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CHANGE RECORD

ISSUE	DATE	SHEET	DESCRIPTION	RELEASE
1.0	July. 27, 2007	1-58	First report drawing up	1.0
1.1	Sept. 20,2007		Added Spar and Noise parameters in Chapter 3 Chip count updated	

INDEX

1 - Introduction

In the following pages, we will describe results of the on wafer S-parameters and noise Temperature measurements. These have been performed on four 3-inch InP wafers, 75 um thickness, processed by NGST, a division of NGC. The foundry process is a HEMT 0.1 um gate length. Those four wafers are a part of a wafer run named CSR18, committed to NGST by CSIRO for the FARADAY consortium. Fig. 1.1 show the wafer run sharing percentage. The job had been carried out by IRA using the C-TIP Facilities in Epping, Sydney, Australia. With this campaign we have identified which devices are specification compliant and within this selection, which are the best, in term of noise temperature and gain. We haven't deeply investigated auto oscillations but the device behaviour didn't show any macroscopic evidence. Suspected response has been reported. Accurate oscillation enquiry as well as high accuracy noise temperature response, 1dB compression point value and 1/f noise characterization will be held on a limited number of samples. In the paper we will describe also the testing procedure adopted and the equipments used to compose the test-benches. In chapter 5, where measurement results are reported, we also suggest some hypothesis for future reverse engineering job. On those considerations we will base some electromagnetic simulation to discover possibly mutual coupling between large section of the stages that compose the MMIC. This activity will be very useful for future design activity. In order to understand the devices response far from the design conditions, some devices have been tested with design modified bias conditions and S-parameters responses are reported. This section will be completed with the noise temperature measurements of the same devices at the reported bias conditions. Table 2.1 show the design specifications of the LNA realized on the Wafer run CSR18.

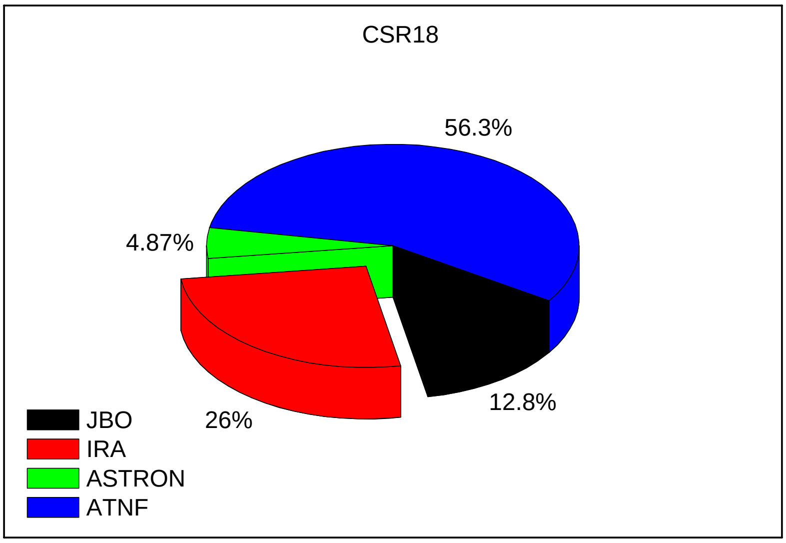


Fig 1.1 – Wafer run sharing percentage

2 - Devices design specification

Design Name	Description	Frequency Range [GHz]	Gain [dB]	Te @ 300 K [K]	Te @ 20 K (estimed) [K]	# stage	Power consumption (Nominal) [mW]	Dimension [mm] X	Dimension [mm] Y	# Working chip
CSR18_6LNA_01A	LNA wout input matching network	4-8	35 ± 0.5	35	3	3	61,56	3,2	2,5	**16**/24
CSR18_10LNA_01A	LNA wout input matching network	8-12	22 ± 0.5	40	4	2	42,12	3,2	2,25	**49**/56
CSR18_32LNA_01A	LNA	26 - 40	23 ± 1	125	20	4	82,08	3,2	2,25	**52**/60
CSR18_32LNA_02A	LNA	26 - 40	25 ± 1	135	25	3	38,88	3,2	2,25	**46**/60
CSR18_43LNA_01A	LNA	33 - 50	27 ± 1.5	155	35	4	51,84	3,2	2,25	**40**/48
CSR18_86LNA_01A	LNA	70 - 90	17 ± 1	280	60	4	76,14	3,2	2,25	**41**/52
CSR18_100LNA_01A	LNA	90 - 115	15 ± 1	400	100	4	52,68	2,5	2,5	**17**/24

Table 2.1 - Devices design specification

Tests have been carried out following the instructions listed in Table 2.2. For the devices a,b we haven't measured the noise because they have been designed with an off-chip matching network for the first stage. Noise performances of the c,d,e devices have been tested up to 39 GHz due to a limit of the Facilities. For the same reason, device g have been tested up to 98 GHz. All the automatic measurements have been conducted using the design bias condition. These are reported in table 2.3.

	Design Name	Spar			Noise		
		Fmin [GHz]	Fmax	N. of points	Fmin	Fmax [GHz]	step
a	CSR18_6LNA_01A	1	10	51	X	X	X
b	CSR18_10LNA_01A	5	15	51	X	X	X
c	CSR18_32LNA_01A	20	50	51	26	39	1
d	CSR18_32LNA_02A	20	50	51	26	39	1
e	CSR18_43LNA_01A	20	50	51	33	39	1
f	CSR18_86LNA_01A	70	118	101	75	90	1
g	CSR18_100LNA_01A	70	118	101	84	98	1

Table 2.2 – Test schedule

Design Name	D1		D2		D3		D4	
	Vd [V]	Id [mA]	Vd [V]	Id mA	Vd [V]	Id mA	Vd [V]	Id mA
CSR18_6LNA_01A	1,26	18	X	X	1,08	18	1,08	18
CSR18_10LNA_01A	1,26	18	1,08	18	X	X	X	X
CSR18_32LNA_01A	1,2	12	1,32	12	1,44	18	1,44	18
CSR18_32LNA_02A	1,08	12	X	X	1,08	12	1,08	12
CSR18_43LNA_01A	1,08	12	1,08	12	1,08	12	1,08	12
CSR18_86LNA_01A	1,08	12	1,17	18	1,17	18	1,17	18
CSR18_100LNA_01A	1,24	12	1,3	12	1,3	12	1,1	6

Table 2.3 – Devices nominal biasing

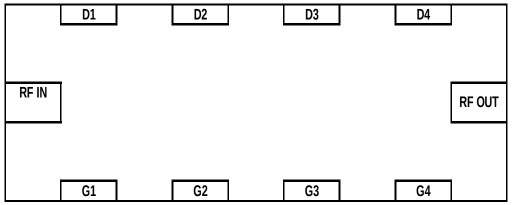


Fig. 2.1 – Bias and RF pad Layout

3 – Datasheets

In order to clarify some datasheet entries we here describe its meaning little widely :

The definition of **Frequency Range**, as reported in the datasheets, isn't exactly related with the theoretical definition of bandwidth @3dB. Some other factors than gain response, like IRL and Te has influence on this definition.

σ indicate the well known standard deviation, which represent the statistical dispersion of values in a given dataset, measuring how widely spread the values in a dataset are.

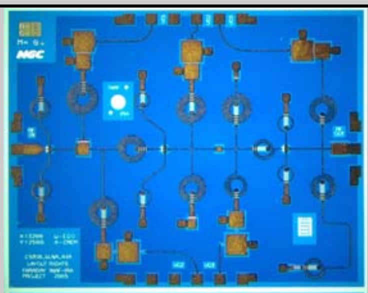
Bandwidth $$BW = f_2 - f_1 \quad (1)$$

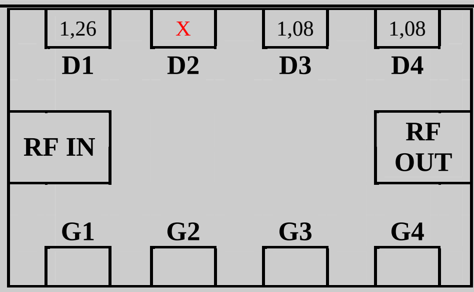
Center Frequency $$f_0 = \sqrt{f_2 \cdot f_1} \quad (2)$$

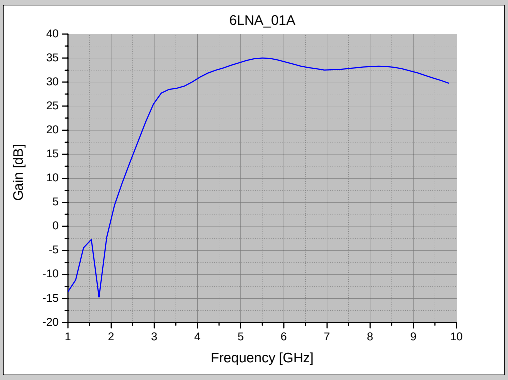
Fractional Bandwidth $$\frac{BW}{f_0} \cdot 100 \quad (3)$$

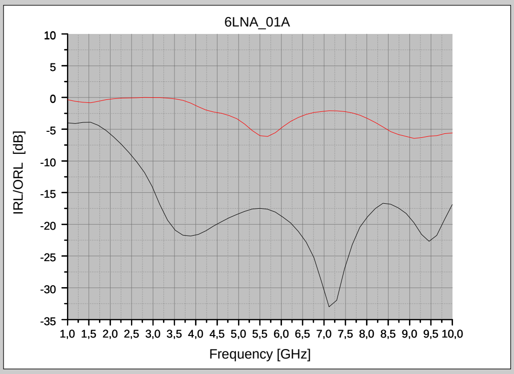
For system design purposes, typical measured S-parameters and simulated Noise parameters are reported for each MMIC design.

P/N	**6LNA_01A**
Rev Date	**20/6/2007**









Frequency Range	4 - 10	**BW**	6	**BW/f_o**	95%

100% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	30,8	33,8	32,9	1	**[dB]**
T_e	-	-	-	-	**[K]**
$\|S_{11}\|$	-3,6	-2,8	-3,3	1,5	**[dB]**
$\|S_{22}\|$	-23,4	-19,4	-21,3	5	**[dB]**

50% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	30,2	34,3	33,4	0,9	**[dB]**
T_e	-	-	-	-	**[K]**
$\|S_{11}\|$	-4,5	-2,6	-3,9	1,5	**[dB]**
$\|S_{22}\|$	-23,5	-18,6	-19,9	3	**[dB]**

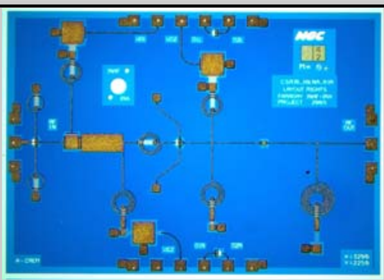
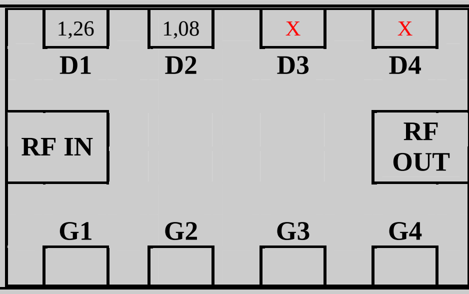
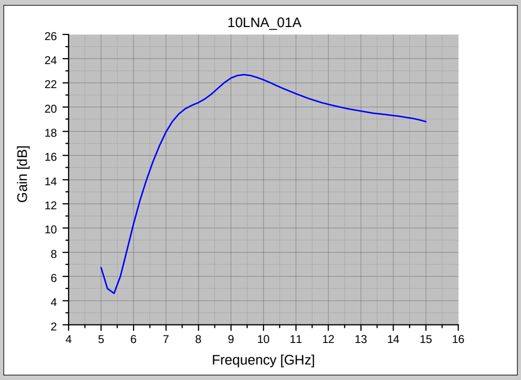
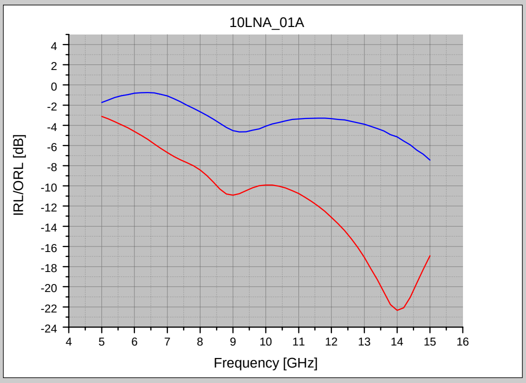
IP_3	
Dissipation [mW]	62
RF Pad	Coplanar G-S-G 200 μm pitch
Bias Pad	Coplanar G-SSSS-G 200 μm pitch
Dimensions	**3.200 x 2.500 x 0.075** mm (L x W x H)
Use as	Designed for Pharos receiver. possibly use in medicina and SRT receivers with HTS filters
Particularity	Off-chip first stage input matching network. Performances reported in this datasheet are related to the MMIC ONLY. For more exhaustive information regarding the combined use with the external matching network, please refer to chapter 5 of IRA Internal Report N.
N° of available samples	16/24

S-Parameters

FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
1,00	0,9474	-0,1605	0,0063	-0,2231	0,0004	0,0000	-0,1912	-0,6009
1,18	0,9169	-0,1768	0,1770	-0,1961	0,0004	-0,0003	-0,3017	-0,5419
1,36	0,8982	-0,1796	0,3434	-0,4888	-0,0001	-0,0005	-0,4329	-0,4606
1,54	0,8920	-0,1683	-0,0781	-0,7755	-0,0002	0,0000	-0,5536	-0,3101
1,72	0,9139	-0,1682	-0,2179	-0,0418	-0,0001	0,0000	-0,5926	-0,1103
1,90	0,9369	-0,1957	0,5833	0,4094	-0,0001	0,0001	-0,5458	0,0705
2,08	0,9455	-0,2326	1,6144	0,3224	0,0000	0,0001	-0,4451	0,2041
2,26	0,9474	-0,2696	2,8320	-0,0500	0,0000	0,0000	-0,3205	0,2833
2,44	0,9396	-0,3051	4,5500	-1,0688	0,0000	0,0000	-0,1941	0,3129
2,62	0,9308	-0,3460	6,7871	-3,2983	0,0001	0,0001	-0,0782	0,3021
2,80	0,9177	-0,3831	8,9688	-8,2622	-0,0001	0,0000	0,0208	0,2575
2,98	0,8990	-0,4244	7,5225	-17,1797	0,0001	-0,0001	0,0875	0,1834
3,16	0,8745	-0,4641	-2,4072	-24,6680	0,0000	0,0000	0,1049	0,1034
3,34	0,8429	-0,5067	-14,5850	-23,1436	0,0000	0,0000	0,0962	0,0547
3,52	0,8011	-0,5431	-22,1904	-17,3398	0,0000	0,0001	0,0905	0,0241
3,70	0,7411	-0,5737	-27,2461	-11,5889	0,0001	0,0000	0,0879	-0,0048
3,88	0,6731	-0,5852	-31,8398	-5,2578	0,0001	0,0000	0,0831	-0,0329
4,06	0,6129	-0,5619	-35,7832	3,3047	0,0000	0,0002	0,0735	-0,0589
4,24	0,5745	-0,5354	-36,6445	13,9648	0,0001	0,0000	0,0604	-0,0806
4,42	0,5630	-0,5174	-33,7207	24,6426	0,0000	0,0001	0,0441	-0,1012
4,60	0,5450	-0,5161	-27,6621	33,7949	0,0002	0,0000	0,0232	-0,1161
4,78	0,5097	-0,5148	-20,1875	42,1094	0,0002	0,0001	0,0058	-0,1269
4,96	0,4655	-0,5051	-10,0039	48,4238	0,0002	0,0001	-0,0161	-0,1337
5,14	0,4190	-0,4725	2,7988	52,4101	0,0003	0,0000	-0,0390	-0,1367
5,32	0,3881	-0,4143	17,5938	51,9062	0,0003	-0,0002	-0,0625	-0,1337
5,50	0,3906	-0,3453	32,0293	45,8223	0,0003	-0,0003	-0,0833	-0,1233
5,68	0,4285	-0,2848	43,0859	34,9492	0,0002	-0,0005	-0,1007	-0,1065
5,86	0,4865	-0,2547	48,7363	21,7637	0,0002	-0,0006	-0,1095	-0,0857
6,04	0,5451	-0,2613	50,0098	9,4004	0,0001	-0,0006	-0,1088	-0,0647
6,22	0,5958	-0,2862	48,3008	-1,1348	-0,0001	-0,0007	-0,1038	-0,0456
6,40	0,6249	-0,3268	44,8789	-9,6719	-0,0001	-0,0006	-0,0933	-0,0308
6,58	0,6400	-0,3738	41,0977	-16,6426	-0,0003	-0,0006	-0,0792	-0,0217
6,76	0,6415	-0,4195	36,9668	-22,4902	-0,0002	-0,0007	-0,0623	-0,0168
6,94	0,6224	-0,4634	32,2090	-27,0000	-0,0005	-0,0008	-0,0436	-0,0135
7,12	0,6010	-0,5023	27,4121	-32,2695	-0,0007	-0,0008	-0,0278	-0,0226
7,30	0,5699	-0,5322	21,8984	-36,5684	-0,0008	-0,0009	-0,0130	-0,0365
7,48	0,5243	-0,5584	15,4004	-40,3574	-0,0013	-0,0009	-0,0039	-0,0559
7,66	0,4759	-0,5704	7,9941	-43,2070	-0,0015	-0,0008	-0,0036	-0,0799
7,84	0,4267	-0,5676	-0,4785	-44,7187	-0,0018	-0,0005	-0,0132	-0,1052
8,02	0,3782	-0,5470	-9,4531	-44,0215	-0,0022	-0,0004	-0,0333	-0,1212
8,20	0,3354	-0,5169	-18,8047	-41,1875	-0,0027	-0,0002	-0,0656	-0,1281
8,38	0,3142	-0,4773	-27,2051	-35,3066	-0,0029	0,0007	-0,1044	-0,1188
8,56	0,2999	-0,4355	-33,3711	-28,2227	-0,0028	0,0013	-0,1219	-0,0945
8,74	0,3074	-0,3989	-37,2598	-19,7578	-0,0028	0,0021	-0,1330	-0,0554
8,92	0,3199	-0,3668	-38,7969	-10,5957	-0,0027	0,0024	-0,1314	-0,0095
9,10	0,3306	-0,3366	-38,1172	-2,2637	-0,0024	0,0032	-0,1067	0,0302
9,28	0,3535	-0,3261	-35,6680	5,0332	-0,0017	0,0036	-0,0648	0,0573
9,46	0,3750	-0,3126	-32,1250	11,0039	-0,0011	0,0042	-0,0151	0,0708
9,64	0,3888	-0,3083	-27,7969	15,8701	-0,0006	0,0046	0,0389	0,0647
9,82	0,4035	-0,3076	-23,0215	19,5264	0,0004	0,0049	0,0921	0,0426
10,00	0,4188	-0,3024	-17,9951	22,0391	0,0014	0,0048	0,1367	0,0037

Noise Parameters

Freq [GHz]	NFmin [dB]	$\|\Gamma_{opt}\|$	$\varphi(\Gamma_{opt})$	Rn
3,5	0,17148	0,89126	17,8411	0,31933
3,6	0,1753	0,88674	18,2411	0,31124
3,7	0,17846	0,88261	18,6105	0,30365
3,8	0,18083	0,87897	18,9552	0,29675
3,9	0,18248	0,87584	19,2882	0,29067
4,0	0,18362	0,87312	19,624	0,28543
4,1	0,18519	0,87062	19,9734	0,28166
4,2	0,1868	0,86814	20,34	0,27837
4,3	0,18861	0,86555	20,7234	0,27538
4,4	0,19067	0,86279	21,1201	0,27257
4,5	0,193	0,85984	21,5259	0,26984
4,6	0,19607	0,85675	21,941	0,26767
4,7	0,19933	0,85352	22,3575	0,26551
4,8	0,20272	0,85019	22,7734	0,26337
4,9	0,20622	0,8468	23,1873	0,26124
5,0	0,20976	0,84336	23,5985	0,25913
5,1	0,21406	0,83998	23,9997	0,25795
5,2	0,21837	0,83661	24,3975	0,2568
5,3	0,22268	0,83325	24,7922	0,25569
5,4	0,22696	0,82992	25,1841	0,2546
5,5	0,2312	0,82663	25,5739	0,25354
5,6	0,23572	0,82336	25,9617	0,25269
5,7	0,24018	0,82013	26,3481	0,25187
5,8	0,24457	0,81694	26,7337	0,25106
5,9	0,24888	0,8138	27,1192	0,25024
6,0	0,2531	0,8107	27,5053	0,24942
6,1	0,25754	0,80764	27,8912	0,24892
6,2	0,26189	0,80462	28,2785	0,24838
6,3	0,26615	0,80161	28,6675	0,24781
6,4	0,2703	0,79861	29,0587	0,24718
6,5	0,27434	0,79563	29,4525	0,2465
6,6	0,27903	0,79264	29,8429	0,2462
6,7	0,28365	0,78964	30,2353	0,24583
6,8	0,2882	0,78663	30,6299	0,24539
6,9	0,29267	0,7836	31,0268	0,24487
7,0	0,29706	0,78055	31,4262	0,24425
7,1	0,30184	0,77739	31,8233	0,24382
7,2	0,30657	0,77419	32,2218	0,2433
7,3	0,31127	0,77092	32,6216	0,24268
7,4	0,31593	0,76759	33,0226	0,24196
7,5	0,32055	0,76419	33,4246	0,24112
7,6	0,32545	0,76071	33,8187	0,24034
7,7	0,33034	0,75716	34,212	0,23947
7,8	0,33523	0,75353	34,6041	0,23852
7,9	0,34013	0,74982	34,9947	0,23748
8,0	0,34505	0,74601	35,3831	0,23636
8,1	0,35047	0,74213	35,7571	0,23553
8,2	0,35597	0,73815	36,1263	0,23464
8,3	0,36153	0,73406	36,4899	0,23368
8,4	0,36719	0,72986	36,8467	0,23268
8,5	0,37295	0,72554	37,1957	0,23162

P/N	10LNA_01A
Rev Date	**20/6/2007**
	
	

Frequency Range	8 -13	BW	5	BW/f_o	49%

100% BW Performance Summary

	Value min	Value max	Value typ	σ	Units
Gain	20,2	21,9	21	0,9	[dB]
T_e	-	-	-		[K]
$\|S_{11}\|$	-4,4	-3,4	-3,9	0,7	[dB]
$\|S_{22}\|$	-12,2	10,2	-10,7	1	[dB]

50% BW Performance Summary

	Value min	Value max	Value typ	σ	Units
Gain	20,8	22,5	21,6	0,6	[dB]
T_e	-	-	-	-	[K]
$\|S_{11}\|$	-4,7	-3,8	-4,2	0,6	[dB]
$\|S_{22}\|$	-11,7	-10,1	-10,5	0,3	[dB]

IP_3	
Dissipation [mW]	42
RF Pad	Coplanar G-S-G 200 µm pitch
Bias Pad	Coplanar G-SSSS-G 200 µm pitch
Dimensions	**3.200 x 2.550 x 0.075** mm (L x W x H)
Use as	For holography applications
Particularity	Off-chip first stage input matching network. Performances reported in this datasheet are related to the MMIC ONLY. For more exhaustive information regarding the combined use with the external matching network, please refer to chapter 5 of IRA Internal Report N.
N° of available samples	49/56

