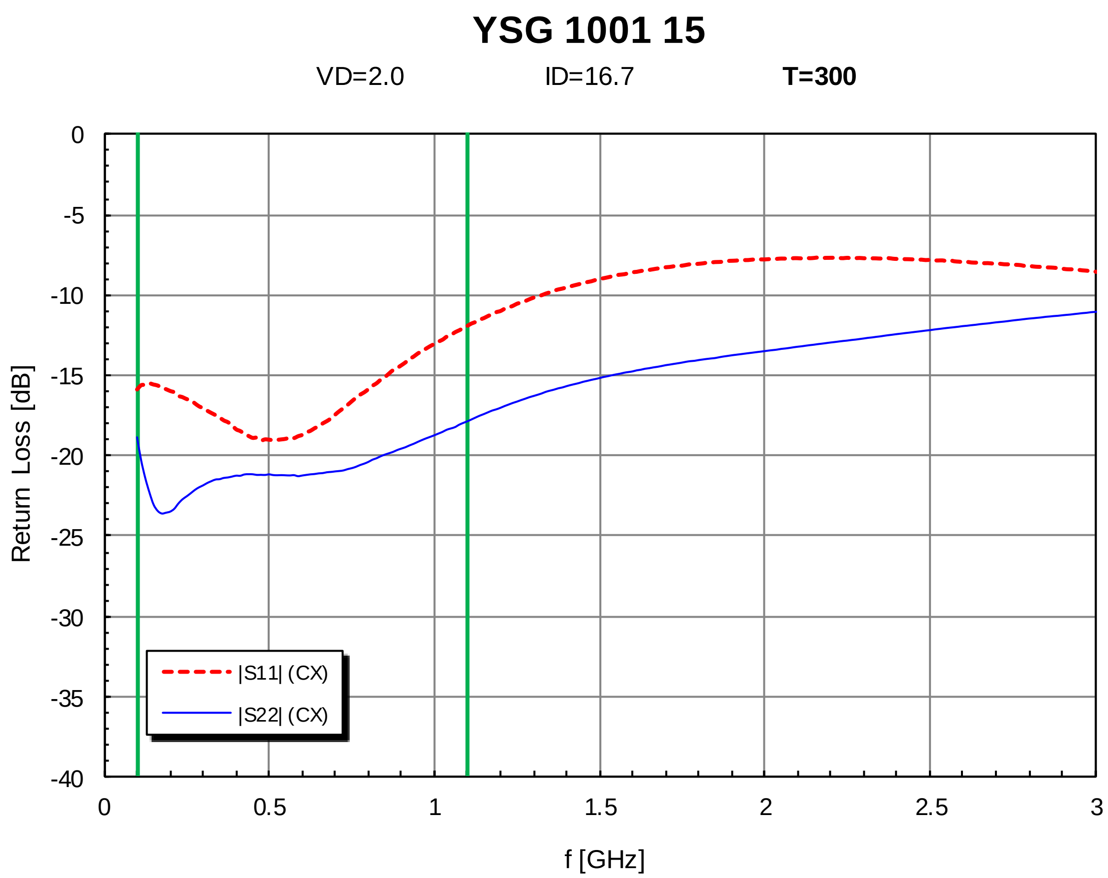
V_D= 2 I_D= 16.5 **T=300**



YSG 1001 15

V_D= 1.7 I_D= 8.7 **T=13.6**

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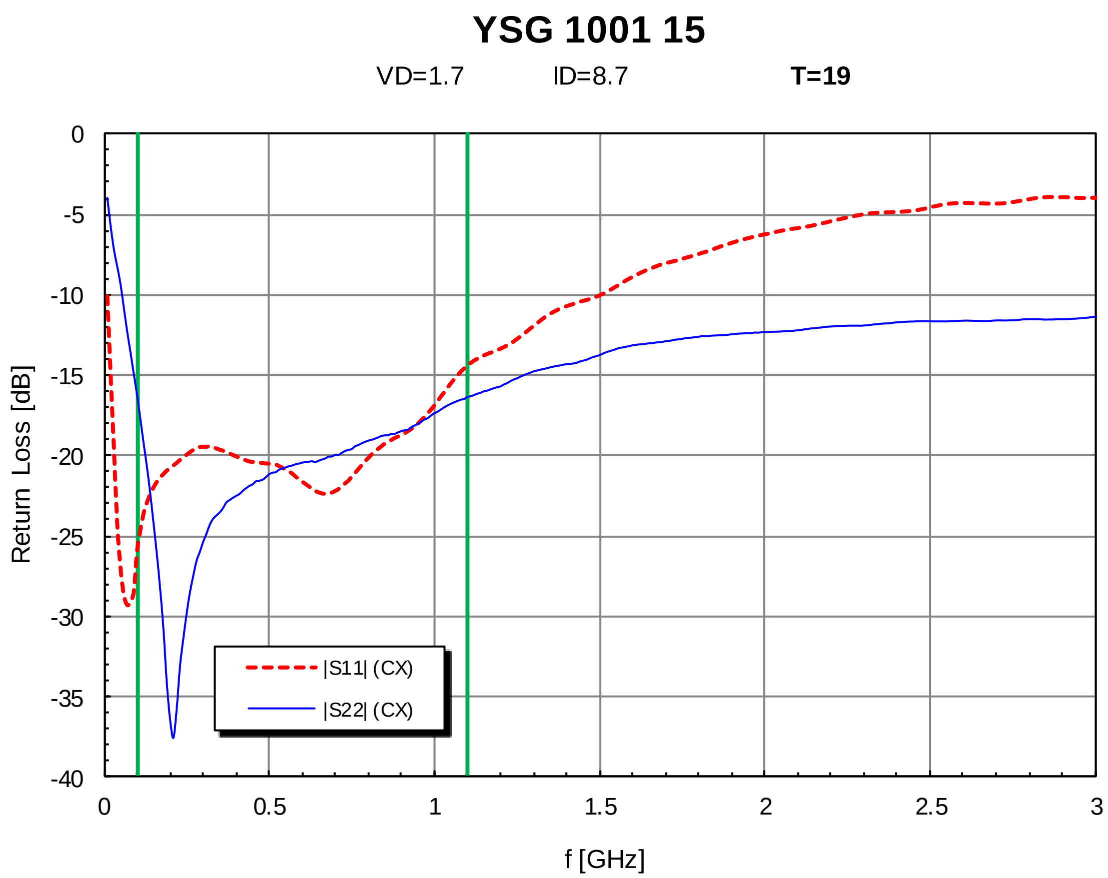
VD=2.0
ID=16.7
T=300
Return Loss [dB]
0
-5
-10
-15
-20
-25
-30
-35
-40
0
0.5
1
1.5
2
2.5
3
f [GHz]
|S11| (CX)
|S22| (CX)


YSG 1001 15
VD=1.7
ID=8.7
T=19
Return Loss [dB]
0
-5
-10
-15
-20
-25
-30
-35
-40
0
0.5
1
1.5
2
2.5
3
f [GHz]
|S11| (CX)
|S22| (CX)

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CRYOGENIC LNA DATA SHEET

DATE: 09/10/17

BAND:	0.1- 1.1 GHz	S/N:	YSG 1002
TRANSISTORS:	ST1: SiGe HBT	ST2: SiGe HBT	

ROOM TEMPERATURE DATA T = 300.0

NOMINAL BIAS	V_c = 2.0	I_c = 16.8	P_{diss} = 33.60

	FREQUENCY BAND:	0.1-1.1
MEASUREMENTS	AVERAGE NOISE TEMP:	77.1
	AVERAGE GAIN:	38.3
	MIN. INPUT RETURN LOSS:	-11.2
	MIN. OUTPUT RETURN LOSS:	-17.5