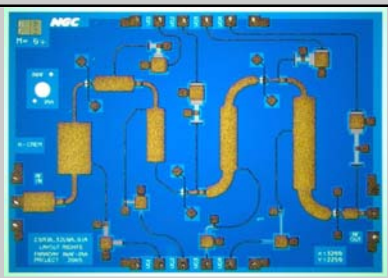
S-Parameters

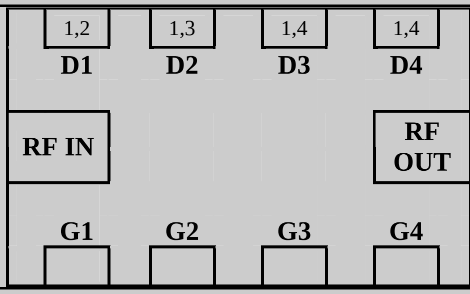
FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
5,0	0,7600	-0,3457	1,4294	-1,2275	-0,0002	-0,0002	-0,2739	-0,6519
5,2	0,7771	-0,3607	1,2526	-0,8792	-0,0002	-0,0001	-0,3210	-0,6088
5,4	0,7883	-0,3851	1,3243	-0,5128	-0,0001	-0,0002	-0,3634	-0,5611
5,6	0,7953	-0,4128	1,6082	-0,2137	0,0000	-0,0003	-0,3996	-0,5097
5,8	0,7953	-0,4449	2,0564	-0,0496	-0,0001	-0,0003	-0,4297	-0,4562
6,0	0,7898	-0,4763	2,6305	-0,0599	-0,0001	-0,0005	-0,4529	-0,4007
6,2	0,7771	-0,5118	3,2780	-0,2765	-0,0001	-0,0006	-0,4686	-0,3439
6,4	0,7614	-0,5459	3,9479	-0,7316	-0,0003	-0,0010	-0,4771	-0,2872
6,6	0,7368	-0,5787	4,5652	-1,4543	-0,0004	-0,0012	-0,4774	-0,2333
6,8	0,7052	-0,6084	5,0330	-2,4634	-0,0005	-0,0014	-0,4719	-0,1825
7,0	0,6668	-0,6316	5,2317	-3,7256	-0,0010	-0,0016	-0,4615	-0,1366
7,2	0,6253	-0,6487	5,0488	-5,1179	-0,0014	-0,0019	-0,4481	-0,0947
7,4	0,5768	-0,6558	4,4290	-6,5051	-0,0018	-0,0019	-0,4333	-0,0577
7,6	0,5337	-0,6504	3,4412	-7,6760	-0,0024	-0,0015	-0,4172	-0,0228
7,8	0,4959	-0,6398	2,2188	-8,5576	-0,0031	-0,0015	-0,3987	0,0112
8,0	0,4639	-0,6282	0,9321	-9,1548	-0,0037	-0,0010	-0,3751	0,0427
8,2	0,4325	-0,6104	-0,3716	-9,6143	-0,0043	-0,0010	-0,3456	0,0685
8,4	0,4065	-0,5868	-1,7915	-9,9951	-0,0050	-0,0009	-0,3138	0,0835
8,6	0,3810	-0,5611	-3,4194	-10,2461	-0,0057	-0,0003	-0,2840	0,0872
8,8	0,3667	-0,5289	-5,3335	-10,1426	-0,0063	0,0008	-0,2646	0,0812
9,0	0,3649	-0,4961	-7,4224	-9,4829	-0,0072	0,0020	-0,2608	0,0752
9,2	0,3755	-0,4651	-9,3257	-8,2021	-0,0073	0,0036	-0,2664	0,0765
9,4	0,3940	-0,4445	-10,7905	-6,4146	-0,0072	0,0051	-0,2763	0,0892
9,6	0,4150	-0,4360	-11,6924	-4,3799	-0,0069	0,0067	-0,2822	0,1124
9,8	0,4334	-0,4346	-12,0464	-2,3442	-0,0065	0,0078	-0,2808	0,1429
10,0	0,4494	-0,4469	-11,9805	-0,4185	-0,0053	0,0089	-0,2704	0,1746
10,2	0,4601	-0,4563	-11,5835	1,3003	-0,0043	0,0099	-0,2515	0,2052
10,4	0,4656	-0,4713	-10,9663	2,7930	-0,0034	0,0104	-0,2266	0,2309
10,6	0,4710	-0,4904	-10,2105	4,0815	-0,0021	0,0112	-0,1967	0,2516
10,8	0,4687	-0,5086	-9,3633	5,1689	-0,0012	0,0117	-0,1646	0,2662
11,0	0,4641	-0,5221	-8,4683	6,0718	0,0000	0,0123	-0,1308	0,2746
11,2	0,4574	-0,5393	-7,5166	6,8198	0,0012	0,0128	-0,0978	0,2774
11,4	0,4467	-0,5539	-6,5581	7,4294	0,0026	0,0130	-0,0659	0,2755
11,6	0,4312	-0,5695	-5,5820	7,9338	0,0038	0,0132	-0,0369	0,2693
11,8	0,4151	-0,5830	-4,6177	8,3052	0,0054	0,0132	-0,0104	0,2591
12,0	0,4005	-0,5958	-3,6626	8,5962	0,0067	0,0133	0,0125	0,2446
12,2	0,3821	-0,6047	-2,7041	8,7813	0,0080	0,0131	0,0329	0,2293
12,4	0,3632	-0,6102	-1,7729	8,8833	0,0094	0,0129	0,0495	0,2118
12,6	0,3431	-0,6182	-0,8301	8,8887	0,0108	0,0125	0,0624	0,1932
12,8	0,3154	-0,6227	0,0708	8,8193	0,0125	0,0125	0,0701	0,1736
13,0	0,2984	-0,6247	0,9712	8,6763	0,0143	0,0118	0,0748	0,1549
13,2	0,2714	-0,6252	1,8188	8,4536	0,0157	0,0108	0,0764	0,1350
13,4	0,2502	-0,6250	2,6914	8,1270	0,0175	0,0099	0,0736	0,1197
13,6	0,2241	-0,6178	3,4819	7,7627	0,0188	0,0091	0,0675	0,1048
13,8	0,2014	-0,6095	4,2554	7,3035	0,0207	0,0071	0,0580	0,0918
14,0	0,1722	-0,5989	4,9883	6,7761	0,0224	0,0058	0,0467	0,0834
14,2	0,1544	-0,5845	5,6621	6,1453	0,0236	0,0039	0,0322	0,0790
14,4	0,1387	-0,5680	6,2759	5,4282	0,0249	0,0009	0,0193	0,0803
14,6	0,1162	-0,5453	6,7961	4,6389	0,0263	-0,0016	0,0063	0,0861
14,8	0,1026	-0,5228	7,1995	3,7966	0,0268	-0,0042	-0,0038	0,0950
15,0	0,0861	-0,4996	7,5090	2,8999	0,0276	-0,0074	-0,0101	0,1096

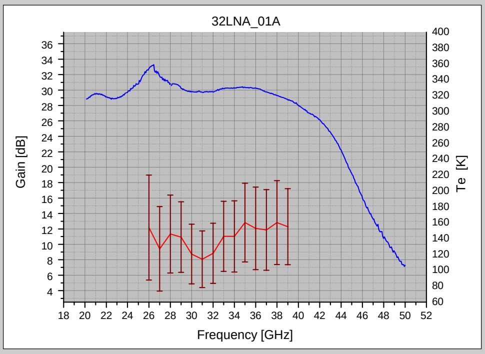
Noise Parameters

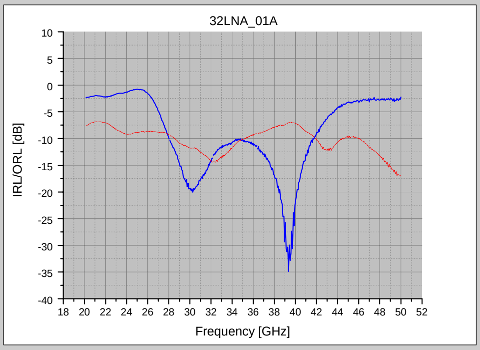
Freq [GHz]	NFmin [dB]	$\lvert\Gamma_{opt}\rvert$	$\varphi(\Gamma_{opt})$	Rn
5,0	1,20591	0,85907	18,2445	1,14684
5,5	0,89752	0,87705	20,2816	1,00109
6,0	0,45506	0,86848	22,7129	0,53666
6,5	0,33982	0,84571	24,8723	0,37663
7,0	0,3141	0,82192	26,755	0,31146
7,5	0,31505	0,79993	28,4706	0,27804
8,0	0,32459	0,7805	30,0544	0,25824
8,5	0,33535	0,76341	31,5572	0,24477
9,0	0,34782	0,74796	33,0115	0,23544
9,5	0,36394	0,73365	34,4872	0,22967
10,5	0,40074	0,708	37,5025	0,22349
10,5	0,40113	0,70775	37,5338	0,22345
11,0	0,41991	0,69554	39,1415	0,22103
11,5	0,44078	0,68322	40,8091	0,21927
12,0	0,46251	0,67042	42,5055	0,21714
12,5	0,48427	0,65755	44,1719	0,21546
13,0	0,50885	0,64333	45,8562	0,21339
13,5	0,53397	0,62811	47,5484	0,21065
14,0	0,55971	0,61059	49,2725	0,20659
14,5	0,58634	0,59064	51,0719	0,20067
15,0	0,60874	0,56794	52,8573	0,19275

P/N	32LNA_01A
Rev Date	**20/6/2007**









Frequency Range	26 - 40	**BW**	14	**BW/f_o**	43%

100% BW Performance Summary

	Value min	Value max	Value typ	σ	Units
Gain	28	32	30	1,3	[dB]
T_e	139	156	145	10	[K]
$\|S_{11}\|$	-14, 5	-12,8	-13,5	6,5	[dB]
$\|S_{22}\|$	-11,4	-8,9	-10,0	2	[dB]

50% BW Performance Summary

	Value min	Value max	Value typ	σ	Units
Gain	28	32,4	30	0,2	[dB]
T_e	134	149	139	12	[K]
$\|S_{11}\|$	-14,3	-11,7	-13,1	3	[dB]
$\|S_{22}\|$	-13,8	-9,8	-11,9	1,5	[dB]

IP_3	
Dissipation [mW]	**82**
RF Pad	Coplanar G-S-G 200 µm pitch
Bias Pad	Coplanar G-SSSS-G 200 µm pitch
Dimensions	**3.200 x 2.550 x 0.075** mm (L x W x H)
Use as	Cryogenic Front end LNA for ground-based radioastronomy applications; Uncooled LNA for noise measurement applications
Particularity	4 stage separately biased LNA
N° of available samples	**52/60**

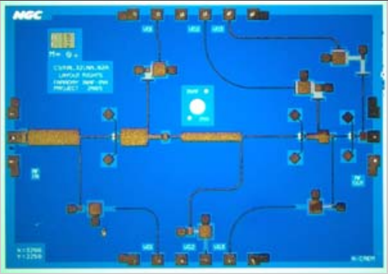
S-Parameters

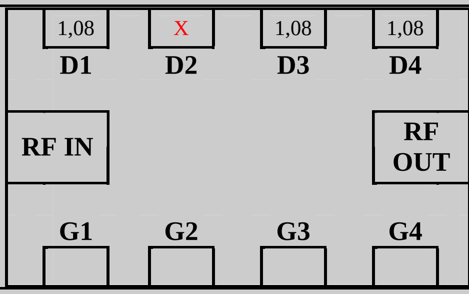
FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
20,0	-0,7277	0,2064	-5,8115	-30,2119	-0,0004	0,0012	-0,2278	-0,2932
20,6	-0,7062	0,3463	-22,7236	-25,1621	0,0000	0,0014	-0,2897	-0,3015
21,2	-0,6258	0,4802	-33,4004	-8,9414	0,0005	0,0018	-0,3478	-0,2671
21,8	-0,5186	0,5677	-31,8975	7,9854	0,0007	0,0015	-0,3743	-0,2172
22,4	-0,4475	0,6270	-24,3887	19,3408	0,0014	0,0024	-0,3860	-0,1614
23,0	-0,3533	0,7417	-15,6807	26,6318	0,0021	0,0014	-0,3663	-0,1247
23,6	-0,1706	0,8272	-5,0352	31,5254	0,0023	0,0002	-0,3499	-0,1074
24,2	0,0426	0,8887	8,0039	33,8262	0,0019	0,0001	-0,3405	-0,1082
24,8	0,3526	0,8571	23,8975	29,8613	0,0015	-0,0015	-0,3510	-0,1012
25,4	0,6866	0,6270	37,3984	16,8047	0,0005	-0,0017	-0,3611	-0,0868
26,0	0,8352	0,1849	42,7949	-3,5566	-0,0005	-0,0016	-0,3639	-0,0649
26,6	0,6766	-0,2621	35,2539	-24,1797	-0,0006	-0,0006	-0,3669	-0,0379
27,2	0,3070	-0,4571	18,4551	-36,0039	-0,0003	0,0005	-0,3658	-0,0151
27,8	-0,0375	-0,4050	0,1387	-37,5762	0,0000	-0,0007	-0,3702	0,0229
28,4	-0,1932	-0,1893	-14,2139	-31,2686	0,0006	-0,0005	-0,3379	0,0512
29,0	-0,1911	-0,0166	-22,3223	-21,5947	-0,0003	-0,0002	-0,3042	0,0567
29,6	-0,1164	0,0729	-26,9775	-12,1357	-0,0006	0,0008	-0,3002	0,0600
30,2	-0,0180	0,1103	-28,8633	-2,1172	-0,0002	-0,0002	-0,2808	0,0631
30,8	0,0928	0,0903	-27,2344	8,3066	-0,0005	0,0003	-0,2601	0,0796
31,4	0,1518	-0,0015	-22,3584	17,3047	0,0001	0,0005	-0,2289	0,0778
32,0	0,1664	-0,1011	-14,7461	24,0068	0,0002	0,0005	-0,1973	0,0657
32,6	0,1395	-0,1985	-5,1748	28,2559	0,0002	0,0001	-0,1770	0,0375
33,2	0,0290	-0,2496	6,0986	28,7471	0,0018	0,0004	-0,1921	0,0073
33,8	-0,0595	-0,2718	17,2647	24,2549	0,0004	-0,0009	-0,1988	-0,0170
34,4	-0,1139	-0,2568	25,8633	15,6738	0,0026	0,0013	-0,2046	-0,0319
35,0	-0,1917	-0,2115	30,3213	3,6475	0,0009	-0,0002	-0,2359	-0,0391
35,6	-0,2164	-0,1633	28,8945	-9,2725	-0,0003	-0,0007	-0,2577	-0,0322
36,2	-0,2210	-0,0996	22,1699	-20,0625	-0,0010	-0,0012	-0,2800	-0,0416
36,8	-0,2205	-0,0761	11,4629	-26,8613	-0,0011	-0,0021	-0,2982	-0,0266
37,4	-0,1865	-0,0051	-0,5771	-28,3281	-0,0009	-0,0001	-0,3263	-0,0173
38,0	-0,1642	0,0347	-12,0986	-24,7969	-0,0024	0,0009	-0,3557	-0,0013
38,6	-0,0746	0,0906	-20,5361	-17,1113	-0,0027	0,0017	-0,3843	0,0423
39,2	-0,0289	0,0726	-25,0723	-6,6748	-0,0032	0,0024	-0,3939	0,0614
39,8	0,0607	0,0512	-24,5049	5,2627	-0,0004	0,0010	-0,4049	0,1430
40,4	0,1108	-0,0126	-18,2979	13,7119	0,0018	0,0010	-0,3624	0,2040
41,0	0,1914	-0,0834	-10,1523	18,7715	0,0027	0,0022	-0,3130	0,2165
41,6	0,2028	-0,1241	-1,0293	20,4453	0,0030	-0,0004	-0,2742	0,2309
42,2	0,2109	-0,2539	7,4814	16,9648	0,0019	0,0011	-0,2260	0,2335
42,8	0,2148	-0,3320	13,0166	10,6416	0,0020	-0,0001	-0,1902	0,1808
43,4	0,1685	-0,4680	14,6919	2,8276	0,0026	-0,0007	-0,1974	0,1481
44,0	0,1033	-0,5752	12,2822	-3,4702	0,0002	-0,0027	-0,2430	0,1451
44,6	-0,0297	-0,6356	7,8340	-6,7332	0,0022	-0,0005	-0,2632	0,1742
45,2	-0,1388	-0,6825	3,8335	-7,4946	0,0003	-0,0002	-0,2425	0,2235
45,8	-0,2441	-0,6552	0,8286	-6,5916	-0,0025	-0,0043	-0,2184	0,2466
46,4	-0,3492	-0,6324	-1,1284	-5,3228	-0,0018	-0,0017	-0,1746	0,2641
47,0	-0,4109	-0,6140	-2,1750	-4,0073	-0,0033	-0,0022	-0,1368	0,2555
47,6	-0,5067	-0,5996	-2,7980	-2,6497	0,0005	0,0002	-0,1050	0,2396
48,2	-0,5139	-0,5317	-2,9364	-1,4719	-0,0012	-0,0022	-0,0875	0,2184
48,8	-0,6288	-0,4506	-2,7928	-0,4890	-0,0017	-0,0023	-0,0501	0,1905
49,4	-0,6014	-0,4359	-2,5143	0,1926	-0,0029	0,0031	-0,0337	0,1631
50,0	-0,6807	-0,3373	-2,1400	0,7196	-0,0077	0,0010	-0,0391	0,1169

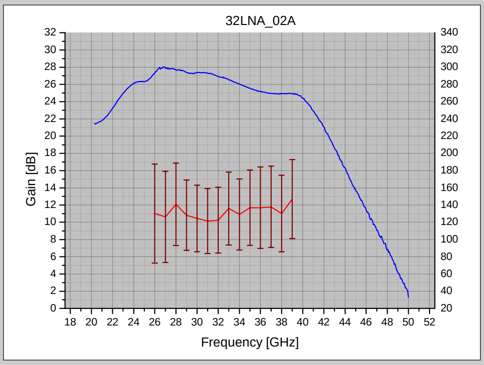
Noise Parameters

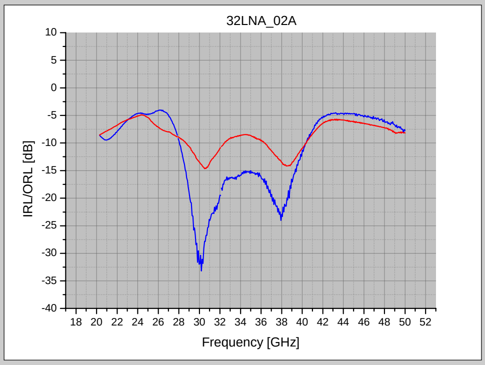
Freq [GHz]	NFmin [dB]	$\|\Gamma_{opt}\|$	$\varphi(\Gamma_{opt})$	Rn
16	7,77295	0,40601	-132,511	1,0682
17	5,16779	0,22471	-149,128	0,51353
18	3,6257	0,28056	177,143	0,25496
19	2,77885	0,40421	176,305	0,1391
20	2,30427	0,49275	-175,306	0,0898
21	2,00413	0,54397	-164,52	0,07813
22	1,78424	0,56442	-152,637	0,09117
23	1,63411	0,56115	-139,959	0,11991
24	1,54116	0,53947	-126,389	0,15684
25	1,48269	0,50233	-111,689	0,19479
26	1,44322	0,45223	-95,6524	0,22694
27	1,41641	0,39308	-78,1528	0,24836
28	1,40202	0,33128	-59,1278	0,25777
29	1,40173	0,27477	-38,5353	0,2575
30	1,41524	0,2304	-16,4664	0,25131
31	1,44012	0,20134	6,38008	0,24226
32	1,47306	0,18606	28,5141	0,23189
33	1,50931	0,1797	48,4805	0,22062
34	1,5453	0,17613	65,7299	0,20863
35	1,57934	0,16988	80,4268	0,19662
36	1,61054	0,15653	92,858	0,1861
37	1,63888	0,13248	102,811	0,17953
38	1,66541	0,09524	107,909	0,18037
39	1,69267	0,04907	90,3819	0,19324
40	1,72518	0,06502	16,6568	0,2239
41	1,76963	0,15669	7,0071	0,27916
42	1,83467	0,27138	14,9413	0,36632
43	1,93047	0,39382	26,7849	0,49241
44	2,06805	0,51024	39,5916	0,6634
45	2,25877	0,61008	52,0804	0,88347
46	2,51374	0,68891	63,6062	1,1545
47	2,84256	0,74762	73,9239	1,47541
48	3,25106	0,78971	83,0285	1,84106
49	3,7382	0,81913	91,0276	2,24091
50	4,29363	0,83929	98,0653	2,65791

P/N	32LNA_02A
Rev Date	20/6/2007









Frequency Range	26 - 40	BW	14	BW/f_o	43%

100% BW Performance Summary

	Value min	Value max	Value typ	σ	Units
Gain	24,7	27,7	25,8	1,3	[dB]
T_e	125	152	140	5	[K]
$\|S_{11}\|$	-19,4	-11,5	-16,3	6	[dB]
$\|S_{22}\|$	-12	-8,8	-10,7	2	[dB]

50% BW Performance Summary

	Value min	Value max	Value typ	σ	Units
Gain	24,6	27,8	25,9	0,9	[dB]
T_e	122	149	137	5	[K]
$\|S_{11}\|$	-23,5	-11,9	-18,3	2	[dB]
$\|S_{22}\|$	-12	-8,8	-10,7	2	[dB]

IP_3	
Dissipation [mW]	40
RF Pad	Coplanar G-S-G 200 µm pitch
Bias Pad	Coplanar G-SSSS-G 200 µm pitch
Dimensions	**3.200 x 2.550 x 0.075** mm (L x W x H)
Use as	Cryogenic Front end LNA for ground-based radioastronomy applications; Uncooled LNA are also used for IRA receiver noise measurements
Particularity	3 stage separately biased LNA
N° of available samples	46/60

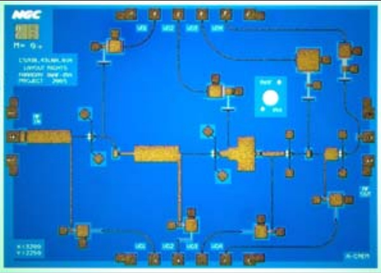
S-Parameters

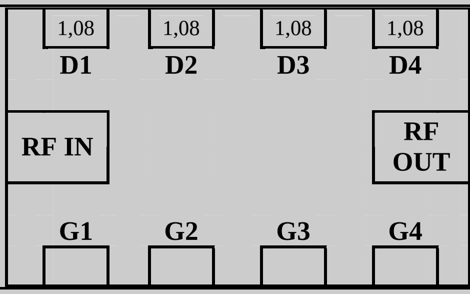
FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
20,0	0,4604	-0,0035	9,9175	3,7856	-0,0005	-0,0006	0,3332	-0,0789
20,6	0,2819	-0,2617	11,0933	-0,1343	-0,0009	-0,0002	0,3330	-0,1607
21,2	0,0862	-0,3568	10,9717	-3,1685	-0,0019	0,0006	0,3140	-0,2404
21,8	-0,0721	-0,3830	10,8384	-6,0610	-0,0010	0,0011	0,2842	-0,3159
22,4	-0,2195	-0,3969	10,1665	-9,6582	-0,0028	0,0008	0,2362	-0,3969
23,0	-0,3738	-0,3539	7,9634	-13,7690	-0,0021	0,0019	0,1584	-0,4628
23,6	-0,5211	-0,2512	3,7314	-17,2998	-0,0022	0,0026	0,0645	-0,5103
24,2	-0,6032	-0,0855	-2,3730	-18,9023	-0,0017	0,0041	-0,0524	-0,5349
24,8	-0,6056	0,0794	-8,3564	-17,6572	0,0010	0,0063	-0,1805	-0,4921
25,4	-0,5721	0,2112	-12,8076	-15,2627	0,0038	0,0052	-0,2525	-0,3959
26,0	-0,5274	0,3867	-17,8594	-12,2891	0,0052	0,0026	-0,2608	-0,3210
26,6	-0,3440	0,5414	-22,5195	-6,4307	0,0045	0,0005	-0,2637	-0,2813
27,2	-0,0673	0,5714	-23,8555	1,7529	0,0037	0,0006	-0,2782	-0,2421
27,8	0,1358	0,4368	-21,6289	8,8662	0,0029	0,0005	-0,2765	-0,1953
28,4	0,1898	0,2325	-17,7285	13,9609	0,0038	-0,0003	-0,2622	-0,1488
29,0	0,1624	0,0945	-13,5557	17,9453	0,0038	-0,0004	-0,2254	-0,1157
29,6	0,1262	0,0260	-8,2842	20,9297	0,0044	-0,0017	-0,1811	-0,1074
30,2	0,0751	-0,0188	-2,3066	22,7207	0,0034	-0,0022	-0,1366	-0,1232
30,8	0,0349	-0,0343	4,2510	22,2490	0,0037	-0,0029	-0,1059	-0,1688
31,4	0,0189	-0,0622	10,1621	19,5459	0,0027	-0,0034	-0,1198	-0,2152
32,0	0,0131	-0,0829	14,3164	15,5205	0,0016	-0,0038	-0,1458	-0,2537
32,6	-0,0414	-0,1081	17,4443	11,0889	0,0015	-0,0033	-0,1932	-0,2742
33,2	-0,0690	-0,0787	18,7529	6,1064	0,0020	-0,0035	-0,2406	-0,2602
33,8	-0,0793	-0,0822	19,1436	1,1211	-0,0005	-0,0046	-0,2806	-0,2441
34,4	-0,1048	-0,0687	18,0596	-3,4443	-0,0005	-0,0042	-0,3085	-0,2146
35,0	-0,1099	-0,0644	16,2051	-7,3125	-0,0019	-0,0036	-0,3203	-0,1739
35,6	-0,0979	-0,0628	13,7012	-10,5947	-0,0025	-0,0036	-0,3188	-0,1280
36,2	-0,1030	-0,0080	10,5977	-13,1851	-0,0027	-0,0030	-0,3075	-0,1007
36,8	-0,0553	-0,0287	7,0889	-15,0947	-0,0043	-0,0032	-0,2735	-0,0636
37,4	-0,0207	-0,0295	3,1699	-16,1729	-0,0055	-0,0026	-0,2345	-0,0579
38,0	0,0180	-0,0720	-1,0869	-16,4902	-0,0072	-0,0009	-0,1952	-0,0706
38,6	0,0581	-0,1110	-5,4106	-15,5039	-0,0076	0,0017	-0,1607	-0,0997
39,2	0,0345	-0,1778	-9,5347	-13,0361	-0,0061	0,0038	-0,1482	-0,1563
39,8	0,0615	-0,2571	-12,9829	-9,0024	-0,0077	0,0054	-0,1589	-0,2128
40,4	0,0034	-0,3334	-14,0913	-4,0020	-0,0041	0,0096	-0,2010	-0,2549
41,0	-0,0635	-0,4412	-13,0425	0,6880	0,0009	0,0095	-0,2571	-0,2855
41,6	-0,2005	-0,4753	-10,8911	4,0410	0,0023	0,0083	-0,3209	-0,2987
42,2	-0,3120	-0,4504	-7,8589	5,8606	0,0026	0,0054	-0,3959	-0,2745
42,8	-0,4226	-0,3531	-5,1619	6,3997	0,0045	0,0020	-0,4509	-0,2315
43,4	-0,5072	-0,2810	-2,9524	6,3589	0,0041	0,0024	-0,4720	-0,1680
44,0	-0,5108	-0,2148	-1,2278	5,8809	0,0043	-0,0011	-0,4847	-0,1151
44,6	-0,5458	-0,1598	-0,0928	4,9587	0,0045	0,0001	-0,4754	-0,0720
45,2	-0,5575	-0,0935	0,7256	4,1460	0,0025	0,0021	-0,4561	-0,0287
45,8	-0,5485	-0,0482	1,1422	3,3466	0,0028	0,0003	-0,4463	-0,0108
46,4	-0,5209	0,0018	1,4476	2,6282	0,0000	-0,0010	-0,4410	0,0121
47,0	-0,4978	0,0515	1,5846	2,0400	0,0023	-0,0017	-0,4280	0,0294
47,6	-0,4880	0,0567	1,6631	1,5247	0,0021	0,0019	-0,4115	0,0503
48,2	-0,4202	0,1081	1,5792	1,0835	0,0015	-0,0005	-0,4025	0,0593
48,8	-0,4138	0,1077	1,4432	0,6808	0,0030	0,0002	-0,3771	0,0679
49,4	-0,3424	0,1354	1,2277	0,4337	0,0019	0,0038	-0,3714	0,0842
50,0	-0,3535	0,0946	0,9447	0,1498	0,0022	0,0005	-0,3550	0,0926

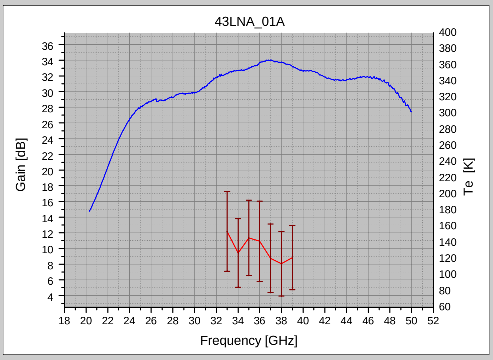
Noise Parameters

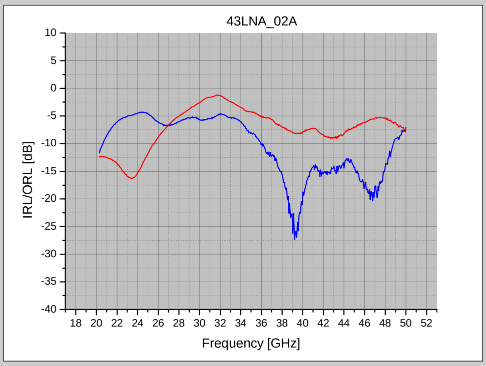
Freq [GHz]	NFmin [dB]	$\|\Gamma_{opt}\|$	$\varphi(\Gamma_{opt})$	Rn
16	12,7769	0,8195	-164,547	1,32311
17	9,50899	0,76875	-148,723	1,49562
18	6,24006	0,6654	-130,968	1,01619
19	4,39029	0,52153	-110,777	0,73658
20	3,33732	0,35645	-86,4927	0,56259
21	2,71726	0,20486	-52,0535	0,44107
22	2,28222	0,13007	8,6119	0,34484
23	1,96211	0,16855	66,6116	0,26913
24	1,74672	0,23648	96,7802	0,21022
25	1,58731	0,28843	116,487	0,16189
26	1,45257	0,31604	132,08	0,12394
27	1,35574	0,32272	145,093	0,0993
28	1,30661	0,31466	155,996	0,08691
29	1,29473	0,29754	165,097	0,08319
30	1,30836	0,27482	172,876	0,08511
31	1,33951	0,248	179,638	0,09097
32	1,38026	0,21845	-174,487	0,09948
33	1,42381	0,18706	-169,368	0,10971
34	1,46484	0,15403	-164,861	0,12109
35	1,4993	0,11878	-160,884	0,13333
36	1,52462	0,08011	-157,827	0,14644
37	1,54024	0,03668	-159,885	0,1606
38	1,54849	0,01795	70,6999	0,17611
39	1,55612	0,07577	55,1762	0,19328
40	1,57655	0,14401	60,9513	0,2124
41	1,6331	0,21915	70,1946	0,23367
42	1,7626	0,29591	81,4062	0,25722
43	2,01772	0,36684	93,8414	0,2834
44	2,46626	0,42507	106,748	0,31326
45	3,18788	0,46686	119,43	0,34999
46	4,27423	0,4916	131,422	0,40255
47	5,8352	0,49986	142,537	0,49545
48	8,04365	0,49187	152,779	0,70667
49	11,3031	0,46684	162,193	1,36748
50	16,7893	0,42214	170,561	4,96845

P/N	43LNA_01A
Rev Date	20/6/2007









Frequency Range	31 - 48	BW	17	BW/f_o	44%

100% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	29,5	33,2	31,6	1,7	[dB]
T_e	157	198	172	6	[K]
$\|S_{11}\|$	-15,2	4,1	-8,4	4	[dB]
$\|S_{22}\|$	-7,4	0,6	-4,5	1,4	[dB]

50% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	29,7	33,6	31,8	0,9	[dB]
T_e	-	-	-	-	[K]
$\|S_{11}\|$	-16,9	-10,4	-15,2	2	[dB]
$\|S_{22}\|$	-8,5	-7,2	-8	0,6	[dB]

IP_3	
Dissipation [mW]	52
RF Pad	Coplanar G-S-G 200 µm pitch
Bias Pad	Coplanar G-SSSS-G 200 µm pitch
Dimensions	**3.200 x 2.550 x 0.075** mm (L x W x H)
Use as	Cryogenic Front end LNA for ground-based radioastronomy applications; Uncooled LNA are also used for IRA receiver noise measurements
Particularity	4 stage separately biased LNA
N° of available samples	40/52

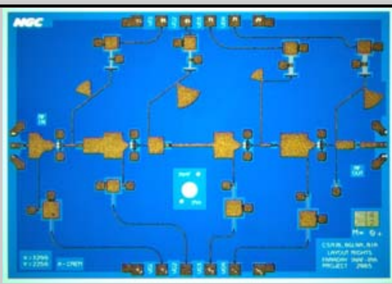
S-Parameters

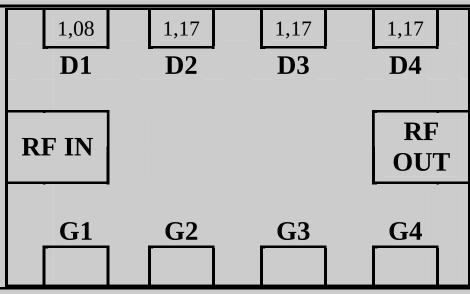
FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
20,0	0,0435	-0,2334	-4,4331	0,0159	-0,0004	0,0003	-0,0071	-0,2539
20,6	-0,0040	-0,3258	-5,3418	0,4998	-0,0006	0,0006	-0,0171	-0,2570
21,2	-0,0890	-0,4029	-6,5483	1,5078	-0,0008	0,0009	-0,0286	-0,2506
21,8	-0,1931	-0,4328	-7,9846	3,3606	-0,0005	0,0004	-0,0355	-0,2322
22,4	-0,3094	-0,4284	-9,1089	6,6836	-0,0005	0,0006	-0,0354	-0,2029
23,0	-0,3757	-0,3762	-8,7446	11,5435	-0,0003	0,0015	-0,0105	-0,1715
23,6	-0,4441	-0,3389	-5,4551	17,0772	0,0006	0,0020	0,0290	-0,1546
24,2	-0,5056	-0,2866	1,2295	21,4463	0,0000	0,0013	0,0805	-0,1561
24,8	-0,5555	-0,1846	10,8291	22,0430	0,0004	0,0009	0,1322	-0,1755
25,4	-0,5315	-0,0831	19,7480	16,9248	0,0007	0,0006	0,1779	-0,2194
26,0	-0,4637	-0,0319	24,3486	9,3027	0,0008	0,0006	0,2067	-0,2665
26,6	-0,4299	-0,0548	26,1709	1,8945	0,0004	0,0004	0,2270	-0,3286
27,2	-0,4430	-0,0462	26,5977	-5,5156	-0,0007	0,0012	0,2324	-0,3993
27,8	-0,4686	-0,0595	25,5010	-13,1963	0,0002	0,0003	0,2118	-0,4770
28,4	-0,4978	-0,0289	21,4522	-21,2178	0,0008	0,0006	0,1802	-0,5396
29,0	-0,5347	0,0423	14,9766	-27,2646	-0,0002	-0,0002	0,1396	-0,5982
29,6	-0,5176	0,1053	7,0088	-31,1543	-0,0005	0,0005	0,0840	-0,6753
30,2	-0,4723	0,1380	-0,8613	-32,3750	0,0002	0,0002	0,0187	-0,7285
30,8	-0,4894	0,1547	-9,3457	-33,4863	-0,0020	0,0002	-0,1073	-0,7918
31,4	-0,4977	0,2179	-19,6406	-32,1973	-0,0015	0,0012	-0,2393	-0,7948
32,0	-0,4965	0,3219	-30,8262	-26,3682	-0,0018	0,0039	-0,3984	-0,7312
32,6	-0,3935	0,3853	-39,2734	-15,8809	0,0008	0,0032	-0,4667	-0,6126
33,2	-0,3205	0,4329	-43,8145	-3,5957	0,0017	0,0031	-0,5041	-0,5382
33,8	-0,2215	0,4581	-43,1387	11,2852	0,0014	0,0021	-0,5070	-0,4445
34,4	-0,0869	0,4494	-37,2441	23,2852	0,0021	0,0022	-0,4992	-0,3717
35,0	-0,0505	0,3832	-30,6895	32,6230	0,0035	0,0003	-0,4811	-0,3505
35,6	0,0308	0,3395	-19,6367	42,0098	0,0021	0,0008	-0,4875	-0,2811
36,2	0,0771	0,2910	-5,8711	46,4492	0,0032	-0,0002	-0,4753	-0,2504
36,8	0,0920	0,2258	9,3340	46,6152	0,0023	-0,0020	-0,4703	-0,2149
37,4	0,1378	0,1815	23,3535	39,5410	0,0025	-0,0019	-0,4473	-0,1756
38,0	0,1492	0,0730	32,8281	29,7813	-0,0010	-0,0016	-0,4075	-0,1652
38,6	0,1478	0,0303	37,8516	18,2617	0,0007	-0,0023	-0,4007	-0,1455
39,2	0,0964	-0,0662	39,4121	6,7344	-0,0008	-0,0016	-0,3854	-0,1378
39,8	0,0411	-0,1448	38,4336	-3,7773	-0,0009	-0,0014	-0,3751	-0,1549
40,4	-0,0693	-0,1383	35,4707	-12,8125	-0,0012	-0,0017	-0,3977	-0,1410
41,0	-0,1339	-0,0998	29,9219	-21,7197	0,0011	-0,0001	-0,4148	-0,1315
41,6	-0,1518	-0,0623	22,0039	-28,5430	0,0030	-0,0027	-0,4028	-0,0904
42,2	-0,1582	-0,0317	13,3936	-31,1523	0,0004	-0,0042	-0,3767	-0,0659
42,8	-0,1714	0,0336	5,6172	-32,3359	-0,0009	-0,0021	-0,3471	-0,0884
43,4	-0,1676	0,0547	-2,7949	-32,8105	-0,0004	0,0013	-0,3450	-0,1106
44,0	-0,1783	0,0638	-11,1016	-31,2100	-0,0017	0,0015	-0,3605	-0,1147
44,6	-0,1496	0,1319	-19,1357	-28,0342	-0,0021	0,0000	-0,3945	-0,1118
45,2	-0,0730	0,1577	-26,9102	-21,3926	-0,0046	0,0008	-0,4223	-0,0876
45,8	0,0160	0,1624	-32,0078	-11,9082	-0,0067	0,0000	-0,4630	-0,0696
46,4	0,1214	0,1208	-33,6113	-0,7148	0,0001	0,0024	-0,4810	-0,0195
47,0	0,1668	0,0122	-30,9971	9,8408	0,0012	-0,0002	-0,4949	0,0310
47,6	0,1919	-0,1144	-24,3477	18,8828	0,0018	0,0024	-0,4834	0,1092
48,2	0,1815	-0,2396	-14,5107	24,2881	0,0011	0,0020	-0,4437	0,1720
48,8	0,0984	-0,3320	-5,7012	25,0400	0,0022	0,0048	-0,3835	0,1969
49,4	-0,0566	-0,3759	1,3564	22,2148	0,0009	-0,0023	-0,3135	0,2270
50,0	-0,1628	-0,4413	6,5566	18,2197	-0,0007	0,0030	-0,2985	0,2688

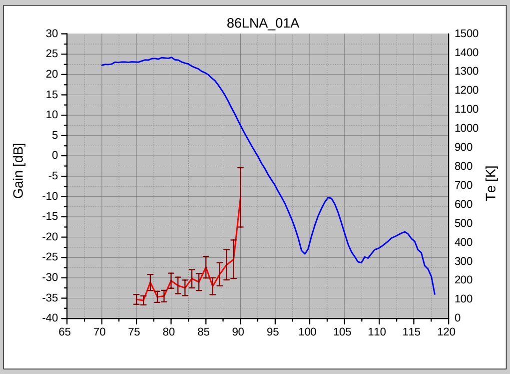
Noise Parameters

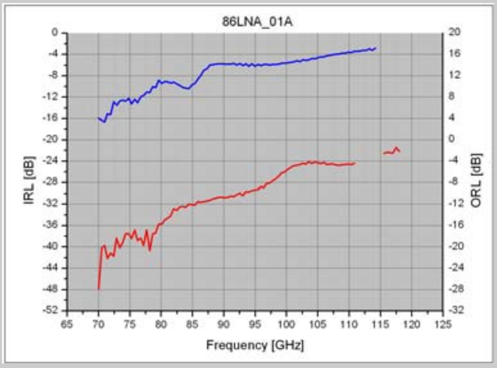
Freq [GHz]	NFmin [dB]	$\|\Gamma_{opt}\|$	$\varphi(\Gamma_{opt})$	Rn
21	6,56032	0,09024	98,0706	1,06941
22	5,05052	0,14917	110,006	0,67872
23	3,96038	0,19054	121,135	0,45128
24	3,25878	0,22451	127,795	0,33072
25	2,81932	0,25892	131,716	0,26285
26	2,54297	0,29569	135,028	0,21948
27	2,36801	0,33313	138,854	0,18772
28	2,22284	0,36646	143,594	0,15966
29	2,03988	0,39049	149,214	0,13177
30	1,85905	0,40511	155,494	0,1081
31	1,71937	0,41205	162,025	0,09132
32	1,6247	0,41255	168,563	0,08111
33	1,56631	0,40712	175,033	0,07642
34	1,53545	0,39604	-178,596	0,07632
35	1,52552	0,37979	-172,359	0,08002
36	1,53142	0,35902	-166,306	0,08677
37	1,54924	0,33456	-160,5	0,09581
38	1,57569	0,30737	-155,005	0,10639
39	1,60782	0,27848	-149,88	0,11785
40	1,64284	0,24888	-145,156	0,12959
41	1,67819	0,21937	-140,812	0,14122
42	1,7116	0,19047	-136,728	0,15251
43	1,74114	0,16223	-132,646	0,16346
44	1,76545	0,13415	-128,099	0,17427
45	1,78397	0,10522	-122,238	0,18527
46	1,79724	0,07424	-113,099	0,19683
47	1,80721	0,04114	-92,5806	0,20924
48	1,81762	0,02437	-10,8838	0,22252
49	1,8343	0,06206	44,5558	0,23634
50	1,86544	0,11635	63,03	0,24987
51	1,92153	0,17751	76,2539	0,26178
52	2,01499	0,24167	88,4567	0,27035
53	2,15929	0,30452	100,508	0,27372
54	2,36724	0,36174	112,539	0,27029
55	2,64858	0,41005	124,483	0,25935
56	3,00797	0,44777	136,255	0,24178
57	3,44398	0,47477	147,828	0,22089
58	3,94992	0,49192	159,247	0,20337

P/N	86LNA_01A
Rev Date	**25/6/2007**









Frequency Range	70 - 85	BW	15	BW/f_o	19%

100% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	16,6	21	18,5	4,4	[dB]
T_e	194	247	219		[K]
$\|S_{11}\|$	-12,2	-7,5	-9,7	3	[dB]
$\|S_{22}\|$	-17,5	-12,1	-16,1	4,5	[dB]

50% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	18,9	23,1	20,9	1,4	[dB]
T_e	-	-	-	-	[K]
$\|S_{11}\|$	-13,6	-9,1	-10,3	1	[dB]
$\|S_{22}\|$	-21,4	-11,4	-16,6	3.3	[dB]

IP_3	
Dissipation [mW]	76,14
RF Pad	Coplanar G-S-G 100 µm pitch
Bias Pad	Coplanar G-SSSS-G 200 µm pitch
Dimensions	**3.200 x 2.250 x 0.075** mm (L x W x H)
Use as	Cryogenic Front end LNA for ground-based radioastronomy applications; Uncooled LNA are also used for IRA receiver noise measurements
Particularity	4 stage separately biased LNA
N° of available samples	41/52

S-Parameters

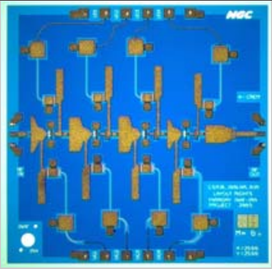
FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
70,00	0,0170	0,1720	4,1440	-6,7668	-0,0077	0,0075	0,0241	0,0710
70,48	0,0387	0,1707	3,0398	-7,5618	-0,0019	-0,0008	0,0191	0,0603
70,96	0,0182	0,1853	1,5769	-7,9790	-0,0039	0,0027	0,0286	0,0568
71,44	0,0336	0,2084	0,0420	-8,4951	0,0008	0,0032	0,0512	0,0447
71,92	0,0634	0,2114	-1,6147	-8,5518	0,0088	0,0112	0,0663	0,0411
72,40	0,0540	0,2433	-3,4595	-7,9854	0,0078	-0,0008	0,0442	0,0473
72,88	0,0967	0,2361	-4,9097	-7,4514	0,0033	-0,0053	0,0833	0,0559
73,36	0,0945	0,2266	-6,3135	-6,1277	0,0056	-0,0027	0,0981	0,0020
73,84	0,1367	0,2330	-7,4229	-5,1418	0,0073	0,0049	0,0951	0,0295
74,32	0,1339	0,2327	-8,4370	-3,4390	0,0028	-0,0017	0,1196	0,0104
74,80	0,1880	0,2183	-8,8491	-1,7974	0,0086	-0,0072	0,1506	-0,0377
75,28	0,1454	0,1920	-9,3301	-0,0679	-0,0017	-0,0052	0,0977	-0,0358
75,76	0,1810	0,2021	-9,3042	1,9155	0,0000	-0,0059	0,1302	-0,0504
76,24	0,1606	0,1963	-8,9146	3,8013	0,0017	-0,0064	0,0808	-0,0727
76,72	0,2002	0,2233	-8,0474	5,9951	0,0001	0,0019	0,1130	-0,0564
77,20	0,2154	0,1999	-6,5002	7,7898	-0,0023	-0,0044	0,0949	-0,0422
77,68	0,2522	0,1827	-4,4771	9,0308	-0,0040	-0,0018	0,1133	-0,0925
78,16	0,2796	0,1496	-2,3667	10,1841	0,0006	-0,0037	0,0745	-0,0740
78,64	0,3119	0,1231	0,1362	10,2354	0,0053	-0,0001	0,0785	-0,1351
79,12	0,3366	0,0891	2,5923	9,8345	-0,0061	-0,0042	0,0872	-0,1298
79,60	0,3564	0,0323	4,9521	8,8945	-0,0005	-0,0031	0,0455	-0,1508
80,08	0,3503	-0,0400	6,8582	7,1372	-0,0038	-0,0017	0,0602	-0,1745
80,56	0,3518	-0,0854	8,1616	5,0640	-0,0037	-0,0077	0,0221	-0,1808
81,04	0,3156	-0,1264	8,7607	2,8418	0,0028	-0,0030	0,0155	-0,1872
81,52	0,2760	-0,1639	8,7266	0,4873	0,0026	0,0004	-0,0231	-0,2071
82,00	0,2561	-0,1974	8,4199	-1,5361	-0,0005	-0,0048	-0,0359	-0,2251
82,48	0,2174	-0,2228	7,4707	-3,2766	-0,0002	-0,0039	-0,0602	-0,2261
82,96	0,1894	-0,2300	6,1516	-4,8052	-0,0039	-0,0023	-0,0866	-0,2307
83,44	0,1772	-0,2468	4,6560	-5,9807	-0,0006	-0,0011	-0,1129	-0,2160
83,92	0,1699	-0,2458	2,9031	-6,6140	-0,0058	0,0031	-0,1282	-0,2073
84,40	0,1553	-0,2711	0,9014	-6,8022	-0,0023	0,0007	-0,1410	-0,2043
84,88	0,1520	-0,3051	-0,7632	-6,5444	-0,0067	0,0026	-0,1695	-0,2009
85,36	0,1138	-0,3417	-2,4871	-5,5950	0,0011	0,0036	-0,1657	-0,1834
85,84	0,1058	-0,3934	-3,5781	-4,3513	-0,0009	-0,0016	-0,2053	-0,1799
86,32	0,0439	-0,4315	-4,2026	-2,8660	-0,0042	0,0039	-0,2159	-0,1571
86,80	-0,0172	-0,4683	-4,2253	-1,2874	-0,0012	0,0022	-0,2369	-0,1459
87,28	-0,1062	-0,4654	-3,8281	-0,1525	-0,0018	0,0038	-0,2566	-0,1239
87,76	-0,1821	-0,4787	-3,1328	0,7614	-0,0015	0,0025	-0,2689	-0,0968
88,24	-0,2452	-0,4439	-2,4448	1,1425	-0,0050	0,0032	-0,2889	-0,0699
88,72	-0,3033	-0,4282	-1,7584	1,4320	-0,0029	-0,0003	-0,2946	-0,0462
89,20	-0,3501	-0,3822	-1,2297	1,4144	-0,0010	-0,0008	-0,3016	-0,0172
89,68	-0,3848	-0,3503	-0,7770	1,3503	0,0026	0,0015	-0,3042	0,0128
90,16	-0,4200	-0,3085	-0,4470	1,2234	0,0011	0,0005	-0,3019	0,0427
90,64	-0,4426	-0,2759	-0,2267	1,0577	0,0059	0,0014	-0,2926	0,0705
91,12	-0,4691	-0,2330	-0,0395	0,9158	0,0045	-0,0024	-0,2977	0,0926
91,60	-0,4834	-0,2170	0,0569	0,7747	0,0037	-0,0080	-0,2835	0,1146
92,08	-0,4989	-0,1520	0,1473	0,6411	0,0034	-0,0073	-0,2840	0,1432
92,56	-0,5162	-0,1357	0,1985	0,5302	-0,0007	-0,0098	-0,2728	0,1825
93,04	-0,5054	-0,0839	0,2162	0,4205	-0,0007	-0,0153	-0,2481	0,1942
93,52	-0,5252	-0,0718	0,2359	0,3337	0,0028	-0,0084	-0,2374	0,2526
94,00	-0,5132	-0,0317	0,2235	0,2654	-0,0035	-0,0050	-0,2144	0,2586