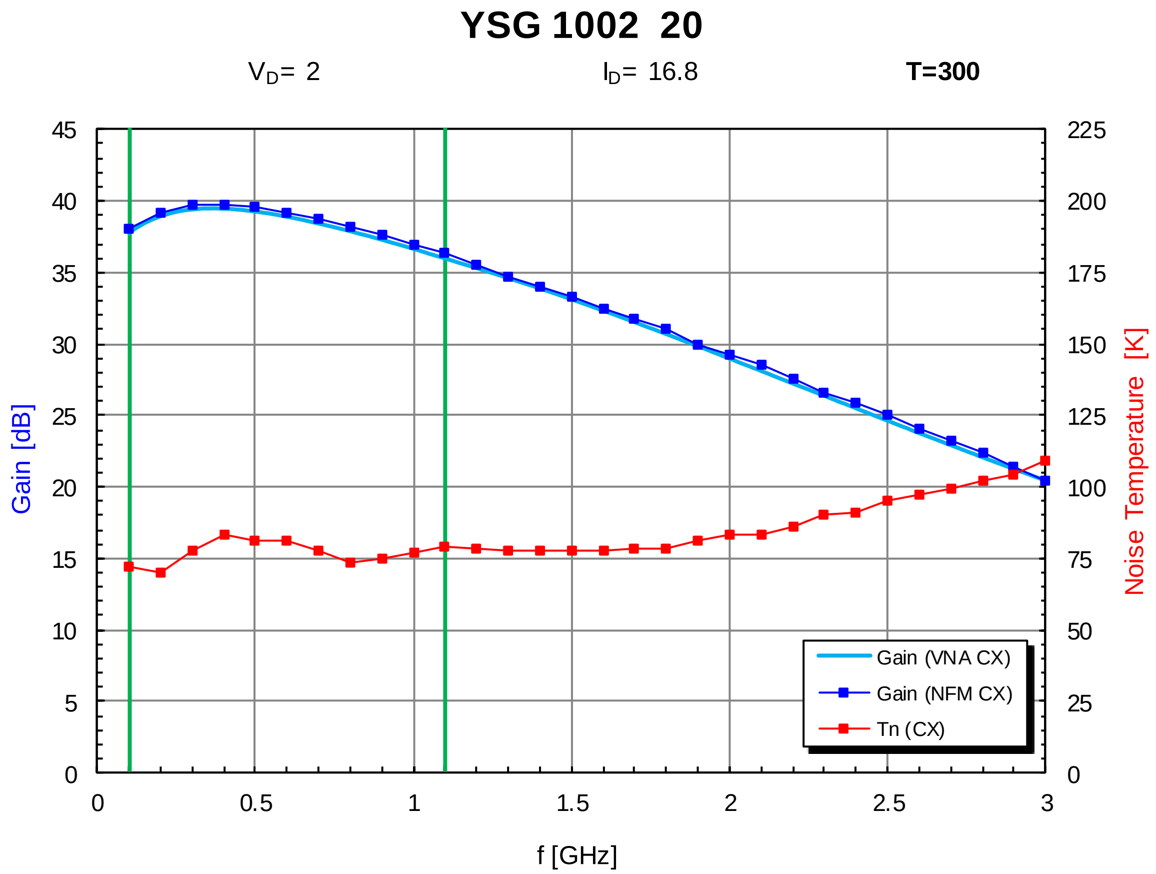
CRYOGENIC TEMPERATURE DATA T = 13.9