94,48	-0,5346	-0,0095	0,2216	0,1936	-0,0094	-0,0053	-0,1937	0,2891
94,96	-0,5068	0,0150	0,2017	0,1573	-0,0055	-0,0034	-0,1462	0,3284
95,44	-0,5274	0,0526	0,1903	0,1019	-0,0073	-0,0050	-0,1341	0,3255
95,92	-0,5162	0,0552	0,1678	0,0770	-0,0067	-0,0008	-0,0433	0,3866
96,40	-0,5226	0,0962	0,1433	0,0451	-0,0036	-0,0028	-0,0263	0,3743
96,88	-0,5203	0,1035	0,1169	0,0278	-0,0034	-0,0022	0,0323	0,4029
97,36	-0,5117	0,1380	0,0919	0,0162	-0,0072	-0,0032	0,1092	0,3999
97,84	-0,5177	0,1445	0,0747	0,0094	-0,0063	-0,0052	0,1501	0,4066
98,32	-0,5116	0,1705	0,0543	0,0114	-0,0077	-0,0001	0,2401	0,3860
98,80	-0,5082	0,1898	0,0366	0,0179	-0,0063	0,0003	0,3036	0,3621
99,28	-0,5145	0,2084	0,0257	0,0275	-0,0078	-0,0036	0,3878	0,3181
99,76	-0,5069	0,2208	0,0171	0,0407	-0,0068	-0,0026	0,4474	0,2620
100,24	-0,5040	0,2486	0,0194	0,0643	-0,0092	0,0057	0,5160	0,1806
100,72	-0,5029	0,2568	0,0362	0,0870	-0,0079	-0,0007	0,5547	0,1029
101,20	-0,4935	0,2793	0,0620	0,0998	-0,0077	0,0035	0,5804	-0,0114
101,68	-0,5025	0,2922	0,1017	0,1013	-0,0031	0,0006	0,5781	-0,1182
102,16	-0,4843	0,3020	0,1473	0,0784	-0,0075	0,0008	0,5584	-0,2102
102,64	-0,4902	0,3407	0,1774	0,0195	-0,0039	0,0039	0,5034	-0,3401
103,12	-0,4827	0,3459	0,1696	-0,0527	-0,0087	0,0039	0,4559	-0,3812
103,60	-0,4713	0,3702	0,1143	-0,0930	-0,0064	0,0033	0,3806	-0,4959
104,08	-0,4729	0,3904	0,0637	-0,0942	-0,0111	0,0046	0,3002	-0,5207
104,56	-0,4611	0,3989	0,0340	-0,0818	-0,0048	0,0057	0,2237	-0,5645
105,04	-0,4532	0,4266	0,0161	-0,0613	-0,0086	0,0043	0,1196	-0,5880
105,52	-0,4464	0,4451	0,0080	-0,0454	-0,0043	-0,0005	0,0663	-0,5846
106,00	-0,4331	0,4679	0,0097	-0,0364	-0,0004	0,0000	-0,0367	-0,5998
106,48	-0,4265	0,4869	0,0152	-0,0352	-0,0029	0,0025	-0,0764	-0,5679
106,96	-0,4132	0,4953	0,0159	-0,0293	-0,0003	0,0066	-0,1495	-0,5591
107,44	-0,4053	0,5192	0,0177	-0,0276	-0,0019	0,0042	-0,1994	-0,5371
107,92	-0,3991	0,5360	0,0189	-0,0323	-0,0027	-0,0005	-0,2316	-0,5201
108,40	-0,3746	0,5508	0,0185	-0,0350	-0,0065	0,0019	-0,2837	-0,4904
108,88	-0,3640	0,5749	0,0189	-0,0382	-0,0013	0,0024	-0,3197	-0,4701
109,36	-0,3428	0,5829	0,0176	-0,0376	-0,0057	0,0027	-0,3537	-0,4481
109,84	-0,3299	0,6152	0,0156	-0,0466	-0,0019	0,0038	-0,4119	-0,4071
110,32	-0,3092	0,6159	0,0048	-0,0504	-0,0030	0,0013	-0,4180	-0,3849
110,80	-0,2947	0,6385	-0,0015	-0,0496	-0,0059	0,0039	-0,4746	-0,3481
111,28	-0,2821	0,6435	-0,0140	-0,0623	-0,0053	0,0014	-0,4905	-0,3059
111,76	-0,2439	0,6648	-0,0232	-0,0610	-0,0027	0,0048	-0,5147	-0,2758
112,24	-0,2456	0,6769	-0,0375	-0,0529	-0,0004	0,0036	-0,5507	-0,2180
112,72	-0,2160	0,6774	-0,0549	-0,0527	-0,0036	0,0045	-0,5526	-0,1970
113,20	-0,2054	0,7079	-0,0662	-0,0313	-0,0004	0,0015	-0,5794	-0,1430
113,68	-0,1755	0,6959	-0,0740	-0,0146	-0,0041	0,0033	-0,5932	-0,1196
114,16	-0,1591	0,7250	-0,0752	0,0153	-0,0041	0,0098	-0,6050	-0,0834
114,64	-0,1201	0,7409	-0,0569	0,0279	-0,0008	-0,0078	-0,6227	-0,0123
115,12	-0,1056	0,7339	-0,0396	0,0390	-0,0077	0,0097	-0,6386	0,0085
115,60	-0,0860	0,7376	-0,0317	0,0424	0,0066	0,0099	-0,6073	0,0534
116,08	-0,0674	0,7579	-0,0133	0,0358	0,0207	-0,0219	-0,5874	0,0779
116,56	-0,0458	0,7468	-0,0128	0,0273	0,0184	0,0340	-0,6140	0,1509
117,04	0,0270	0,7533	0,0019	0,0238	0,0224	0,0007	-0,5979	0,1745
117,52	0,0330	0,8599	-0,0073	0,0225	0,0153	0,0147	-0,5546	0,1974
118,00	-0,1949	0,7511	-0,0023	0,0107	0,0245	0,0074	-0,6338	0,2361

Noise Parameters

Freq [GHz]	NFmin [dB]	$\|\Gamma_{opt}\|$	$\varphi(\Gamma_{opt})$	Rn
60	3,70874	0,64685	-154,158	0,20342
61	3,0649	0,59276	-147,451	0,20719
62	2,78964	0,54126	-142,217	0,21309
63	2,68006	0,50171	-137,758	0,22288
64	2,63729	0,47081	-133,558	0,23541
65	2,62446	0,44494	-129,382	0,24976
66	2,62738	0,42185	-125,145	0,26532
67	2,64007	0,40024	-120,834	0,28156
68	2,65953	0,37944	-116,459	0,29806
69	2,68379	0,35917	-112,039	0,31443
70	2,71113	0,33936	-107,59	0,33034
71	2,73998	0,32006	-103,116	0,34555
72	2,76853	0,30134	-98,6057	0,35986
73	2,79489	0,28328	-94,0303	0,37308
74	2,81768	0,26592	-89,334	0,38519
75	2,83615	0,24923	-84,436	0,39619
76	2,84979	0,23313	-79,239	0,40611
77	2,85855	0,21754	-73,6305	0,41497
78	2,86281	0,20241	-67,4779	0,42278
79	2,86293	0,18773	-60,6032	0,42952
80	2,85943	0,17359	-52,784	0,43514
81	2,85323	0,16028	-43,7656	0,43961
82	2,84538	0,14827	-33,2385	0,44286
83	2,83736	0,13833	-20,9138	0,44484
84	2,83122	0,13157	-6,67528	0,4455
85	2,82966	0,12917	9,16936	0,44479
86	2,83608	0,132	25,7278	0,44273
87	2,85408	0,14001	41,7322	0,4396
88	2,88707	0,15206	56,0046	0,43647
89	2,93833	0,16667	67,6342	0,4361
90	3,01202	0,18373	75,7542	0,44462
91	3,11865	0,20835	79,6387	0,47462
92	3,28803	0,25658	80,3994	0,55095
93	3,59414	0,35224	83,0009	0,72228
94	4,21074	0,49966	91,5323	1,09471
95	5,52557	0,66385	104,741	1,95247

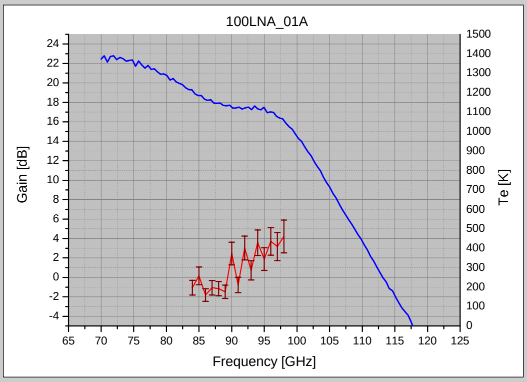
P/N	**100LNA_01A**
Rev Date	**26/6/2007**

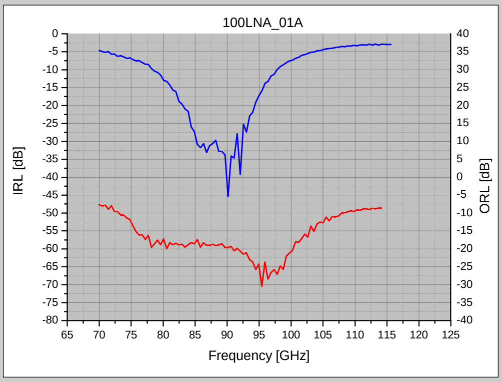


1,24	1,3	1,3	1,1
D1	**D2**	**D3**	**D4**

RF IN — **RF OUT**

G1	**G2**	**G3**	**G4**





Frequency Range	70 - 95	**BW**	25	**BW/f_o**	30%

100% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	15,9	20,3	18,1	3,5	[dB]
T_e	289	362	312	60	[K]
$\|S_{11}\|$	-15,7	-10,2	-13,2	-	[dB]
$\|S_{22}\|$	-19,8	-16,7	-17,9	4	[dB]

50% BW Performance Summary

	Value			σ	Units
	min	max	typ		
Gain	15,6	20,2	17,8	1,5	[dB]
T_e	264	344	285	50	[K]
$\|S_{11}\|$	-22,2	-13,6	-18,3	-	[dB]
$\|S_{22}\|$	-23,7	-18,9	-21,3	3	[dB]

IP_3	
Dissipation [mW]	**53**
RF Pad	Coplanar G-S-G 100 µm pitch
Bias Pad	Coplanar G-SSSS-G 200 µm pitch
Dimensions	**2.500 x 2.500 x 0.075** mm (L x W x H)
Use as	Cryogenic Front end LNA for ground-based radioastronomy applications; Uncooled LNA are also used for IRA receiver noise measurements
Particularity	4 stage separately biased LNA
N° of available samples	17/24

S-Parameters

FREQ	Re(S11)	Im(S11)	Re(S21)	Im(S21)	Re(S12)	Im(S12)	Re(S22)	Im(S22)
70,00	-0,2045	0,5608	-12,0049	1,9189	0,0096	-0,0012	0,3224	0,1569
70,48	-0,1838	0,5626	-11,6621	3,7920	0,0069	-0,0098	0,2623	0,1751
70,96	-0,1176	0,5619	-10,4995	5,1226	0,0006	-0,0005	0,3497	0,1431
71,44	-0,0604	0,5935	-9,8325	6,9731	-0,0036	-0,0116	0,3340	0,1229
71,92	-0,0714	0,5242	-8,5981	8,3062	0,0078	-0,0008	0,3185	0,0516
72,40	-0,0211	0,5242	-6,8662	9,3960	-0,0011	-0,0054	0,3047	0,0321
72,88	-0,0076	0,5142	-5,9019	10,3721	0,0025	-0,0111	0,3004	0,0192
73,36	-0,0021	0,5005	-3,7388	10,9263	-0,0031	-0,0102	0,2577	-0,0271
73,84	0,0558	0,4906	-2,2871	11,1943	0,0008	-0,0087	0,2444	-0,0049
74,32	0,0450	0,4752	-0,4912	11,4849	0,0045	-0,0132	0,2348	-0,0214
74,80	0,0706	0,4739	1,3174	11,3208	-0,0059	-0,0047	0,2152	-0,0185
75,28	0,0582	0,4525	3,0518	10,5689	-0,0060	-0,0055	0,1801	-0,0217
75,76	0,0996	0,4607	4,9326	10,3145	-0,0045	-0,0134	0,1724	0,0163
76,24	0,1149	0,4200	6,0483	8,8662	-0,0066	-0,0077	0,1538	0,0093
76,72	0,1473	0,4043	7,4023	7,6067	-0,0014	-0,0074	0,1548	0,0169
77,20	0,1407	0,3827	8,6060	6,6147	0,0004	-0,0066	0,1384	0,0452
77,68	0,1751	0,3515	8,9082	4,7080	0,0000	-0,0094	0,1477	0,0309
78,16	0,1675	0,3251	9,5493	3,3970	-0,0042	-0,0058	0,1317	0,0607
78,64	0,1889	0,2999	9,8247	2,0933	-0,0063	-0,0046	0,1529	0,0190
79,12	0,1762	0,2682	9,7080	0,4370	0,0001	-0,0047	0,1321	0,0500
79,60	0,1675	0,2342	9,5322	-1,1064	-0,0062	0,0007	0,1007	0,0303
80,08	0,1675	0,2153	9,1699	-2,4731	-0,0020	0,0005	0,1311	0,0514
80,56	0,1449	0,2003	8,1963	-3,8042	-0,0044	0,0072	0,0849	0,0419
81,04	0,1580	0,1667	7,7429	-4,8127	-0,0019	-0,0052	0,1362	0,0400
81,52	0,1514	0,1460	6,5640	-5,7363	-0,0033	-0,0049	0,1264	0,0311
82,00	0,1348	0,1352	5,4167	-6,4944	-0,0044	0,0017	0,1120	0,0353
82,48	0,1180	0,1167	4,4661	-7,0791	0,0003	-0,0021	0,1304	0,0416
82,96	0,1069	0,1079	3,3352	-7,4458	-0,0029	-0,0028	0,1272	0,0340
83,44	0,0931	0,1019	2,1082	-7,5979	-0,0031	0,0031	0,1236	0,0433
83,92	0,0831	0,1011	1,1606	-7,8452	-0,0007	-0,0030	0,1371	0,0370
84,40	0,0670	0,0876	-0,1338	-7,6155	0,0022	-0,0015	0,1393	0,0306
84,88	0,0606	0,0804	-1,0256	-7,4094	-0,0019	-0,0033	0,1285	0,0305
85,36	0,0437	0,0882	-2,0659	-7,0325	0,0011	-0,0047	0,1468	0,0310
85,84	0,0463	0,0825	-2,8184	-6,5249	-0,0017	-0,0004	0,1217	0,0285
86,32	0,0336	0,0860	-3,5923	-6,1394	-0,0053	-0,0018	0,1226	0,0370
86,80	0,0296	0,0823	-4,4304	-5,4287	-0,0026	-0,0019	0,1239	0,0328
87,28	0,0202	0,0943	-4,9668	-4,6799	0,0015	-0,0020	0,1229	0,0274
87,76	0,0185	0,0736	-5,6941	-3,9204	-0,0006	-0,0011	0,1291	0,0388
88,24	0,0181	0,0924	-5,9465	-3,2546	-0,0002	-0,0009	0,1193	0,0408
88,72	0,0158	0,0830	-6,3853	-2,1323	0,0026	0,0017	0,1360	0,0321
89,20	0,0181	0,0836	-6,5713	-1,4648	0,0020	-0,0004	0,1285	0,0340
89,68	0,0284	0,0771	-6,6199	-0,3970	-0,0053	-0,0063	0,1140	0,0420
90,16	0,0271	0,0678	-6,5647	0,5813	0,0030	-0,0025	0,1284	0,0271
90,64	0,0408	0,0494	-6,5112	1,3320	0,0043	-0,0043	0,1255	0,0273
91,12	0,0171	0,0488	-6,1128	2,4241	0,0093	-0,0071	0,1074	0,0087
91,60	0,0298	0,0265	-5,7544	3,2107	0,0018	-0,0097	0,1126	0,0159
92,08	0,0250	0,0440	-5,1545	4,1438	0,0024	-0,0098	0,0988	0,0131
92,56	0,0364	0,0177	-4,3748	4,9285	-0,0015	-0,0043	0,1012	0,0128
93,04	0,0495	0,0189	-3,5078	5,4531	-0,0024	-0,0095	0,0933	0,0107
93,52	0,0226	-0,0209	-2,4836	6,1125	0,0002	-0,0147	0,0828	0,0410
94,00	0,0484	-0,0266	-1,5220	6,1594	-0,0010	-0,0044	0,0846	0,0108

94,48	0,0161	-0,0653	-0,2239	6,3665	-0,0032	-0,0093	0,0694	0,0258
94,96	0,0349	-0,0871	0,5483	6,3557	-0,0021	-0,0086	0,0849	0,0472
95,44	-0,0131	-0,1118	1,9258	5,6589	-0,0083	-0,0081	0,0600	0,0197
95,92	-0,0299	-0,1510	2,6995	5,4805	-0,0026	-0,0100	0,0979	0,0590
96,40	-0,0628	-0,1477	3,6257	4,6501	-0,0053	-0,0011	0,0654	0,0296
96,88	-0,0931	-0,1877	4,1458	3,8003	-0,0069	-0,0008	0,0707	0,0539
97,36	-0,1332	-0,1796	4,6631	3,0166	-0,0064	-0,0058	0,0863	0,0528
97,84	-0,1866	-0,2002	4,9832	1,9980	-0,0050	-0,0003	0,0558	0,0633
98,32	-0,2220	-0,2048	5,0105	1,0925	-0,0049	-0,0013	0,0790	0,0651
98,80	-0,2741	-0,1786	4,9426	0,2134	-0,0081	0,0001	0,0640	0,0697
99,28	-0,3125	-0,1694	4,6514	-0,6243	-0,0120	-0,0041	0,0842	0,0785
99,76	-0,3438	-0,1523	4,2537	-1,3250	-0,0096	-0,0017	0,0729	0,0955
100,24	-0,3787	-0,1227	3,7766	-1,8744	-0,0061	-0,0005	0,0924	0,1028
100,72	-0,4116	-0,1120	3,2430	-2,3214	-0,0105	-0,0014	0,0914	0,1191
101,20	-0,4232	-0,0834	2,6987	-2,6663	-0,0096	0,0021	0,0958	0,1194
101,68	-0,4706	-0,0510	2,1030	-2,8638	-0,0076	0,0019	0,1057	0,1326
102,16	-0,4790	-0,0325	1,5415	-2,9563	-0,0035	0,0022	0,1204	0,1517
102,64	-0,5117	0,0188	0,9954	-2,9928	-0,0066	-0,0004	0,1303	0,1253
103,12	-0,5289	0,0389	0,5162	-2,9224	-0,0054	0,0002	0,1564	0,1760
103,60	-0,5313	0,0899	0,0492	-2,7880	-0,0055	0,0021	0,1632	0,1313
104,08	-0,5490	0,1208	-0,3315	-2,5918	-0,0026	0,0040	0,1844	0,1748
104,56	-0,5504	0,1503	-0,6481	-2,3514	-0,0053	-0,0006	0,2120	0,1541
105,04	-0,5608	0,1953	-0,9108	-2,1066	-0,0012	-0,0003	0,2122	0,1476
105,52	-0,5604	0,2296	-1,1141	-1,8477	-0,0025	0,0015	0,2629	0,1429
106,00	-0,5563	0,2634	-1,2868	-1,5756	-0,0031	0,0013	0,2444	0,1167
106,48	-0,5558	0,3003	-1,3737	-1,3029	-0,0009	-0,0003	0,2794	0,1257
106,96	-0,5499	0,3246	-1,4476	-1,0391	-0,0009	0,0026	0,2810	0,1072
107,44	-0,5422	0,3655	-1,4714	-0,8110	-0,0048	0,0002	0,2889	0,0970
107,92	-0,5343	0,3942	-1,4804	-0,5509	-0,0001	0,0000	0,3214	0,0791
108,40	-0,5109	0,4202	-1,4582	-0,3621	0,0022	0,0010	0,3245	0,0632
108,88	-0,5024	0,4599	-1,3914	-0,1201	-0,0002	-0,0069	0,3316	0,0454
109,36	-0,4808	0,4722	-1,3292	0,0146	-0,0017	-0,0041	0,3482	0,0201
109,84	-0,4711	0,5193	-1,2454	0,2191	0,0040	-0,0041	0,3347	0,0077
110,32	-0,4451	0,5240	-1,1308	0,3290	0,0049	-0,0062	0,3526	-0,0185
110,80	-0,4221	0,5581	-1,0170	0,4521	0,0030	-0,0035	0,3422	-0,0297
111,28	-0,4190	0,5695	-0,8790	0,5488	0,0000	-0,0082	0,3537	-0,0456
111,76	-0,3741	0,5962	-0,7731	0,5817	-0,0007	0,0003	0,3562	-0,0689
112,24	-0,3771	0,6142	-0,6216	0,6682	-0,0041	-0,0053	0,3434	-0,0704
112,72	-0,3416	0,6201	-0,5516	0,6592	-0,0035	-0,0063	0,3520	-0,1140
113,20	-0,3350	0,6491	-0,4030	0,6992	-0,0069	-0,0065	0,3387	-0,1117
113,68	-0,2983	0,6444	-0,3421	0,6859	-0,0074	-0,0079	0,3348	-0,1492
114,16	-0,2806	0,6750	-0,2024	0,6899	-0,0034	-0,0047	0,3235	-0,1653
114,64	-0,2608	0,6891	-0,1409	0,6772	-0,0074	-0,0052	0,3191	-0,1698
115,12	-0,2312	0,6843	-0,0407	0,6523	-0,0014	0,0152	0,2997	-0,2234
115,60	-0,2240	0,6879	0,0271	0,6118	-0,0059	0,0022	0,2757	-0,2094
116,08	-0,1925	0,7041	0,1008	0,5703	-0,0071	0,0062	0,2600	-0,2511
116,56	-0,1885	0,6975	0,1495	0,5309	-0,0114	0,0191	0,2659	-0,2268
117,04	-0,1458	0,6970	0,2136	0,4846	0,0492	-0,0091	0,2518	-0,2438
117,52	-0,0997	0,7939	0,2241	0,4342	-0,0378	0,0463	0,2701	-0,2889
118,00	-0,3544	0,7116	0,2570	0,3729	-0,0559	-0,0637	0,2272	-0,3401

Noise Parameters

Freq [GHz]	NFmin [dB]	$\lvert\Gamma_{opt}\rvert$	$\varphi(\Gamma_{opt})$	Rn
70	2,32808	0,62866	-171,897	0,07234
71	2,34051	0,61647	-168,172	0,08161
72	2,36121	0,6032	-164,426	0,09324
73	2,3898	0,58895	-160,657	0,10701
74	2,4258	0,5738	-156,862	0,1227
75	2,468	0,55777	-153,052	0,14006
76	2,51455	0,54094	-149,246	0,1587
77	2,56485	0,52342	-145,449	0,17837
78	2,61862	0,50527	-141,658	0,19888
79	2,67518	0,48651	-137,877	0,21999
80	2,73374	0,46718	-134,113	0,24143
81	2,7936	0,44734	-130,373	0,26293
82	2,8541	0,42699	-126,663	0,28424
83	2,91475	0,40617	-122,99	0,30512
84	2,97511	0,38493	-119,36	0,32533
85	3,03493	0,3633	-115,787	0,34466
86	3,09411	0,34136	-112,282	0,36293
87	3,15251	0,31921	-108,856	0,38002
88	3,20921	0,29683	-105,514	0,39575
89	3,26308	0,27415	-102,282	0,40975
90	3,31437	0,25121	-99,2199	0,42183
91	3,36369	0,22822	-96,394	0,43198
92	3,41128	0,20532	-93,8853	0,4402
93	3,45726	0,18271	-91,8072	0,4465
94	3,50176	0,16063	-90,3225	0,45097
95	3,54487	0,13938	-89,6653	0,45373
96	3,58672	0,11937	-90,1657	0,455
97	3,62764	0,10115	-92,2677	0,45509
98	3,66834	0,0854	-96,4936	0,45446
99	3,70981	0,07293	-103,233	0,45369
100	3,7533	0,06439	-112,258	0,45348
101	3,80007	0,05973	-122,319	0,45458
102	3,85103	0,05786	-131,885	0,45761
103	3,90633	0,05716	-140,386	0,46287
104	3,96555	0,0564	-148,612	0,47021
105	4,02891	0,05548	-158,059	0,47917
106	4,09867	0,05567	-169,902	0,48943
107	4,17897	0,05917	176,178	0,5009
108	4,27245	0,0685	162,41	0,51314
109	4,37663	0,08573	151,7	0,52403
110	4,49013	0,11124	145,609	0,53115
111	4,62419	0,14318	143,325	0,5354
112	4,80662	0,17981	142,993	0,54215
113	5,0786	0,22243	143,309	0,55807
114	5,44824	0,27552	145,208	0,57504
115	5,82499	0,33587	150,842	0,56008
116	6,16967	0,39324	159,13	0,51168
117	6,56021	0,444	168,04	0,46303
118	7,05353	0,48754	176,93	0,44003

4 - TestBenches description

In this chapter we will describe with more details, the testing facilities and the instruments setup. We will also introduce accuracy and uncertainty. For the noise Temperature, where accurate results are harder to obtain, we will explain how these terms have been included in the measurement report in order to interpret correctly measurement results. The aim of this campaign, as anticipated, wasn't the extreme accuracy but the high volume of measurements in order to classify the working MMIC. Anyway, the definition of the accuracy is important for a correct measurement results understanding.

4.1 - 4-50 GHz S-parameter setup

This setup doesn't present any particular difficulties. SOLT is the calibration method which have been used, performed over two different frequency ranges: from 1 to 10 GHz, for the devices Table 2.2 a,b and from 20 to 50 GHz for the Table 2.2 c,d,e. The provided cal-kit was particularly damaged and the first set of data collected present an unacceptable ripple. Next tentative, more harmful for the cal-kit "health" conditions, worked better. Used equipment are listed in table 4.1.1 then the measurement setup conditions are reported in table 4.1.2.

	Model	**SN**
VNA	HP8510	
Probe In	GGB 67A GSG 200P	29982
Probe Out	GGB 67A GSG 200P	30701
Cable RF In	Gore 4FOBCOBXO34.03GW4O	03977029
Cable RF Out		03977028

Table 4.1.1 – 4 to 50 GHz S-parameter setup components

Calibration SOLT		
Frequency Range	**1-10 GHz**	**20-50 GHz**
N° of Points	51	51
Cal Power	10 dBm	10 dBm
Meas. Power	-5 dBm	-5 dBm
Attenuation P1	20 dB	20 dB
Attenuation P2	0 dB	0 dB
Power Slope	0.1 dB/GHz	0.1 dB/GHz

Table 4.1.2 – 4 to 50 GHz Setup settings

4.2- 78-118 GHz S-parameter setup

This setup is a little more difficult than the previous one. In order to extend the VNA 8510 frequency range, external millimetric test-set extension has been used. To drive the internal components of this extension a secondary Frequency synthesizer is necessary. Because elements that compose the test set have active devices inside, the relationship between realised output power at B, C and D and the nominal Power A displayed on the 8510 is not a simple offset where

$$PWR_A = PWR_{B/C/D} + b \qquad (4)$$

Rather the observed relationship is

$$PWR_A = m_1 \cdot PWR_{B/C/D} + m_2 \cdot freq + b \qquad (5)$$

$$m_1 > 1 \quad m_2 > 1$$

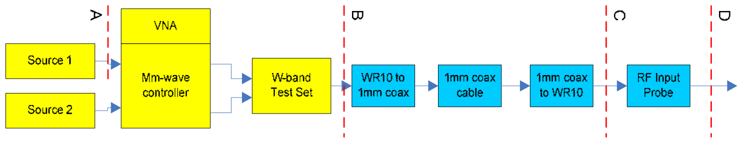


Fig 4.2.1 – RF input setup with WR10 mmWave extension

Linear regressions were estimated using measured data. The data consisted of measured power at C when source 1 nominal power ranged from -30 to -50 dBm. The usable "RF Level DUT IN" range is from -23 to -14 dBm. The measurement dynamic range is heavily compromised but this avoid test set components saturation or damaging. Calibration details are listed below. LNA measures are not in compression but not so far as we'd like. This choice seems to be the best compromise between calibration accuracy, measurement ripple and compression

	Model	SN
VNA	HP8510	
Millimeter Test set Extension		
Probe In	GGB 120 GSG 100 BT	
Probe Out	GGB 120 GSG 100 BT	
Cable RF In		
Cable RF Out		

Table 4.2.1 – 78 to 118 GHz S-parameter setup components

Calibration SOLT	
Frequency Range	70-118 GHz
N° of Points	101
Cal Power	-30 dBm
Meas. Power	-47 dBm
Attenuation P1	0 dB
Attenuation P2	0 dB
Power Slope	0 dB/GHz

Table 4.2.1 – 78 to 118 GHz Setup settings

4.3 - 26-39 Noise Temperature setup

This setup have been used to characterise the MMIC of the table 2.2.c,d,e. It is represented in figure 4.3.1 and the components are listed in table 4.3.1. The frequency range move from 26 to 39 GHz. The NFM extension, built by C-TIP allows to test the noise up to 39 GHz. In order to increase the measurement accuracy we applied some useful tricks. We have to improve the noise source matching, and take into account the losses in the probes. The effective ENR must be translated (Fig 4.3.6), moving the NS reference plane on the RF input probetips, using the equation:

$$ENR(dB) = ENR_{NS}(dB) + G_{av_{PROBES}}(dB) + G_{av_{6DbPAD}}(dB) \quad (6)$$

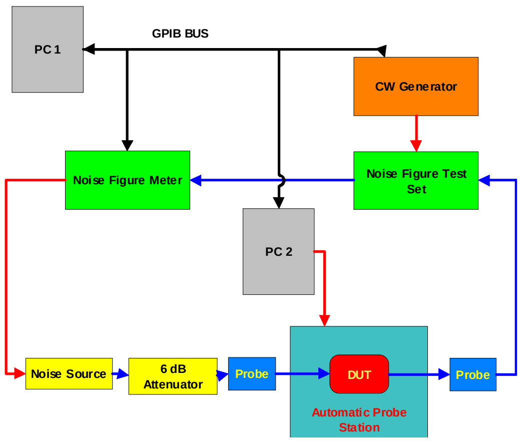


Figure 4.3.1 - Noise Measurement setup

	Model	SN
NFM	HP8970	
Noise Source	346C-K01	3328A04559
Attenuator	Wiltron 41V-6	960061
40 GHz NFM ext.		
Probe In	GGB 67A GSG 200P	29982
Probe Out	GGB 67A GSG 200P	30701
Cable RF Out		

Table 4.3.1 – 26 to 39 GHz Noise setup components

In order to correctly translate the Noise source reference plane, the available gain of the input RF probe and the 6dB precision attenuator should be calculated. We used the insertion loss instead of the available gain because the software to calculate the available gain weren't fixed. We will demonstrate that the introduced error is negligible where the matching if higher.

$$ENR(dB) = ENR_{NS}(dB) + S_{21_{PROBES}}(dB) + S_{21_{6DbPAD}}(dB) \quad (7)$$

Probe available gain, based on the reflecting coefficients indicated in fig. 3.2.2, is calculated using the equation that follows

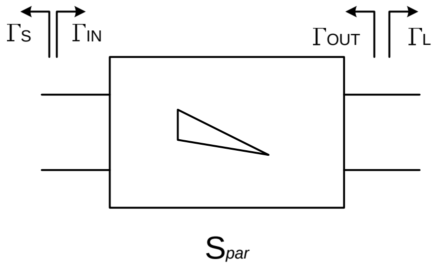


Fig 4.3.2 – Probe block and reflecting coefficient definition

$$G_{av}^{PROBE}(dB) = \left|S_{21}^{PROBE}\right|^2 \cdot \frac{1-\left|\Gamma_s\right|^2}{\left|1-\Gamma_s \cdot S_{11}^{PROBE}\right| \cdot \left(1-\left|\Gamma_{OUT}\right|^2\right)}$$

$$\Gamma_{OUT} = S_{22}^{PROBE} + \frac{S_{21}^{PROBE} \cdot S_{12}^{PROBE} \cdot \Gamma_s}{1-\Gamma_s \cdot S_{11}^{PROBE}} \qquad (8)$$

during probe characterisation (probe input port connected to the VNA) as well as measurements (input port connected to a matched noise source) $\Gamma_S \cong 0$, then $\Gamma_{OUT} = S_{22}^{PROBE}$ expression could be so simplified

$$G_{av}^{PROBE}(dB) = \left|S_{21}^{PROBE}\right|^2 \cdot \frac{1-\left|\Gamma_s\right|^2}{\left|1-\Gamma_s \cdot S_{11}^{PROBE}\right| \cdot \left(1-\left|S_{22}^{PROBE}\right|^2\right)} \qquad (9)$$

It is clear that probe S-parameters are necessary. These are indirectly calculated by solving an equation system based on the gamma in measurements when the probetips are connected to the calibration standards, OPEN, SHORT and LOAD

$$\begin{cases} \Gamma_{IN}^{OPEN} = S_{11_{PROBE}} + \dfrac{S_{21_{PROBE}} \cdot S_{12_{PROBE}} \cdot \Gamma_L^{OPEN}}{1-\Gamma_L^{OPEN} \cdot S_{22_{SONDA}}} \\ \Gamma_{IN}^{SHORT} = S_{11_{PROBE}} + \dfrac{S_{21_{PROBE}} \cdot S_{12_{PROBE}} \cdot \Gamma_L^{SHORT}}{1-\Gamma_L^{SHORT} \cdot S_{22_{PROBE}}} \\ \Gamma_{IN}^{LOAD} = S_{11_{PROBE}} + \dfrac{S_{21_{PROBE}} \cdot S_{12_{PROBE}} \cdot \Gamma_L^{LOAD}}{1-\Gamma_L^{LOAD} \cdot S_{22_{PROBE}}} \end{cases} \tag{10}$$

If properly inverted and the probe could be considered like a reciprocal network ($S_{21_{PROBE}} \cong S_{12_{PROBE}}$) we can define the available gain. The equation system is shown below

$$\begin{cases} S_{11_{PROBE}} = \Gamma_{IN}^{LOAD} + \dfrac{S_{21_{PROBE}} \cdot S_{12_{PROBE}}}{1-\Gamma_L^{OPEN}} \\ S_{22_{PROBE}} = \dfrac{\left(\dfrac{\Gamma_{IN}^{SHORT} - S_{11_{PROBE}}}{\Gamma_L^{SHORT}} - \dfrac{\Gamma_{IN}^{OPEN} - S_{11_{PROBE}}}{\Gamma_L^{OPEN}} \right)}{\Gamma_{IN}^{SHORT} - \Gamma_{IN}^{OPEN}} \\ S_{21_{PROBE}} \cdot S_{12_{PROBE}} = \dfrac{\Gamma_{IN}^{SHORT} - S_{11_{PROBE}}}{\Gamma_L^{SHORT}} + S_{22_{PROBE}} \cdot (S_{11_{PROBE}} - \Gamma_{IN}^{SHORT}) \end{cases} \tag{11}$$

We will get Γ_L^{OPEN}, Γ_L^{SHORT}, Γ_L^{LOAD} from the calibration kit datasheet and collect Γ_{IN}^{OPEN}, Γ_{IN}^{SHORT}, Γ_{IN}^{LOAD} from the S_1P probe measurements, reported in fig 4.3.3, with the VNA reference plane at the probe input (fig 4.3.3).

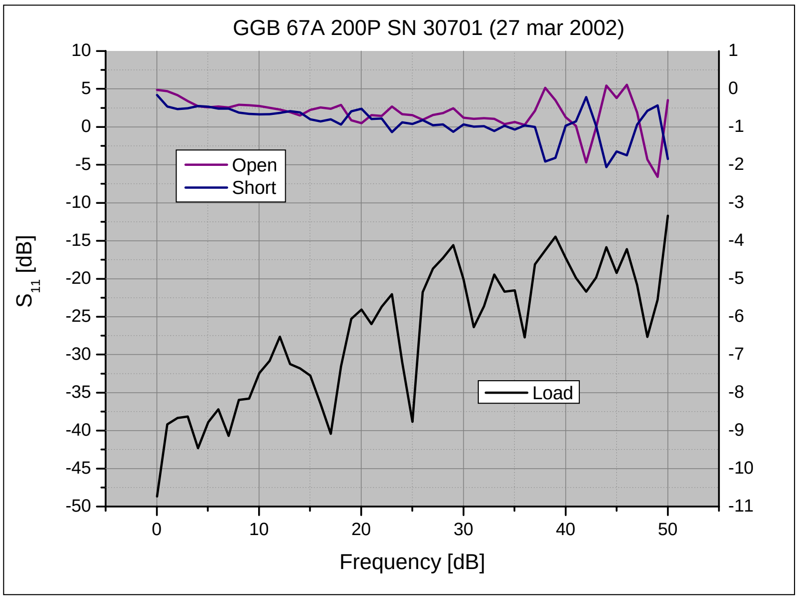


Fig 4.3.3 – Probe S_1p standard measurements

It is widely demonstrated, by the results reported in graphs (fig 4.3.4 for the probes, and fig 4.3.5 for the attenuator), that for a moderate accuracy measurement campaign, if the elements which compose the test setup are well matched, we can approximate the Available Gain with the Insertion Loss. Following the scheme in fig 4.3.6 the ENR table used for the measurements is listed in table 4.3.2, where the unadjusted ENR table, pad attenuator values and probe losses come from the manufacturer datasheets

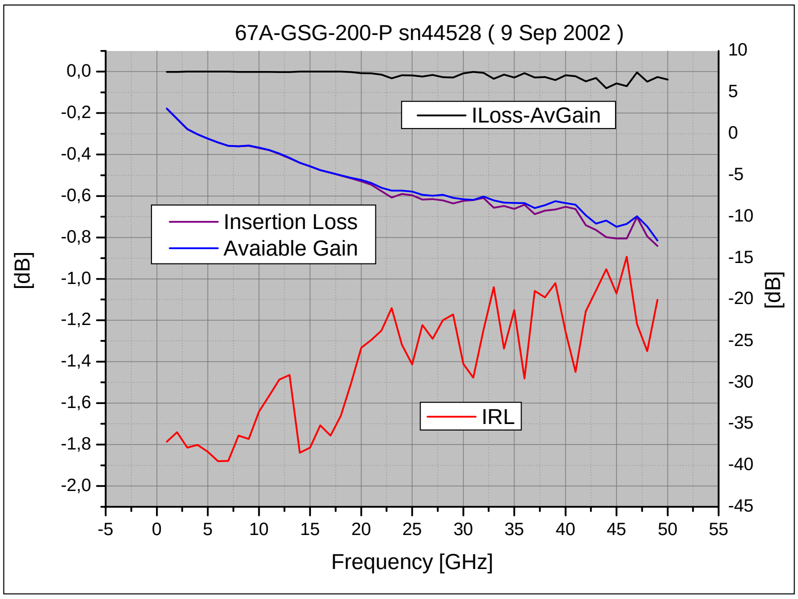


Fig 4.3.4 – Input probe IL vs G_{AV} comparison

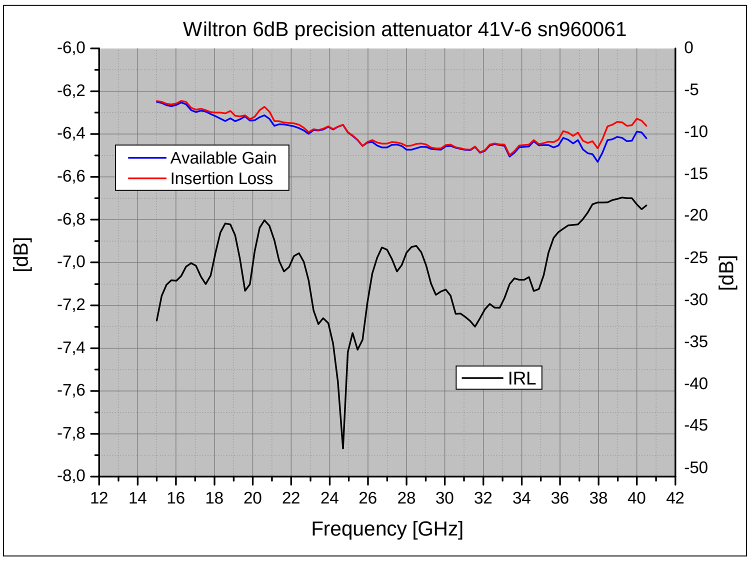


Fig 4.3.5 – 6dB attenuator Pad IL vs G_{AV} comparison

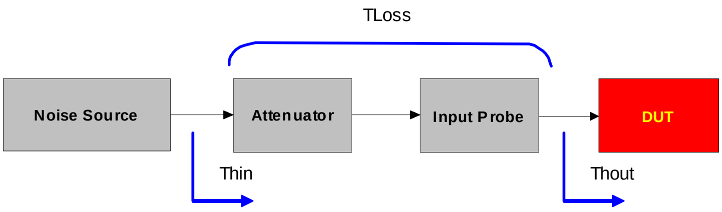


Fig 4.3.6 – ENR translation description

Frequency [GHz]	Unadjusted NS ENR [dB]	Precision Pad insertion loss [dB]	RF INPUT probe losses [dB]	Adjusted ENR [dB]
26	12,52	6,39	0,57	**5,56**
27	12,16	6,39	0,58	**5,19**
28	11,76	6,43	0,58	**4,75**
29	11,47	6,41	0,59	**4,47**
30	11,33	6,44	0,60	**4,29**
31	11,39	6,46	0,60	**4,33**
32	11,39	6,43	0,61	**4,35**
33	11,45	6,44	0,62	**4,39**
34	11,42	6,45	0,62	**4,35**
35	11,41	6,41	0,63	**4,37**
36	11,43	6,41	0,64	**4,38**
37	11,38	6,43	0,64	**4,31**
38	11,30	6,43	0,65	**4,22**
39	11,23	6,39	0,66	**4,18**
40	11,08	6,40	0,67	**4,01**

Table 4.3.2 – 26 to 40 GHz ENR translation

4.4 - 75-98 Noise temperature setup

In order to characterise the noise performances of the devices of table 2.2 f,g we have set up a W-band test bench (schematically described in Fig 4.4.1). Compared with the previous one it looks identical from the conceptual point of view. Major changes are the noise source, the receiver, which extend over the W-band the 8970 measurement capabilities and the 100 um pitch probes. These components are all WR10 waveguide flanged and optimized for this frequency range. The waveguide isolator is used to improve the noise source match as well as the precision attenuator used in the 26 to 39 setup. In order to match the 8970 dynamic range, to measure the 100LNA_01A, a 10dB attenuator pad has been connected between the receiver and the NFM. For the same reason, to measure the 86LNA_01A a 20dB attenuator pad has been used. Table 4.4.1 is a component list. Fig. 4.4.3 a,b are pictures of the setup.

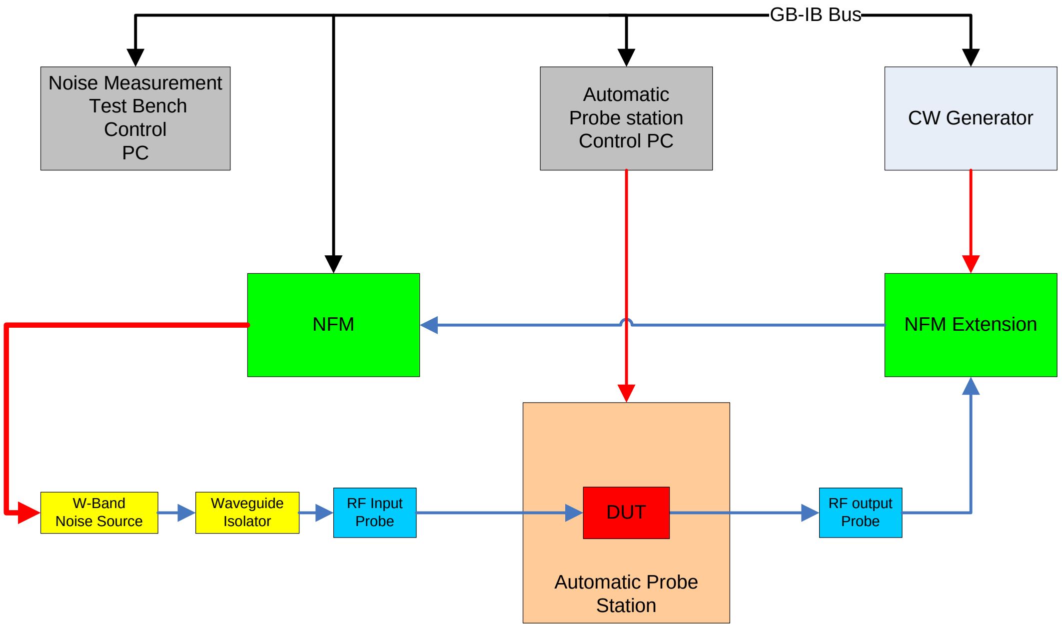


Fig. 4.4.1 – Wband Noise setup description

	Model	SN
NFM	HP8970	
Noise Source	Noise/COM NC5110 opt 5	K314
Isolator	Dorado FI-10	147
70-100 GHz NFM ext.	Millitech	
Probe In	GGB 120 GSG 100BT	15160
Probe Out	GGB 120 GSG 100BT	8402

Table 4.4.1 – 75 to 98 GHz Noise setup components

Adopting the same principles developed in the previous paragraph, we will move the reference plane forward to the probetips as described in Fig. 4.4.2. The components value table 4.3.2 has been collected by the datasheets provided by the manufacturer. We have estimated a 0.2 dB losses for the waveguide bend between the isolator and the probe (fig. 4.4.3-a).