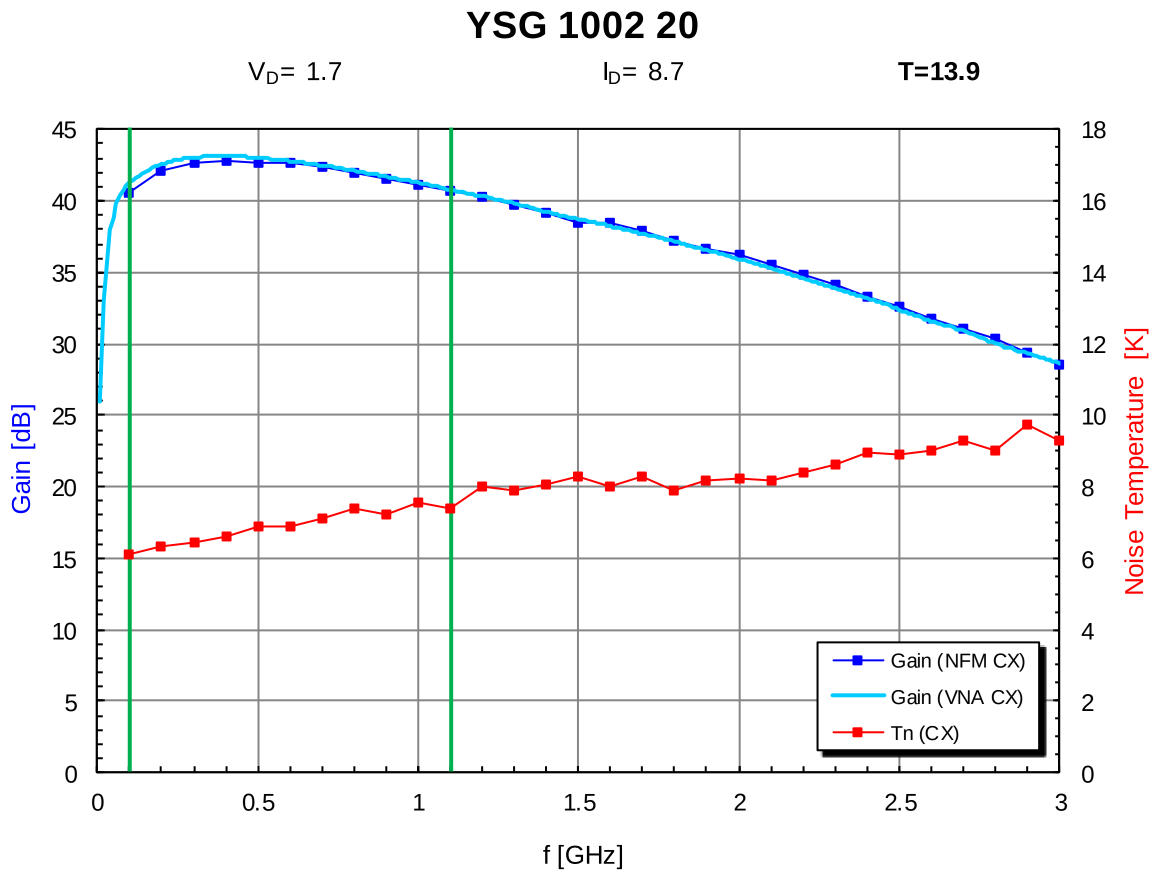
NOMINAL BIAS	V_c = 1.70	I_c = 8.7	P_{diss} = 14.79

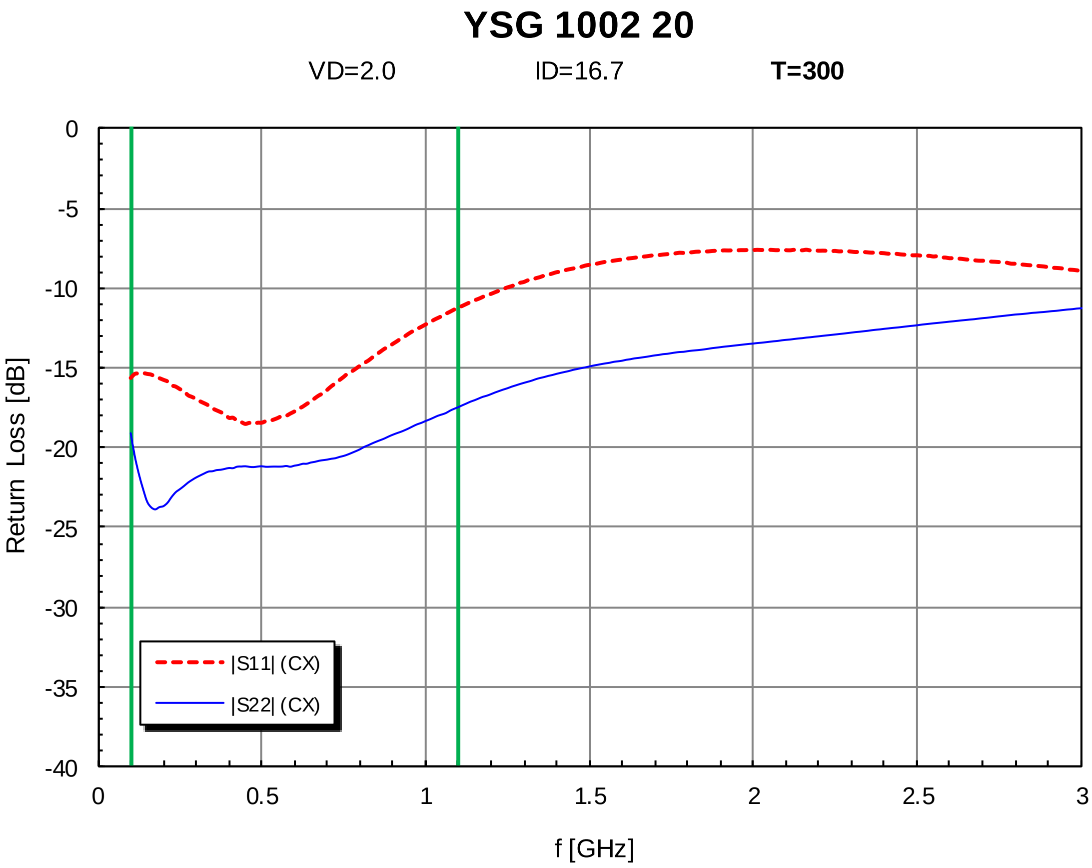
	FREQUENCY BAND:	0.1-1.1
MEASUREMENTS	AVERAGE NOISE TEMP:	6.9
	MIN. - MAX. NOISE TEMP:	6.1 - 7.6
	AVERAGE GAIN:	42.3
	MIN. INPUT RETURN LOSS:	-13.4
	MIN. OUTPUT RETURN LOSS:	-16.2

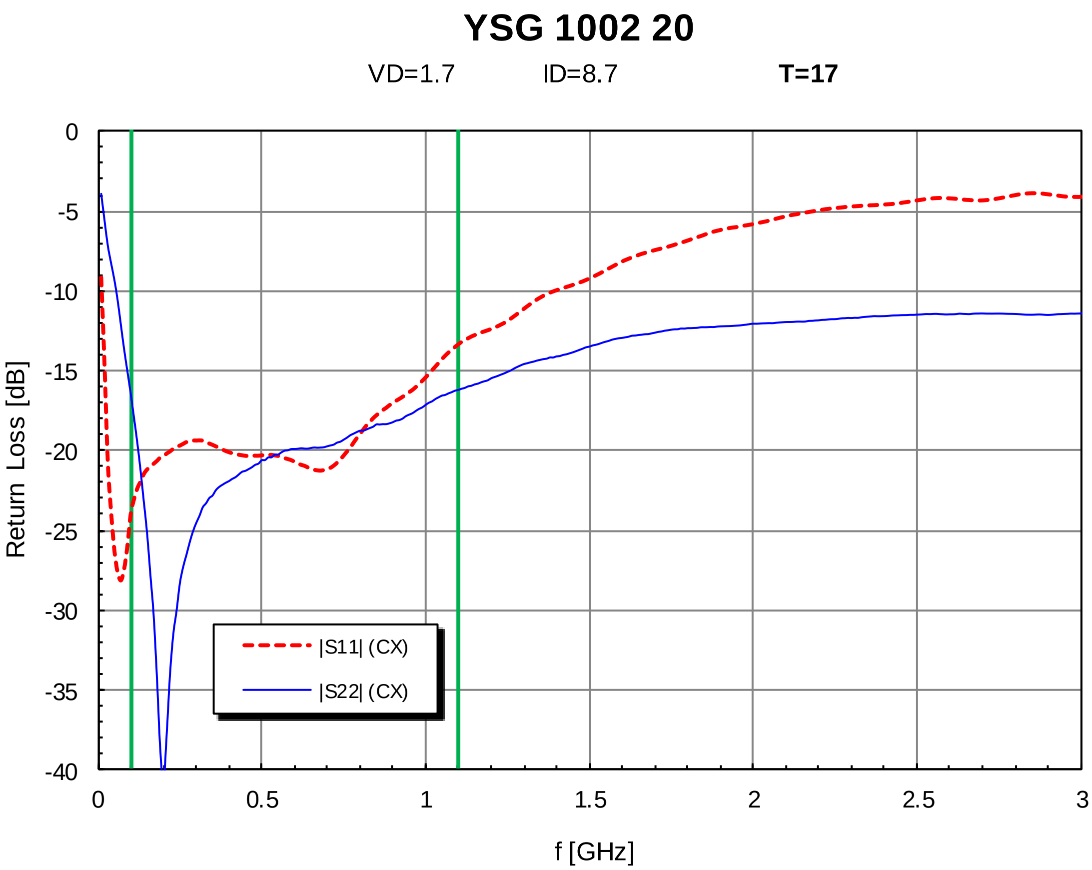
REMARKS: Gain data from VNA measurements
Coaxial noise measurements according to cold att. method