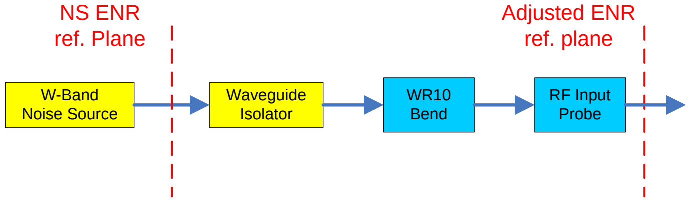


Fig 4.4.2 – Wband ENR translation

Frequency [GHz]	Unadjusted NS ENR [dB]	Pad insertion loss [dB]	RF INPUT probe losses [dB]	Bend Losses (estimated)	Adjusted ENR [dB]
75,00	17,70	1,95	0,56	0,20	**14,99**
76,00	17,73	1,95	0,60	0,20	**14,98**
77,00	18,93	1,88	0,62	0,20	**16,23**
78,00	18,68	1,80	0,63	0,20	**16,05**
79,00	18,62	1,73	0,63	0,20	**16,06**
80,00	19,10	1,66	0,63	0,20	**16,61**
81,00	18,44	1,64	0,62	0,20	**15,98**
82,00	18,20	1,60	0,60	0,20	**15,80**
83,00	17,82	1,54	0,58	0,20	**15,50**
84,00	17,62	1,46	0,56	0,20	**15,40**
85,00	17,15	1,40	0,54	0,20	**15,01**
86,00	16,25	1,36	0,52	0,20	**14,17**
87,00	15,68	1,30	0,50	0,20	**13,68**
88,00	15,60	1,25	0,47	0,20	**13,68**
89,00	15,05	1,22	0,45	0,20	**13,18**
90,00	15,40	1,25	0,44	0,20	**13,51**
91,00	14,43	1,30	0,42	0,20	**12,51**
92,00	14,43	1,34	0,41	0,20	**12,48**
93,00	14,20	1,34	0,40	0,20	**12,26**
94,00	13,50	1,35	0,39	0,20	**11,56**
95,00	13,74	1,34	0,39	0,20	**11,81**
96,00	12,90	1,34	0,39	0,20	**10,97**
97,00	13,22	1,36	0,39	0,20	**11,27**
98,00	12,41	1,35	0,39	0,20	**10,47**

Table 4.3.2 – 75 to 98 GHz ENR translation

a b

Fig. 4.4.3 – Wband noise setup

4.4 Uncertainty and accuracy

In order to provide more exhaustive noise measurements information and clarify the results, it is necessary to define an error bar. It should include all the terms which have influences on the absolute value. It takes into account the noise measurement system, which include the noise source, the DUT, the noise receiver and the system architecture. Duncan Boyd suggested a quite flexible uncertainty model. All the aspects related to the accuracy aren't explicitly considered by this model and have been briefly discussed in the previous paragraphs. This model associate a measurement uncertainty to a particular NF value based on the knowledge of VSWR's of the elements which composes the measurement system. Model accuracy is related to a reasonable DUT reverse isolation.

After the system calibration we record some data:

F1 : DUT Noise factor
G1 : DUT gain
F2 : Uncorrected test receiver Noise factor

The general equation for the noise figure of two cascaded stages is:

$$F_{12} = F_1 + \frac{F_2 - 1}{G_1} \qquad (12)$$

Because we are interested to estimate DUT NF uncertainty, F1, it will be rearranged

$$F_1 = F_{12} - \frac{F_2 - 1}{G_1} \tag{13}$$

Applying Taylor theorem to the previous equation we can find the F1 uncertainty

$$\delta F_1 = \frac{\partial F_1}{\partial F_{12}} \cdot \delta F_{12} + \frac{\partial F_1}{\partial F_2} \cdot \delta F_2 + \frac{\partial F_1}{\partial G_1} \cdot \delta G_1 \tag{14}$$

the coefficient will be solved and results are

$$\begin{cases} \dfrac{\partial F_1}{\partial F_{12}} = 1 \\ \dfrac{\partial F_1}{\partial F_2} = -\dfrac{1}{G_1} \\ \dfrac{\partial F_1}{\partial G_1} = \dfrac{F_2 - 1}{G_1^{\,2}} \end{cases} \tag{15}$$

so that

$$\delta F_1 = \delta F_{12} - \frac{1}{G_1} \cdot \delta F_2 + \frac{F_2 - 1}{G_1^{\,2}} \cdot \delta G_1 \tag{16}$$

because generally units is logarithmic decibel, or dB the expression become

$$\delta NF_1 = \frac{F_{12}}{F_1} \delta NF_{12} - \frac{F_2}{F_1 \cdot G_1} \cdot \delta NF_2 + \frac{F_2 - 1}{F_1 \cdot G_1} \cdot \delta G_1 (dB) \tag{17}$$

ENR uncertainty doesn’t explicitly appear in the equation but it is clear that there is an uncertainty associated with the ENR and this will contribute to the overall uncertainty

The δENR only influences the first two terms in the previous equation

$$\left(\frac{F_{12}}{F_1} - \frac{F_2}{F_1 \cdot G_1}\right) \cdot \delta ENR \qquad (18)$$

Since the causes of the uncertainties in the four δ factors are different, the terms can be combined in a root-sum-of-squares (RSS) fashion, which provides a realistic overall uncertainty value. The equation for the overall NF uncertainty is therefore:

$$\delta NF = \left\{ \left[\left(\frac{F_{12}}{F_1} \right) \cdot \delta NF_{12} \right]^2 + \left[\frac{F_2}{F_1 \cdot G_1} \cdot \delta NF_2 \right]^2 + \left[\frac{F_2 - 1}{F_1 \cdot G_1} \cdot \delta G_1(dB) \right]^2 + \left[\left(\frac{F_{12}}{F_1} - \frac{F_2}{F_1 \cdot G_1} \right) \cdot \delta ENR \right]^2 \right\}^{0.5} \qquad (19)$$

One of the most significant parameters affecting the uncertainties in is δENR, the uncertainty of the noise source. For best uncertainty when measuring low-noise devices, low ENR sources should be used. This results in a lower δInstrumentNF since the low ENR exercises less of the measurement detector’s dynamic range. There is a further advantage for using a low-ENR source in that its impedance is more constant between the on and off states. This is because a low ENR source (with ENR of typically 5 dB) is basically a high-ENR source (with ENR of typically 15 dB) with an additional attenuator. Our measurement system wasn’t provided of a low-ENR noise source. In order to reduce the ENR value down to match the detector dynamic range and improve the isolation a 6dB attenuator pad has been used in a 26 to 39 GHz system. then a waveguide isolator has been used in the 75 to 98 GHz. The suggested model doesn’t take into account attenuator/isolator and input probe uncertainty. We consider the insertion losses of these components and move forward the reference plane to the probetips. this operation increase the ENR uncertainty but measurements are more accurate. As demonstrate in the previous paragraph, if chain components are very well isolated, error introduced by using the insertion loss instead of the available gain are negligible. More relevant is the uncertainty introduced by the attenuator/isolator and input probe, because they aren’t considered in the model and just only estimated within ENR uncertainty. Hence the overall estimated NF uncertainty is a best case. Real condition would require wider error bars. Estimated Uncertainty spreadsheet are listed in table 4.5.1-5

From tables 4.5.2-6 we calculate the percentage relative uncertainty showed in table 4.5.1. It is clear the relevance of this factor when we consider ultra low noise devices. Uncertainty weight decrease while the frequency raise. Even if an high uncertainty value can be unacceptable at room temperature, it become a paradox at cryogenic temperature, because in first approximation, uncertainty is a temperature invariant.

$\frac{U(Te)}{Te}\cdot 100$				
32LNA_01A	32LNA_02A	43LNA_01A	86LNA_01A	100LNA_01A
42 %	44 %	31 %	23 %	19 %
42 %	42 %	32 %	23 %	18 %
34 %	34 %	29 %	22 %	20 %
34 %	34 %	34 %	24 %	19 %
32 %	32 %	35 %	25 %	19 %
32 %	32 %	36 %	20 %	20 %
31 %	31 %	32 %	24 %	16 %
30 %	30 %		24 %	19 %
30 %	30 %		23 %	15 %
28 %	29 %		23 %	17 %
32 %	33 %		21 %	15 %
33 %	34 %		26 %	17 %
34 %	35 %		26 %	16 %
30 %	30 %		28 %	18 %
			33 %	18 %
			25 %	

Table 4.5.1 – Percentage Relative Uncertainty

	DUT NF			Instrument NF			DUT GAIN		Combined NF						match								Uncertainties				Uncert NS-DUT IN			Uncert NS-NFA			Uncert DUT OUT-NFA							
Freq	F1	Linear	Kelvin	F2	Linear	Kelvin	G1	Linear	F12	Linear	F12/F1	F2/F1G1	(F2-1)/ F1G1	(F12/F1)-(F2/F1G1)	NS	Refl Coef	DUT Input	Refl Coef	DUT Output	Refl Coef	NF Ric	Refl Coef	Instrument NF	Instrument Gain	Noise Source ENR *		Negative	Positive	Max	Negative	Positive	Max	Negative	Positive	Max	U (NF12)	U (NF2)	U (G1)	U [dB]	U [K]
26,00	1,85	1,531	154	7	5,012	1163	32,6	1814	1,53	1,856	1,212	0,002	0,001	1,211	-26,8	0,046	-0,89	0,902	-8,60	0,371	**-18,0**	0,126	0,10	0,15	0,331	0,000	0,365	0,351	0,365	0,050	0,050	0,050	0,416	0,397	0,416	0,377	0,112	0,554	**0,60**	**65,4**
27,00	1,58	1,439	127	7	5,012	1163	32,6	1806	1,44	1,587	1,103	0,002	0,002	1,101	-25,1	0,056	-3,58	0,662	-8,63	0,370	**-18,0**	0,126	0,10	0,15	0,345	0,000	0,327	0,315	0,327	0,061	0,061	0,061	0,414	0,396	0,414	0,341	0,117	0,531	**0,53**	**53,6**
28,00	1,77	1,503	146	7	5,012	1163	31,5	1403	1,51	1,778	1,183	0,002	0,002	1,181	-24,3	0,061	-9,37	0,340	-9,08	0,352	**-18,0**	0,126	0,10	0,15	0,344	0,000	0,181	0,178	0,181	0,067	0,066	0,067	0,393	0,376	0,393	0,206	0,120	0,444	**0,47**	**49,6**
29,00	1,73	1,489	142	7	5,012	1163	30,6	1144	1,49	1,740	1,168	0,003	0,002	1,165	-25,9	0,051	-13,3	0,217	-10,1	0,313	**-18,0**	0,126	0,10	0,15	0,372	0,000	0,097	0,096	0,097	0,056	0,055	0,056	0,349	0,335	0,349	0,138	0,114	0,377	**0,46**	**48,2**
30,00	1,51	1,416	121	7	5,012	1163	29,9	983	1,42	1,522	1,075	0,004	0,003	1,072	-28,7	0,037	-19,3	0,109	-10,9	0,284	**-18,0**	0,126	0,10	0,15	0,352	0,000	0,035	0,035	0,035	0,040	0,040	0,040	0,316	0,305	0,316	0,106	0,108	0,334	**0,39**	**38,8**
31,00	1,44	1,393	114	7	5,012	1163	29,7	933	1,40	1,453	1,043	0,004	0,003	1,039	-32,0	0,025	-17,6	0,132	-12,4	0,239	**-18,0**	0,126	0,10	0,15	0,345	0,000	0,029	0,029	0,029	0,028	0,027	0,028	0,265	0,257	0,265	0,104	0,104	0,285	**0,37**	**36,2**
32,00	1,52	1,419	122	7	5,012	1163	29,7	928	1,42	1,533	1,080	0,004	0,003	1,077	-31,1	0,028	-14,9	0,180	-13,6	0,208	**-18,0**	0,126	0,10	0,15	0,337	0,000	0,044	0,044	0,044	0,031	0,031	0,031	0,230	0,225	0,230	0,109	0,104	0,255	**0,38**	**37,6**
33,00	1,74	1,493	143	7	5,012	1163	29,9	980	1,50	1,752	1,174	0,003	0,003	1,170	-29,7	0,033	-11,6	0,263	-14,2	0,195	**-18,0**	0,126	0,10	0,15	0,332	0,000	0,075	0,074	0,075	0,036	0,036	0,036	0,216	0,211	0,216	0,124	0,106	0,250	**0,41**	**43,1**
34,00	1,74	1,493	143	7	5,012	1163	30,1	1021	1,50	1,751	1,173	0,003	0,003	1,170	-27,5	0,042	-11,1	0,279	-12,8	0,228	**-18,0**	0,126	0,10	0,15	0,323	0,000	0,102	0,101	0,102	0,046	0,046	0,046	0,253	0,246	0,253	0,142	0,110	0,292	**0,41**	**42,9**
35,00	1,91	1,552	160	7	5,012	1163	30,1	1031	1,56	1,921	1,237	0,003	0,003	1,234	-27,0	0,045	-10,9	0,285	-11,6	0,262	**-18,0**	0,126	0,10	0,15	0,307	0,000	0,111	0,110	0,111	0,049	0,049	0,049	0,292	0,282	0,292	0,149	0,111	0,329	**0,42**	**45,4**
36,00	1,84	1,528	153	7	5,012	1163	29,9	978	1,53	1,852	1,212	0,003	0,003	1,209	-21,5	0,084	-11,7	0,260	-10,5	0,300	**-18,0**	0,126	0,10	0,15	0,320	0,000	0,193	0,189	0,193	0,093	0,092	0,093	0,335	0,322	0,335	0,216	0,136	0,404	**0,46**	**49,6**
37,00	1,82	1,521	151	7	5,012	1163	29,4	861	1,53	1,833	1,206	0,004	0,003	1,202	-20,3	0,096	-13,2	0,218	-9,40	0,339	**-18,0**	0,126	0,10	0,15	0,336	0,000	0,184	0,181	0,184	0,106	0,105	0,106	0,379	0,363	0,379	0,209	0,145	0,439	**0,47**	**50,4**
38,00	1,91	1,552	160	7	5,012	1163	29,1	820	1,56	1,924	1,239	0,004	0,003	1,235	-18,4	0,121	-15,6	0,165	-8,89	0,360	**-18,0**	0,126	0,10	0,15	0,347	0,000	0,175	0,172	0,175	0,133	0,131	0,133	0,402	0,385	0,402	0,201	0,166	0,462	**0,49**	**53,7**
39,00	1,86	1,535	155	7	5,012	1163	28,5	714	1,54	1,876	1,222	0,005	0,004	1,218	-17,7	0,130	-21,2	0,087	-7,59	0,417	**-18,0**	0,126	0,10	0,15	0,328	0,000	0,098	0,097	0,098	0,143	0,141	0,143	0,469	0,445	0,469	0,139	0,174	0,505	**0,43**	**46,4**

Table 4.5.2 – 32LNA_01A Uncertainty

	DUT NF			Instrument NF			DUT GAIN		Combined NF						match								Uncertainties				Uncert NS-DUT IN			Uncert NS-NFA			Uncert DUT OUT-NFA							
Freq	F1	Linear	Kelvin	F2	Linear	Kelvin	G1	Linear	F12	Linear	F12/F1	F2/F1G1	(F2-1)/ F1G1	(F12/F1)-(F2/F1G1)	NS	Refl Coef	DUT Input	Refl Coef	DUT Output	Refl Coef	NF Ric	Refl Coef	Instrument NF	Instrument Gain	Noise Source ENR *		Negative	Positive	Max	Negative	Positive	Max	Negative	Positive	Max	U (NF12)	U (NF2)	U (G1)	U [dB]	U [K]
26,00	1,61	1,449	130	**7,00**	5,012	1163	32,6	1814	1,45	1,617	1,11586	0,002	0,002	1,114	-26,8	0,04564	-0,89	0,902	-8,60	0,3714	**-18,0**	0,1259	0,10	0,15	0,331	0,000	0,365	0,351	0,365	0,050	0,050	0,050	0,416	0,397	0,416	0,377	0,112	0,554	**0,55**	**56,7**
27,000	1,57	1,435	126	**7,00**	5,012	1163	32,6	1806	1,44	1,577	1,098	0,002	0,002	1,096	-25,1	0,056	-3,58	0,662	-8,63	0,370	**-18,0**	0,126	0,10	0,15	0,345	0,000	0,327	0,315	0,327	0,061	0,061	0,061	0,414	0,396	0,414	0,341	0,117	0,531	**0,52**	**53,3**
28,000	1,72	1,486	141	**7,00**	5,012	1163	31,5	1403	1,49	1,728	1,163	0,002	0,002	1,161	-24,3	0,061	-9,37	0,340	-9,08	0,352	**-18,0**	0,126	0,10	0,15	0,344	0,000	0,181	0,178	0,181	0,067	0,066	0,067	0,393	0,376	0,393	0,206	0,120	0,444	**0,46**	**48,2**
29,000	1,59	1,442	128	**7,00**	5,012	1163	30,6	1144	1,45	1,601	1,110	0,003	0,002	1,107	-25,9	0,051	-13,3	0,217	-10,1	0,313	**-18,0**	0,126	0,10	0,15	0,372	0,000	0,097	0,096	0,097	0,056	0,055	0,056	0,349	0,335	0,349	0,138	0,114	0,377	**0,44**	**44,2**
30,000	1,55	1,429	124	**7,00**	5,012	1163	29,9	983,1	1,43	1,562	1,093	0,004	0,003	1,090	-28,7	0,037	-19,3	0,109	-10,9	0,284	**-18,0**	0,126	0,10	0,15	0,352	0,000	0,035	0,035	0,035	0,040	0,040	0,040	0,316	0,305	0,316	0,106	0,108	0,334	**0,40**	**39,9**
31,000	1,52	1,419	122	**7,00**	5,012	1163	29,7	933,3	1,42	1,533	1,080	0,004	0,003	1,077	-32,0	0,025	-17,6	0,132	-12,4	0,239	**-18,0**	0,126	0,10	0,15	0,345	0,000	0,029	0,029	0,029	0,028	0,027	0,028	0,265	0,257	0,265	0,104	0,104	0,285	**0,39**	**38,3**
32,000	1,53	1,422	122	**7,00**	5,012	1163	29,7	927,9	1,43	1,543	1,085	0,004	0,003	1,081	-31,1	0,028	-14,9	0,180	-13,6	0,208	**-18,0**	0,126	0,10	0,15	0,337	0,000	0,044	0,044	0,044	0,031	0,031	0,031	0,230	0,225	0,230	0,109	0,104	0,255	**0,38**	**37,9**
33,000	1,67	1,469	136	**7,00**	5,012	1163	29,9	979,9	1,47	1,682	1,145	0,003	0,003	1,142	-29,7	0,033	-11,6	0,263	-14,2	0,195	**-18,0**	0,126	0,10	0,15	0,332	0,000	0,075	0,074	0,075	0,036	0,036	0,036	0,216	0,211	0,216	0,124	0,106	0,250	**0,40**	**41,4**
34,000	1,60	1,445	129	**7,00**	5,012	1163	30,1	1021	1,45	1,612	1,115	0,003	0,003	1,112	-27,5	0,042	-11,1	0,279	-12,8	0,228	**-18,0**	0,126	0,10	0,15	0,323	0,000	0,102	0,101	0,102	0,046	0,046	0,046	0,253	0,246	0,253	0,142	0,110	0,292	**0,39**	**39,4**
35,000	1,68	1,472	137	**7,00**	5,012	1163	30,1	1031	1,48	1,691	1,149	0,003	0,003	1,146	-27,0	0,045	-10,9	0,285	-11,6	0,262	**-18,0**	0,126	0,10	0,15	0,307	0,000	0,111	0,110	0,111	0,049	0,049	0,049	0,292	0,282	0,292	0,149	0,111	0,329	**0,39**	**39,9**
36,000	1,68	1,472	137	**7,00**	5,012	1163	29,9	977,7	1,48	1,692	1,149	0,003	0,003	1,146	-21,5	0,084	-11,7	0,260	-10,5	0,300	**-18,0**	0,126	0,10	0,15	0,320	0,000	0,193	0,189	0,193	0,093	0,092	0,093	0,335	0,322	0,335	0,216	0,136	0,404	**0,44**	**45,2**
37,000	1,69	1,476	138	**7,00**	5,012	1163	29,4	861,0	1,48	1,704	1,154	0,004	0,003	1,151	-20,3	0,096	-13,2	0,218	-9,4	0,339	**-18,0**	0,126	0,10	0,15	0,336	0,000	0,184	0,181	0,184	0,106	0,105	0,106	0,379	0,363	0,379	0,209	0,145	0,439	**0,45**	**46,7**
38,000	1,61	1,449	130	**7,00**	5,012	1163	29,1	819,8	1,45	1,625	1,121	0,004	0,003	1,117	-18,4	0,121	-15,6	0,165	-8,9	0,360	**-18,0**	0,126	0,10	0,15	0,347	0,000	0,175	0,172	0,175	0,133	0,131	0,133	0,402	0,385	0,402	0,201	0,166	0,462	**0,44**	**45,1**
39,000	1,78	1,507	147	**7,00**	5,012	1163	28,5	714,2	1,51	1,796	1,192	0,005	0,004	1,188	-17,7	0,130	-21,2	0,087	-7,6	0,417	**-18,0**	0,126	0,10	0,15	0,328	0,000	0,098	0,097	0,098	0,143	0,141	0,143	0,469	0,445	0,469	0,139	0,174	0,505	**0,42**	**44,4**

Table 4.5.3 – 32LNA_02A Uncertainty

	DUT NF			Instrument NF			DUT GAIN		Combined NF						match								Uncertainties				Uncert NS-DUT IN			Uncert NS-NFA			Uncert DUT OUT-NFA							
Freq	F1	Linear	Kelvin	F2	Linear	Kelvin	G1	Linear	F12	Linear	F12/F1	F2/F1G1	(F2-1)/ F1G1	(F12/F1)-(F2/F1G1)	NS	Refl Coef	DUT Input	Refl Coef	DUT Output	Refl Coef	NF Ric	Refl Coef	Instrument NF	Instrument Gain	Noise Source ENR *		Negative	Positive	Max	Negative	Positive	Max	Negative	Positive	Max	U (NF12)	U (NF2)	U (G1)	U [dB]	U [K]
33,00	1,85	1,531	154	**7,00**	5,012	1163	34,0	2508	1,53	1,855	1,211	0,001	0,001	1,210	-29,7	0,033	-5,97	0,503	-2,72	0,731	**-18,0**	0,126	0,10	0,15	0,332	0,000	0,144	0,142	0,144	0,036	0,036	0,036	0,838	0,765	0,838	0,174	0,106	0,853	**0,45**	**48,4**
34,00	1,58	1,439	127	**7,00**	5,012	1163	33,9	2475	1,44	1,585	1,102	0,001	0,001	1,100	-27,5	0,042	-7,44	0,425	-4,36	0,606	**-18,0**	0,126	0,10	0,15	0,323	0,000	0,156	0,153	0,156	0,046	0,046	0,046	0,689	0,638	0,689	0,184	0,110	0,710	**0,41**	**40,8**
35,00	1,77	1,503	146	**7,00**	5,012	1163	34,1	2561	1,50	1,775	1,181	0,001	0,001	1,179	-27,0	0,045	-9,22	0,346	-4,68	0,583	**-18,0**	0,126	0,10	0,15	0,307	0,000	0,135	0,133	0,135	0,049	0,049	0,049	0,662	0,615	0,662	0,167	0,111	0,681	**0,41**	**43,0**
36,00	1,73	1,489	142	**7,00**	5,012	1163	30,6	1144	1,49	1,740	1,168	0,003	0,002	1,165	-21,5	0,084	-11,0	0,282	-5,60	0,525	**-18,0**	0,126	0,10	0,15	0,320	0,000	0,209	0,204	0,209	0,093	0,092	0,093	0,594	0,556	0,594	0,231	0,136	0,637	**0,45**	**47,6**
37,00	1,51	1,416	121	**7,00**	5,012	1163	29,9	983,1	1,42	1,522	1,075	0,004	0,003	1,072	-20,3	0,096	-12,8	0,228	-6,85	0,454	**-18,0**	0,126	0,10	0,15	0,336	0,000	0,193	0,189	0,193	0,106	0,105	0,106	0,512	0,483	0,512	0,216	0,145	0,559	**0,42**	**42,1**
38,00	1,44	1,393	114	**7,00**	5,012	1163	29,7	933,3	1,40	1,453	1,043	0,004	0,003	1,039	-18,4	0,121	-15,1	0,176	-7,59	0,418	**-18,0**	0,126	0,10	0,15	0,347	0,000	0,187	0,183	0,187	0,133	0,131	0,133	0,469	0,445	0,469	0,211	0,166	0,524	**0,42**	**40,8**
39,00	1,52	1,419	122	**7,00**	5,012	1163	29,7	927,9	1,42	1,533	1,080	0,004	0,003	1,077	-17,7	0,130	-19,4	0,108	-8,32	0,384	**-18,0**	0,126	0,10	0,15	0,328	0,000	0,122	0,120	0,122	0,143	0,141	0,143	0,430	0,410	0,430	0,157	0,174	0,474	**0,39**	**38,5**