V_c in Volts, I_c in mA, P_{diss} in mW, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz


YSG 1002 20
V_D= 2
I_D= 16.8
T=300
Gain [dB]
Noise Temperature [K]
f [GHz]
Gain (VNA CX)
Gain (NFM CX)
Tn (CX)


YSG 1002 20
V_D= 1.7
I_D= 8.7
T=13.9
Gain [dB]
Noise Temperature [K]
f [GHz]
Gain (NFM CX)
Gain (VNA CX)
Tn (CX)


YSG 1002 20
VD=2.0
ID=16.7
T=300
Return Loss [dB]
0
-5
-10
-15
-20
-25
-30
-35
-40
0
0.5
1
1.5
2
2.5
3
f [GHz]
|S11| (CX)
|S22| (CX)


YSG 1002 20
VD=1.7
ID=8.7
T=17
Return Loss [dB]
0
-5
-10
-15
-20
-25
-30
-35
-40
0
0.5
1
1.5
2
2.5
3
f [GHz]
|S11| (CX)
|S22| (CX)

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CRYOGENIC LNA DATA SHEET

DATE: 09/10/17

BAND:	0.1- 1.1 GHz	S/N:	**YSG 1004**
TRANSISTORS:	ST1: SiGe HBT	ST2:	SiGe HBT

ROOM TEMPERATURE DATA	T = 300.0		
NOMINAL BIAS	**V_c = 2.0**	I_c = 16.8	P_{diss} = 33.60
	FREQUENCY BAND:	0.1-1.1	
MEASUREMENTS	AVERAGE NOISE TEMP:	77.2	
	AVERAGE GAIN:	38.5	
	MIN. INPUT RETURN LOSS:	-11.5	
	MIN. OUTPUT RETURN LOSS:	-18.2	

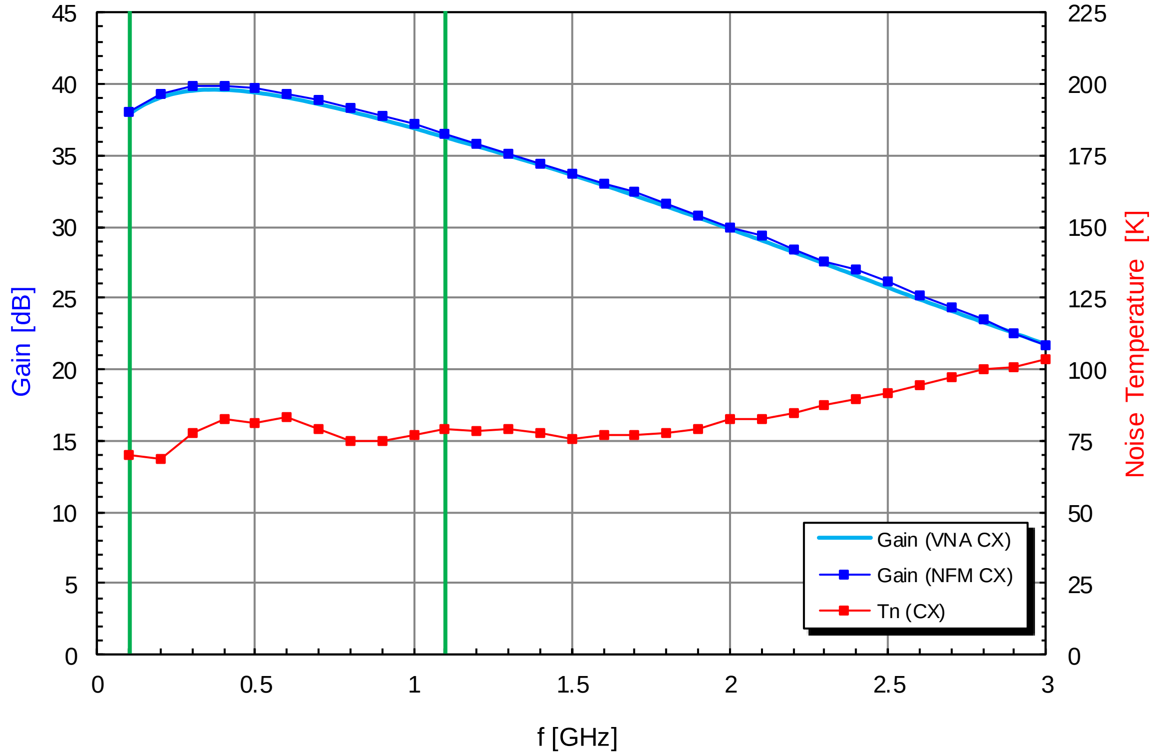
CRYOGENIC TEMPERATURE DATA	T = 13.8		
NOMINAL BIAS	**V_c = 1.70**	I_c = 8.8	P_{diss} = 14.88
	FREQUENCY BAND:	0.1-1.1	
MEASUREMENTS	AVERAGE NOISE TEMP:	6.8	
	MIN. - MAX. NOISE TEMP:	6 - 7.5	
	AVERAGE GAIN:	42.6	
	MIN. INPUT RETURN LOSS:	-14.3	
	MIN. OUTPUT RETURN LOSS:	-16.2	

REMARKS: Gain data from VNA measurements
Coaxial noise measurements according to cold att. method

V_c in Volts, I_c in mA, P_{diss} in mW, Noise temperature in K, Gain and Return loss in dB, Frequency band in GHz