Table 4.5.4 – 43LNA_01A Uncertainty

Freq	DUT NF F1	DUT NF Linear	DUT NF Kelvin	Instrument NF F2	Instrument NF Linear	Instrument NF Kelvin	DUT GAIN G1	DUT GAIN Linear	Combined NF F12	Combined NF Linear	F12/F1	F2/F1G1	(F2-1)/F1G1	(F12/F1)-(F2/F1G1)
75,00	1,40	1,380	110	7,000	5,012	1163	21,7	148,8	1,407	1,484	1,075	0,024	0,020	1,051
76,00	1,30	1,349	101	7,000	5,012	1163	22,1	161,8	1,374	1,379	1,022	0,023	0,018	0,999
77,00	2,25	1,679	197	7,000	5,012	1163	22,2	166,5	1,703	2,312	1,377	0,018	0,014	1,359
78,00	1,49	1,409	119	7,000	5,012	1163	22,5	178,7	1,432	1,559	1,106	0,020	0,016	1,086
79,00	1,51	1,416	121	7,000	5,012	1163	22,7	186,1	1,437	1,576	1,113	0,019	0,015	1,094
80,00	2,30	1,698	202	7,000	5,012	1163	22,3	171,4	1,722	2,359	1,389	0,017	0,014	1,372
81,00	2,09	1,618	179	7,000	5,012	1163	21,8	150,7	1,645	2,161	1,335	0,021	0,016	1,315
82,00	1,97	1,574	166	7,000	5,012	1163	21,0	125,2	1,606	2,058	1,307	0,025	0,020	1,282
83,00	2,39	1,734	213	7,000	5,012	1163	20,4	108,7	1,771	2,481	1,431	0,027	0,021	1,405
84,00	2,24	1,675	196	7,000	5,012	1163	19,8	94,56	1,717	2,349	1,402	0,032	0,025	1,371
85,00	2,89	1,945	274	7,000	5,012	1163	18,7	74,83	1,999	3,008	1,546	0,034	0,028	1,512
86,00	2,02	1,592	172	7,000	5,012	1163	16,9	49,26	1,674	2,237	1,405	0,064	0,051	1,341
87,00	2,58	1,811	235	7,000	5,012	1163	14,9	30,69	1,942	2,883	1,591	0,090	0,072	1,501
88,00	2,96	1,977	283	7,000	5,012	1163	12,1	16,39	2,222	3,467	1,754	0,155	0,124	1,599
89,00	3,16	2,070	310	7,000	5,012	1163	9,13	8,182	2,560	4,083	1,972	0,296	0,237	1,677
90,00	5,04	3,192	636	7,000	5,012	1163	5,89	3,879	4,226	6,259	1,961	0,405	0,324	1,556

Freq	match NS	Refl Coef	DUT Input	Refl Coef	DUT Output	Refl Coef	NF Ric	Refl Coef	Uncertainties Instrument NF	Instrument Gain	Noise Source ENR *	
75,00	-25,0	0,056	-13,0	0,223	-19,9	0,101	-18,0	0,126	0,10	0,15	0,210	0,000
76,00	-25,0	0,056	-13,1	0,221	-18,7	0,116	-18,0	0,126	0,10	0,15	0,210	0,000
77,00	-25,0	0,056	-11,1	0,277	-19,7	0,103	-18,0	0,126	0,10	0,15	0,210	0,000
78,00	-25,0	0,056	-10,4	0,302	-20,2	0,098	-18,0	0,126	0,10	0,15	0,210	0,000
79,00	-25,0	0,056	-9,74	0,326	-18,8	0,115	-18,0	0,126	0,10	0,15	0,210	0,000
80,00	-25,0	0,056	-15,1	0,176	-16,6	0,148	-18,0	0,126	0,10	0,15	0,210	0,000
81,00	-25,0	0,056	-8,87	0,360	-15,6	0,165	-18,0	0,126	0,10	0,15	0,210	0,000
82,00	-25,0	0,056	-9,12	0,350	-13,6	0,209	-18,0	0,126	0,10	0,15	0,210	0,000
83,00	-25,0	0,056	-9,56	0,333	-13,5	0,212	-18,0	0,126	0,10	0,15	0,210	0,000
84,00	-25,0	0,056	-9,96	0,318	-12,8	0,229	-18,0	0,126	0,10	0,15	0,210	0,000
85,00	-25,0	0,056	-10,1	0,311	-12,5	0,238	-18,0	0,126	0,10	0,15	0,210	0,000
86,00	-25,0	0,056	-8,88	0,360	-11,7	0,261	-18,0	0,126	0,10	0,15	0,210	0,000
87,00	-25,0	0,056	-7,39	0,427	-11,5	0,265	-18,0	0,126	0,10	0,15	0,210	0,000
88,00	-25,0	0,056	-6,02	0,500	-11,3	0,273	-18,0	0,126	0,10	0,15	0,210	0,000
89,00	-25,0	0,056	-4,94	0,566	-10,9	0,285	-18,0	0,126	0,10	0,15	0,210	0,000
90,00	-25,0	0,056	-4,83	0,574	-10,8	0,290	-18,0	0,126	0,10	0,15	0,210	0,000

Freq	Uncert NS-DUT IN Negative	Positive	Max	Uncert NS-NFA Negative	Positive	Max	Uncert DUT OUT-NFA Negative	Positive	Max	U (NF12)	U (NF2)	U (G1)	U [dB]	U [K]
75,00	0,109	0,108	0,109	0,062	0,061	0,062	0,111	0,110	0,111	0,148	0,117	0,193	**0,270**	**25,6**
76,00	0,109	0,107	0,109	0,062	0,061	0,062	0,128	0,126	0,128	0,147	0,117	0,203	**0,256**	**23,8**
77,00	0,137	0,134	0,137	0,062	0,061	0,062	0,114	0,112	0,114	0,168	0,117	0,211	**0,364**	**42,5**
78,00	0,149	0,146	0,149	0,062	0,061	0,062	0,108	0,106	0,108	0,178	0,117	0,215	**0,298**	**29,1**
79,00	0,161	0,158	0,161	0,062	0,061	0,062	0,127	0,125	0,127	0,188	0,117	0,233	**0,308**	**30,1**
80,00	0,086	0,086	0,086	0,062	0,061	0,062	0,163	0,160	0,163	0,132	0,117	0,217	**0,338**	**39,9**
81,00	0,178	0,174	0,178	0,062	0,061	0,062	0,183	0,179	0,183	0,203	0,117	0,277	**0,382**	**43,2**
82,00	0,173	0,169	0,173	0,062	0,061	0,062	0,231	0,225	0,231	0,199	0,117	0,307	**0,369**	**40,5**
83,00	0,164	0,161	0,164	0,062	0,061	0,062	0,235	0,229	0,235	0,191	0,117	0,306	**0,397**	**48,1**
84,00	0,156	0,154	0,156	0,062	0,061	0,062	0,254	0,246	0,254	0,185	0,117	0,316	**0,383**	**44,7**
85,00	0,153	0,151	0,153	0,062	0,061	0,062	0,264	0,256	0,264	0,182	0,117	0,323	**0,419**	**57,1**
86,00	0,178	0,174	0,178	0,062	0,061	0,062	0,290	0,280	0,290	0,203	0,117	0,355	**0,396**	**44,0**
87,00	0,211	0,206	0,211	0,062	0,061	0,062	0,295	0,285	0,295	0,232	0,117	0,376	**0,479**	**61,3**
88,00	0,248	0,241	0,248	0,062	0,061	0,062	0,304	0,294	0,304	0,266	0,117	0,403	**0,567**	**80,0**
89,00	0,281	0,272	0,281	0,062	0,061	0,062	0,317	0,306	0,317	0,297	0,117	0,432	**0,679**	**102**
90,00	0,285	0,276	0,285	0,062	0,061	0,062	0,323	0,311	0,323	0,301	0,117	0,439	**0,677**	**156**

Table 4.5.5 – 86LNA_01A Uncertainty

Freq	DUT NF F1	DUT NF Linear	DUT NF Kelvin	Instrument NF F2	Instrument NF Linear	Instrument NF Kelvin	DUT GAIN G1	DUT GAIN Linear	Combined NF F12	Combined NF Linear	F12/F1	F2/F1G1	(F2-1)/F1G1	(F12/F1)-(F2/F1G1)
84,00	2,25	1,679	197	7,00	5,012	1163	19,3	85,763	1,73	2,369	1,411	0,035	0,028	1,377
85,00	2,76	1,888	258	7,00	5,012	1163	18,9	77,019	1,94	2,878	1,524	0,034	0,028	1,490
86,00	1,90	1,549	159	7,00	5,012	1163	18,7	74,405	1,60	2,049	1,323	0,043	0,035	1,279
87,00	2,25	1,679	197	7,00	5,012	1163	18,6	72,661	1,73	2,391	1,424	0,041	0,033	1,383
88,00	2,21	1,663	192	7,00	5,012	1163	18,3	67,004	1,72	2,364	1,421	0,045	0,036	1,376
89,00	2,06	1,607	176	7,00	5,012	1163	18,2	65,630	1,67	2,222	1,383	0,048	0,038	1,335
90,00	3,59	2,286	373	7,00	5,012	1163	18,2	65,917	2,35	3,704	1,621	0,033	0,027	1,587
91,00	2,38	1,730	212	7,00	5,012	1163	18,0	63,067	1,79	2,537	1,467	0,046	0,037	1,421
92,00	3,77	2,382	401	7,00	5,012	1163	18,0	62,762	2,45	3,885	1,631	0,034	0,027	1,597
93,00	2,98	1,986	286	7,00	5,012	1163	18,1	64,239	2,05	3,114	1,568	0,039	0,031	1,529
94,00	3,94	2,477	428	7,00	5,012	1163	17,9	61,150	2,54	4,054	1,636	0,033	0,026	1,603
95,00	3,40	2,188	344	7,00	5,012	1163	17,6	57,677	2,26	3,536	1,616	0,040	0,032	1,577
96,00	3,98	2,500	435	7,00	5,012	1163	17,3	54,313	2,57	4,106	1,642	0,037	0,030	1,605
97,00	3,82	2,410	409	7,00	5,012	1163	16,6	45,331	2,50	3,977	1,650	0,046	0,037	1,604
98,00	4,13	2,588	461	7,00	5,012	1163	16,0	40,216	2,69	4,294	1,659	0,048	0,039	1,611

Freq	match NS	Refl Coef	DUT Input	Refl Coef	DUT Output	Refl Coef	NF Ric	Refl Coef	Uncertainties Instrument NF	Instrument Gain	Noise Source ENR *	
84,00	-25,0	0,056	-21,6	0,083	-18,8	0,115	-18,0	0,126	0,10	0,15	0,21	0,000
85,00	-25,0	0,056	-30,8	0,029	-17,4	0,135	-18,0	0,126	0,10	0,15	0,21	0,000
86,00	-25,0	0,056	-30,7	0,029	-18,3	0,122	-18,0	0,126	0,10	0,15	0,21	0,000
87,00	-25,0	0,056	-31,2	0,028	-19,0	0,112	-18,0	0,126	0,10	0,15	0,21	0,000
88,00	-25,0	0,056	-29,7	0,033	-19,1	0,111	-18,0	0,126	0,10	0,15	0,21	0,000
89,00	-25,0	0,056	-32,8	0,023	-18,5	0,118	-18,0	0,126	0,10	0,15	0,21	0,000
90,00	-25,0	0,056	-45,3	0,005	-19,6	0,105	-18,0	0,126	0,10	0,15	0,21	0,000
91,00	-25,0	0,056	-34,6	0,019	-20,6	0,094	-18,0	0,126	0,10	0,15	0,21	0,000
92,00	-25,0	0,056	-39,2	0,011	-20,6	0,093	-18,0	0,126	0,10	0,15	0,21	0,000
93,00	-25,0	0,056	-27,4	0,043	-21,1	0,088	-18,0	0,126	0,10	0,15	0,21	0,000
94,00	-25,0	0,056	-21,9	0,080	-23,7	0,065	-18,0	0,126	0,10	0,15	0,21	0,000
95,00	-25,0	0,056	-17,3	0,136	-24,2	0,061	-18,0	0,126	0,10	0,15	0,21	0,000
96,00	-25,0	0,056	-13,8	0,204	-23,7	0,065	-18,0	0,126	0,10	0,15	0,21	0,000
97,00	-25,0	0,056	-11,3	0,273	-25,8	0,051	-18,0	0,126	0,10	0,15	0,21	0,000
98,00	-25,0	0,056	-9,2	0,348	-24,8	0,058	-18,0	0,126	0,10	0,15	0,21	0,000

Freq	Uncert NS-DUT IN Negative	Positive	Max	Uncert NS-NFA Negative	Positive	Max	Uncert DUT OUT-NFA Negative	Positive	Max	U (NF12)	U (NF2)	U (G1)	U [dB]	U [K]
84,00	0,041	0,041	0,041	0,062	0,061	0,062	0,126	0,125	0,126	0,108	0,117	0,176	**0,324**	**37,7**
85,00	0,014	0,014	0,014	0,062	0,061	0,062	0,149	0,147	0,149	0,101	0,117	0,189	**0,346**	**45,4**
86,00	0,014	0,014	0,014	0,062	0,061	0,062	0,134	0,132	0,134	0,101	0,117	0,178	**0,298**	**31,9**
87,00	0,013	0,013	0,013	0,062	0,061	0,062	0,124	0,122	0,124	0,101	0,117	0,170	**0,322**	**37,4**
88,00	0,016	0,016	0,016	0,062	0,061	0,062	0,122	0,121	0,122	0,101	0,117	0,169	**0,321**	**37,0**
89,00	0,011	0,011	0,011	0,062	0,061	0,062	0,130	0,128	0,130	0,101	0,117	0,175	**0,311**	**34,6**
90,00	0,003	0,003	0,003	0,062	0,061	0,062	0,115	0,114	0,115	0,100	0,117	0,163	**0,368**	**58,6**
91,00	0,009	0,009	0,009	0,062	0,061	0,062	0,103	0,102	0,103	0,100	0,117	0,155	**0,330**	**39,7**
92,00	0,005	0,005	0,005	0,062	0,061	0,062	0,102	0,101	0,102	0,100	0,117	0,155	**0,370**	**61,5**
93,00	0,021	0,021	0,021	0,062	0,061	0,062	0,097	0,096	0,097	0,102	0,117	0,153	**0,356**	**49,2**
94,00	0,039	0,039	0,039	0,062	0,061	0,062	0,072	0,071	0,072	0,107	0,117	0,142	**0,376**	**65,1**
95,00	0,067	0,066	0,067	0,062	0,061	0,062	0,067	0,067	0,067	0,120	0,117	0,150	**0,380**	**58,0**
96,00	0,100	0,099	0,100	0,062	0,061	0,062	0,072	0,071	0,072	0,141	0,117	0,169	**0,404**	**70,7**
97,00	0,134	0,132	0,134	0,062	0,061	0,062	0,056	0,056	0,056	0,167	0,117	0,185	**0,429**	**72,6**
98,00	0,171	0,168	0,171	0,062	0,061	0,062	0,063	0,063	0,063	0,198	0,117	0,215	**0,464**	**84,6**

Table 4.5.6 – 100LNA_01A Uncertainty

5 - Measurement results

5.1 Description

Measurements that will be shown this chapter are S-parameter, in dB units, and noise temperature, in Kelvin degree units. The first and the second graph of each design show the simulations compared with the "all working" MMICs behaviour. Devices have been grouped by design and wafer serial number. Responses of MMIC which lies on the same wafer are drawn on the same colour. In order to have an high accuracy characterisation to compare with the simulations, for some devices, an higher number of points have been stored. Moreover, Gain and IRL with bias far from the design condition have been collected and shown in a graph. Bias details are listed in the table below the related graph. Cross reference with noise test with the same bias condition will be coming soon . In order to get more information regarding the devices, some analysis have been conducted on the collected data. We represent the distribution of the average gain and Te over 100%BW. The pie graph of figure 5.1.1 represent the devices distribution of the CSR18 portion of IRA. We have measured only the LNA's. STF are Stage test Fixture, which will be used for reverse engineering activity, HCA are discrete device which could be useful in order to create a cryogenic model and the TRL cal kit will be used to calibrate the instruments for modelling the devices.

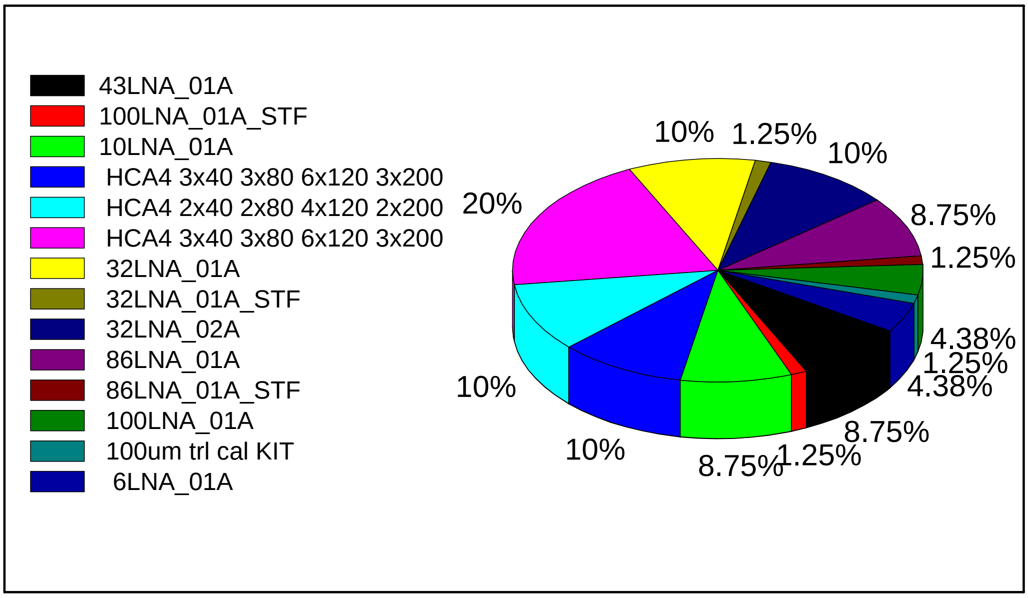


Fig. 5.1.1 – IRA device sharing percentage

5.2 – 6LNA_01A

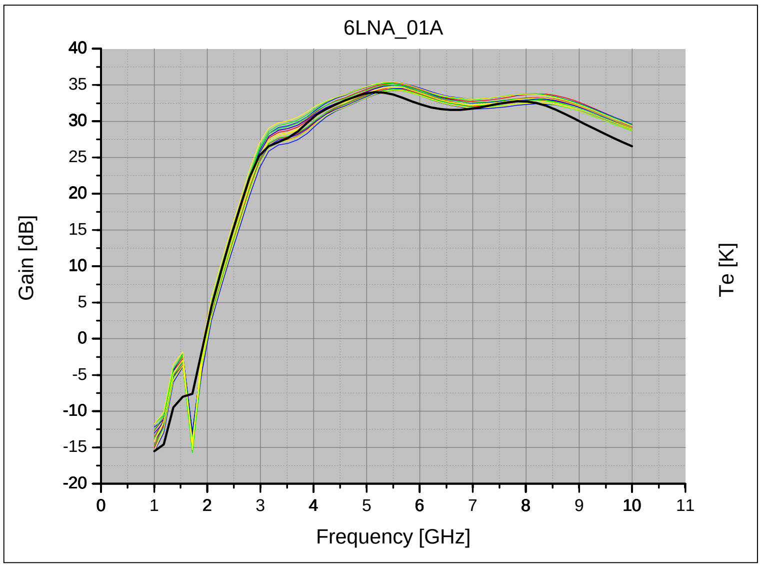


Fig 5.2.1 – 6LNA_01A Gain

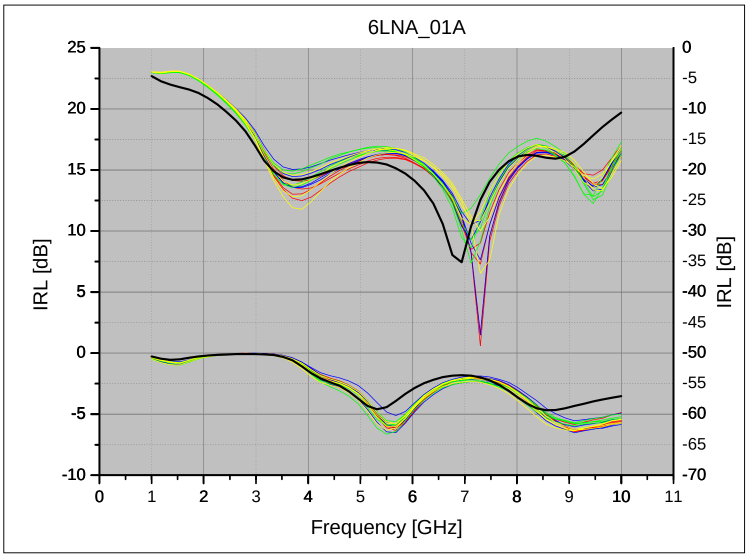


Fig 5.2.2 – 6LNA_01A IRL & ORL

■ 4245-013 ■ 4245-016
■ 4245-018 ■ 4245-019

This LNA have been designed following the specification imposed by the PHAROS receiver constraints. PHAROS is a focal plane array receiver funded by RADIONET, which is a Network of excellence supported within FP6. This device had been carried out by a collaboration between the Microwave group of Tor Vergata University in Rome and IRA. Tor Vergata hadn't access to the NGC library models and the Foundry Rules. Device implementation had been followed by IRA.