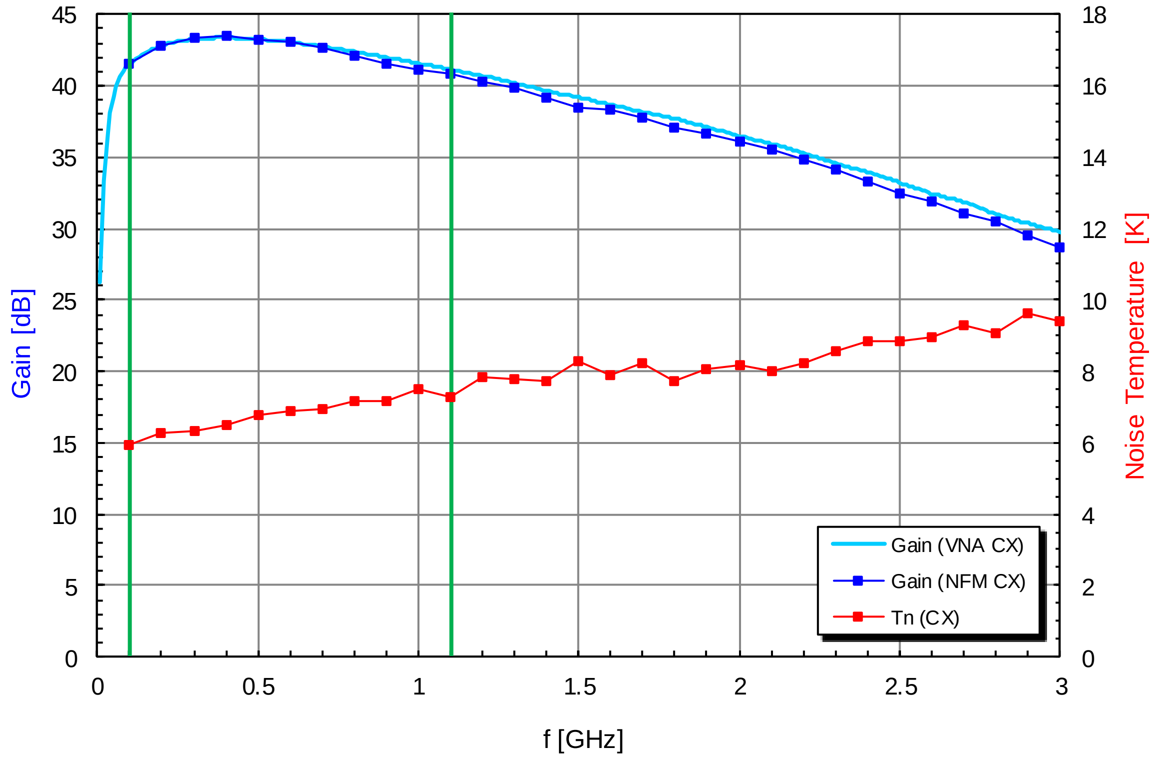
YSG 1004 4

V_D= 2 I_D= 16.8 **T=300**



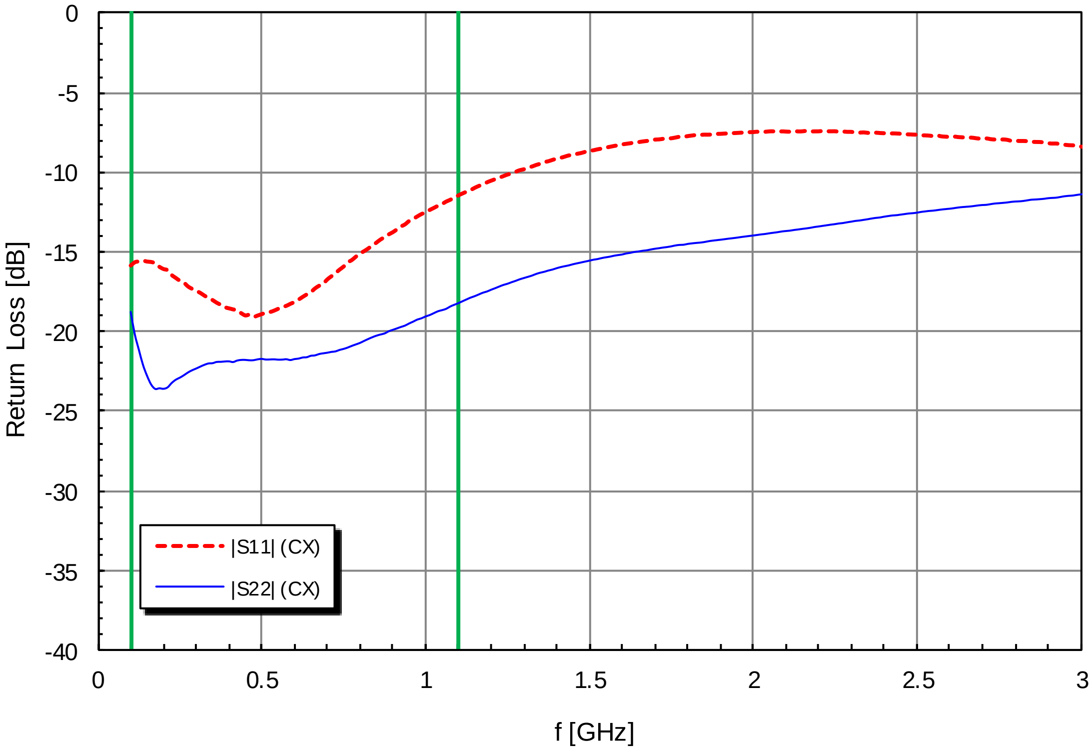
YSG 1004 4

V_D= 1.7 I_D= 8.75 **T=13.8**



YSG 1004 4

VD=2 ID=16.6 **T=300**



YSG 1004 4

VD=1.7 ID=8.6 **T=18**