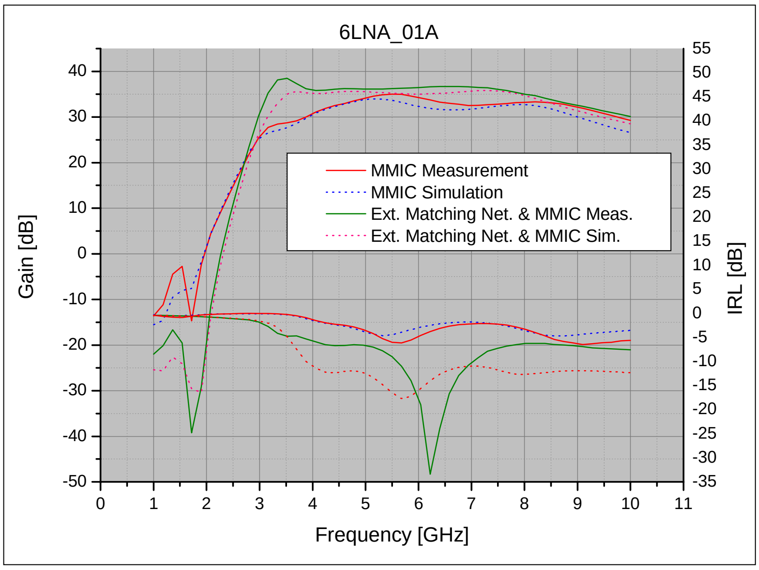


Fig 5.2.3 – 6LNA_01A IRL & Gain including simulated off chip network

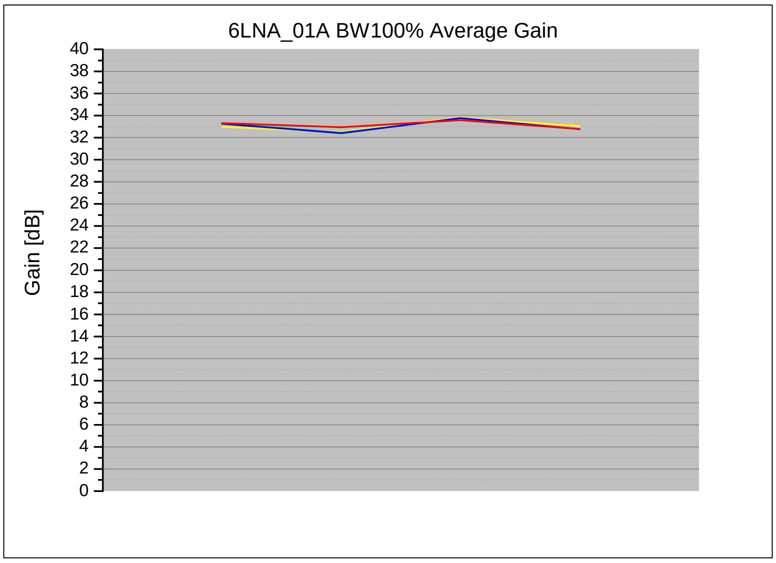


Fig 5.2.3 – 6LNA_01A BW100% Average Gain

Because this LNA has an off-chip matching network, MMIC-only simulation and measurements are compared in fig 5.2.1-2. The result of the combined response of MMIC measure with input matching network are shown Fig. 5.2.3. The external matching network gives a useful degree of freedom. It allows to specialise the LNA with a fractional bandwidth up to 110% or, with a more selective network, to obtain narrow bandwidth. In order to optimise the overall noise response and adapt the amplifier gain response to the IRA receiver specifications, we are planning to implement HTS filter in a input matching network. Filter and LNA have to provide gain between 4.3-5.8 GHz and 5.7-7.7 GHz.

5.3 - 10LNA_01A

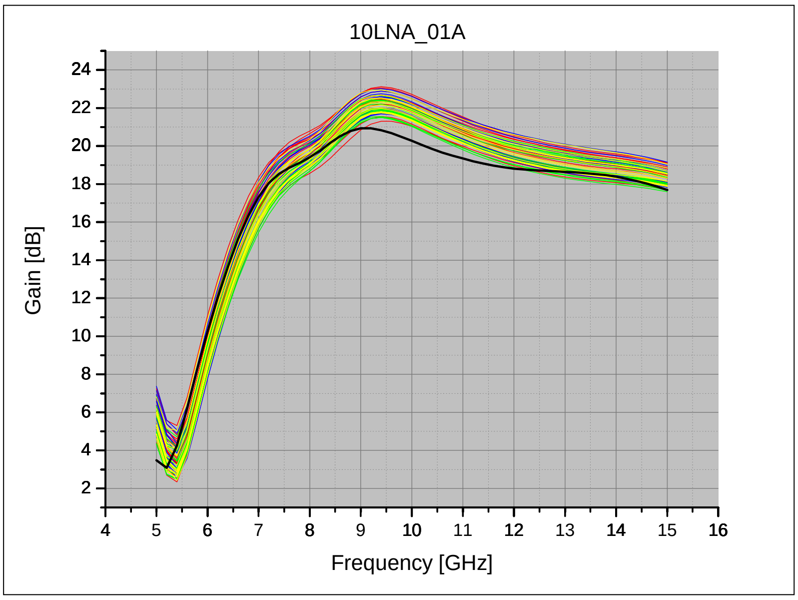


Fig 5.3.1 – 10LNA_01A Gain

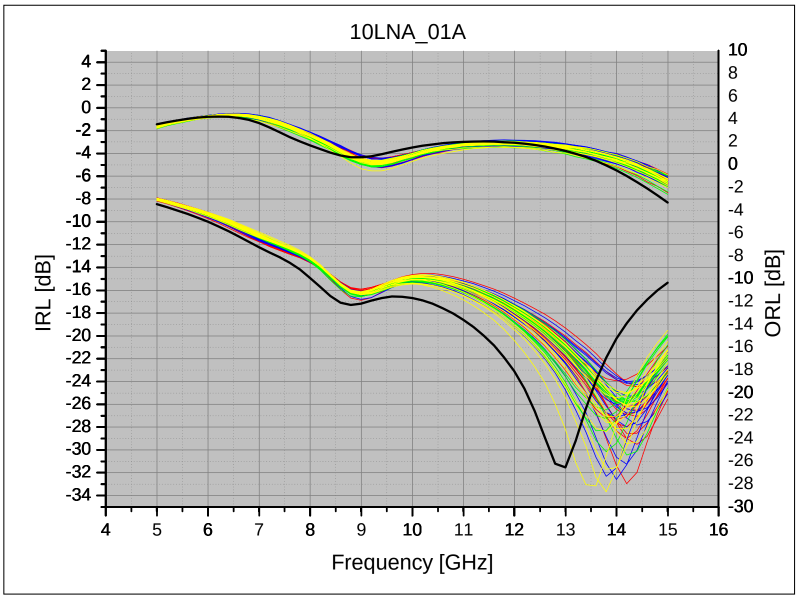


Fig 5.3.2 – 10LNA_01A IRL & ORL

4245-013	4245-016
4245-018	4245-019

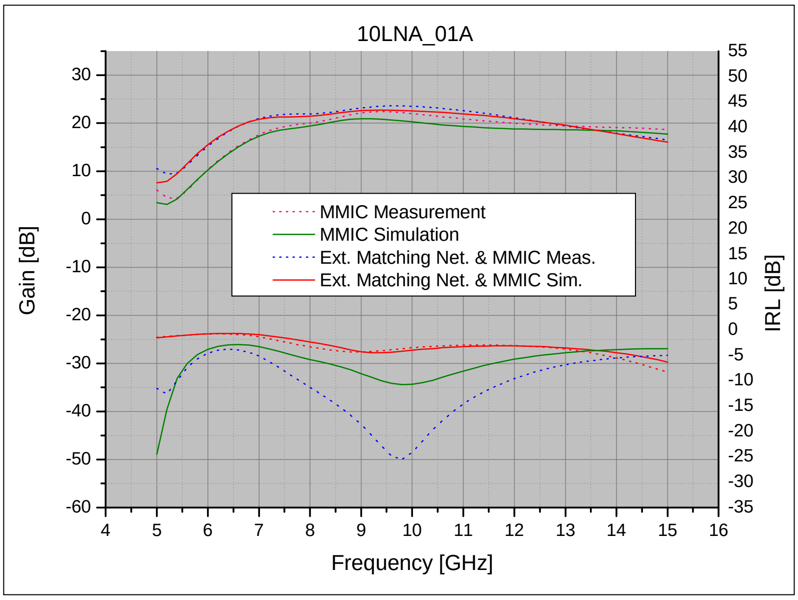


Fig 5.3.3 – 6LNA_01A IRL & Gain including simulated off chip network

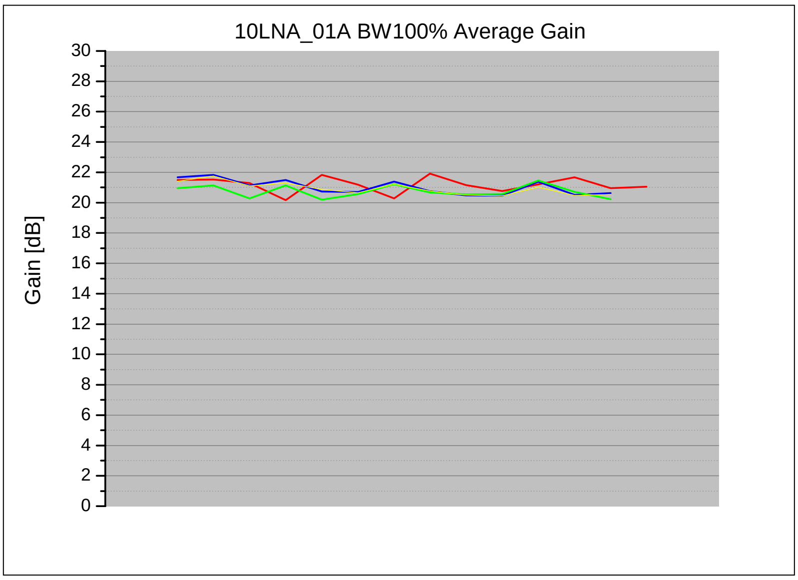


Fig 5.3.4 – 10LNA_01A BW100% Average Gain

The same consideration exposed for the previous device can be applied to this LNA. It has been designed in order to be installed in holography measurement system. This kind of equipment are used in radioastronomy to define with accuracy shape deformation of the parabolic dish. Also in this case the input matching network is off-chip. Specified working bandwidth lie between 8 to 12 GHz with a BW% of 49%. Accepting a poor IRL on the bandwidth edges, it can operate between 7,5 to 15 GHz extending the BW% up to 71%.

5.4 – 32LNA_01A

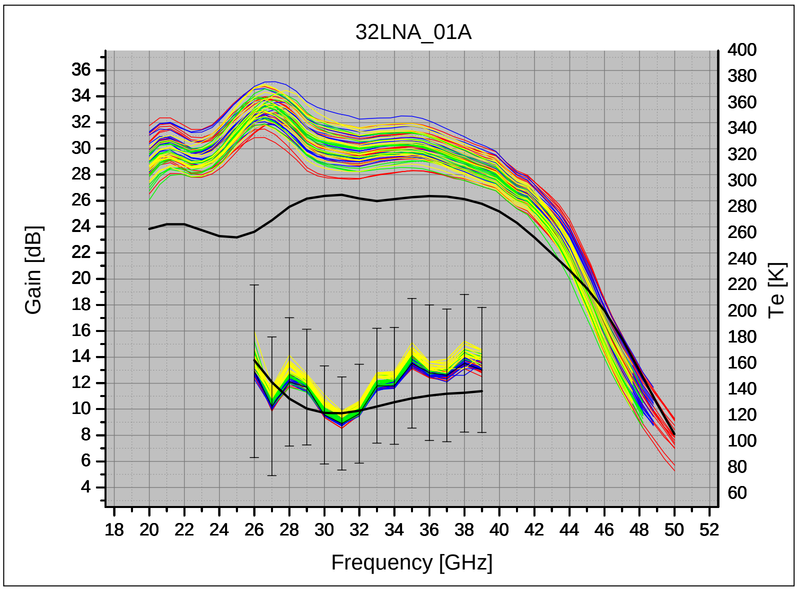


Fig 5.4.1 – 32LNA_01A Gain & Te

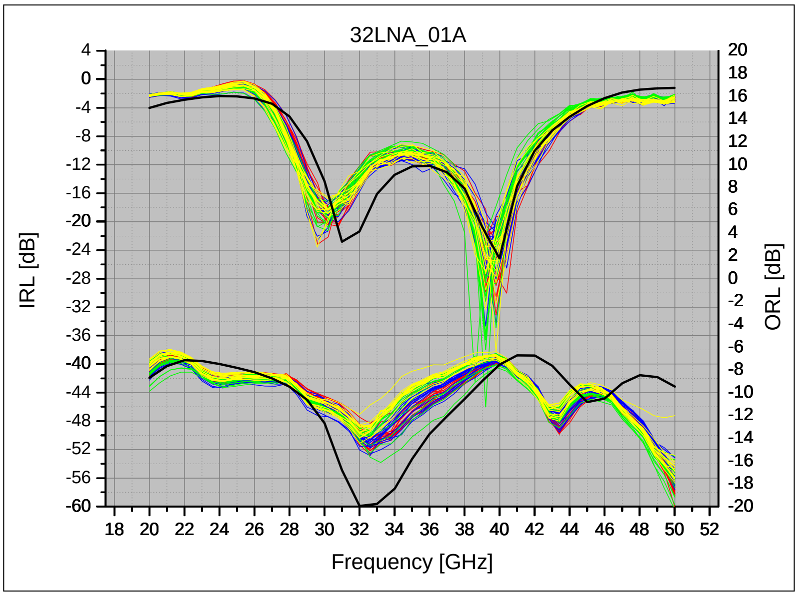


Fig 5.4.2 – 32LNA_01A IRL & ORL

■ 4245-013	■ 4245-016
■ 4245-018	■ 4245-019

The noise temperature response of this design, according the estimated accuracy, match the specification. Gain in the working bandwidth is 6dB higher than the simulation, with an unwanted gain excess at the lower limit of BW, near 26 GHz.

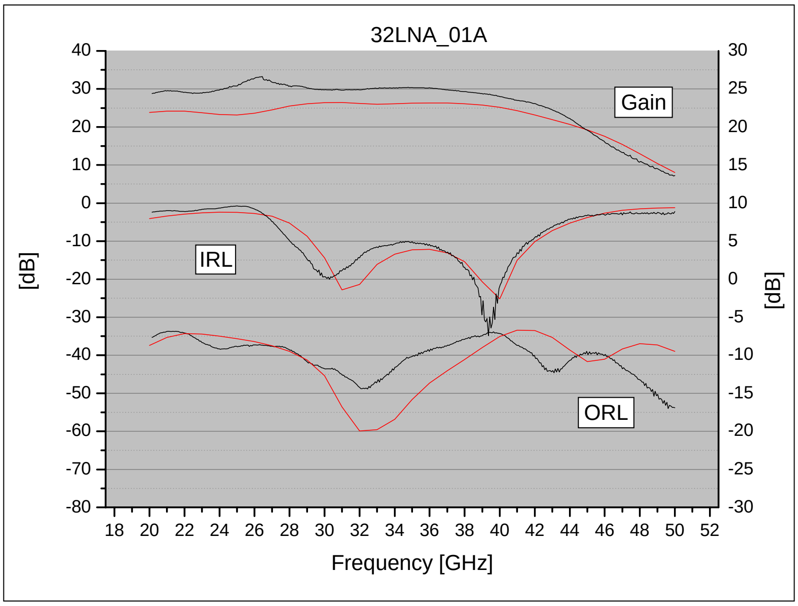


Fig 5.4.3 – 32LNA_01A Hi Resolution Gain & IRL & ORL

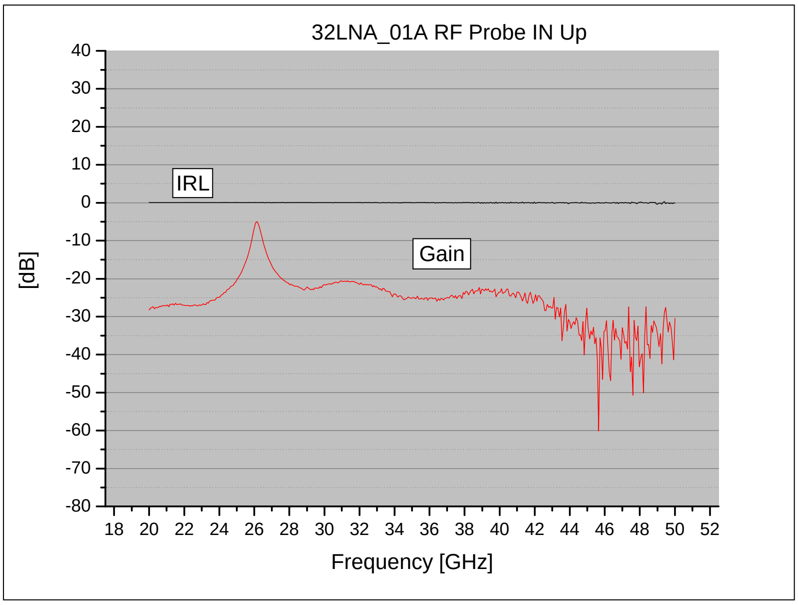


Fig 5.4.4 – 32LNA_01A IRL & Gain With RF in Raised Up

Considering fig. 5.4.4. the gain response has been collected with the rf input probe raised up. It is clear around 26 GHz a “gain peak” without RF input. For this design autooscillations will be deeply investigated. Evaluating the ORL differences between meas. and simulation in fig 5.4.3 the “anomalous” behaviour could be closer to the RF output than the RF input. EM simulations of part of MMIC circuit we will define which more accuracy the reasons of those differences.

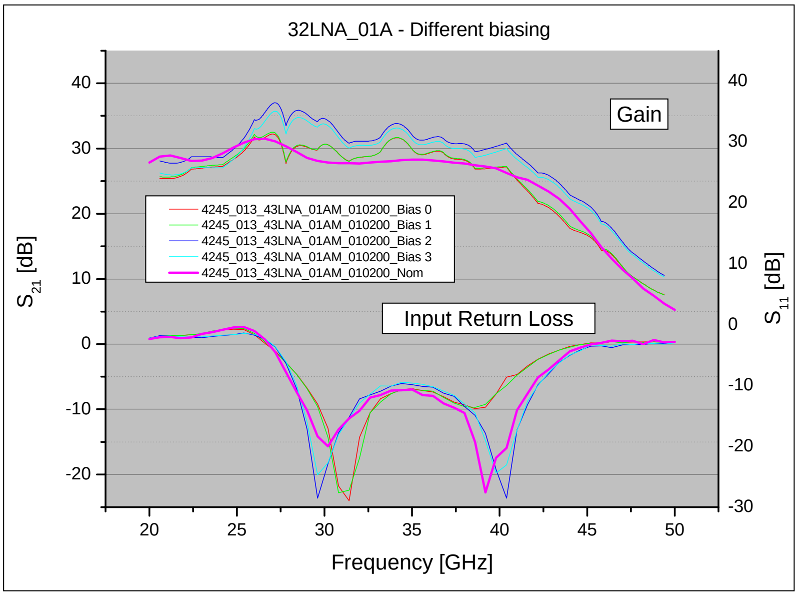


Fig 5.4.5 – 32LNA_01A IRL & Gain with several different biasing conditions

Measurement Name	D1 Vd [V]	D1 Id [mA]	D2 Vd [V]	D2 Id mA	D3 Vd [V]	D3 Id mA	D4 Vd [V]	D4 Id mA
CSR18_32LNA_01A_Nom	1,2	12	1,32	12	1,44	18	1,44	18
CSR18_32LNA_01A_Bias 0	0,5	5	1,32	5	1,44	8	1,44	11
CSR18_32LNA_01A_Bias 1	0.5	5	1,1	5	1,44	8	1,44	11
CSR18_32LNA_01A_Bias 2	1,2	5	1,32	5	1,44	18	1,44	18
CSR18_32LNA_01A_Bias 3	1,2	5	1,32	5	1,44	8	1,44	18

Table 5.4.1 – 32LNA_01A biasing

Measurements with bias condition set different to the design specifications show which is possible reducing sensibly the power consumption while having enough gain. In order to define the “BEST BIAS”, this data must be joined with the related noise response.

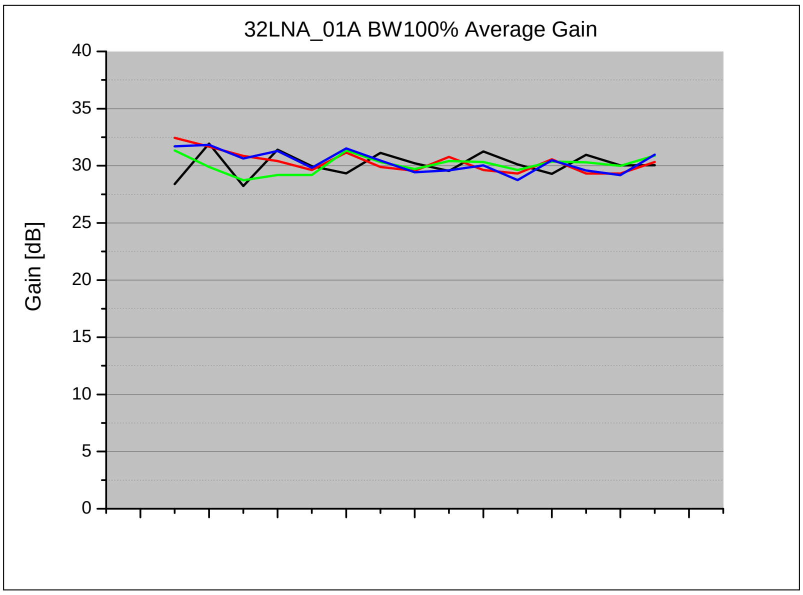


Fig 5.4.6 – 32LNA_01A BW100% Average Gain

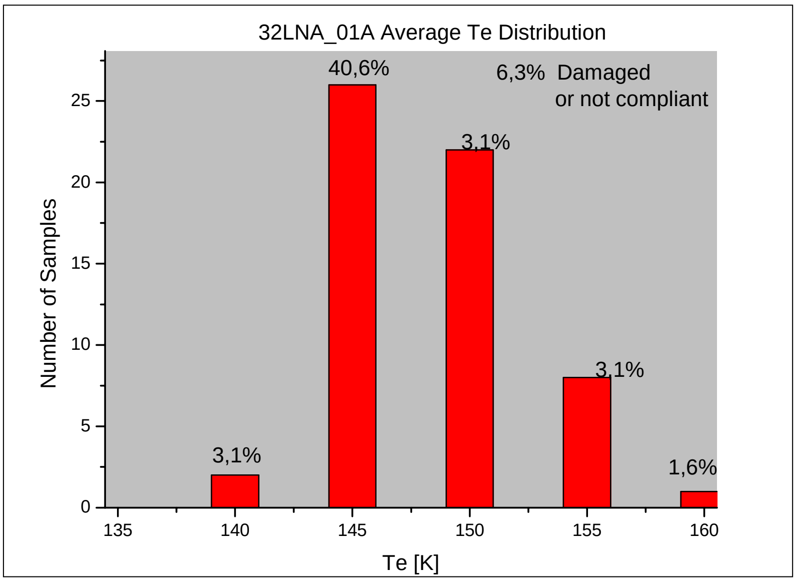


Fig 5.4.7 – 132NA_01A Average Te distribution

Figure 5.4.6 shows the average gain of each device in the frequency range between 26 to 40 GHz. The typical value is 30 dB. Figure 5.4.7 gives a distribution of the average Te, in the working bandwidth of this device, on the wafer-run

5.5– 32LNA_02A

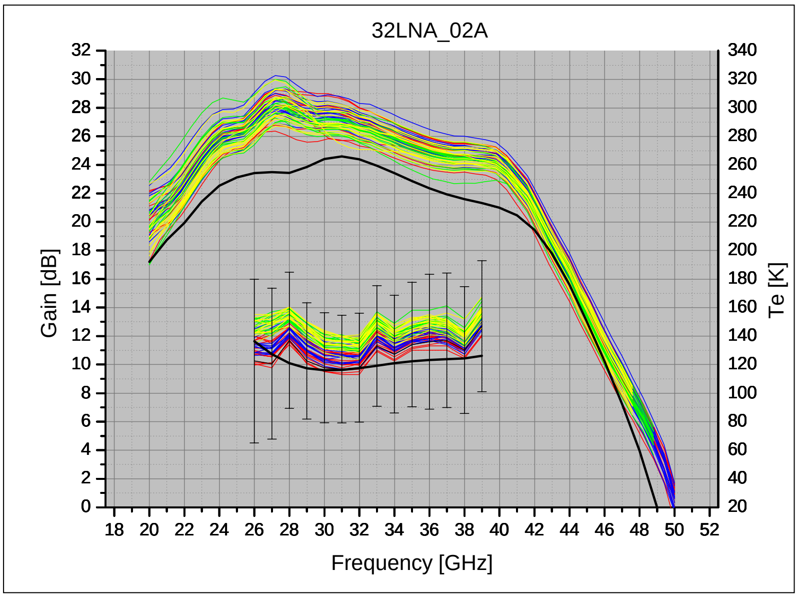


Fig 5.5.1 – 32LNA_02A Gain & Te

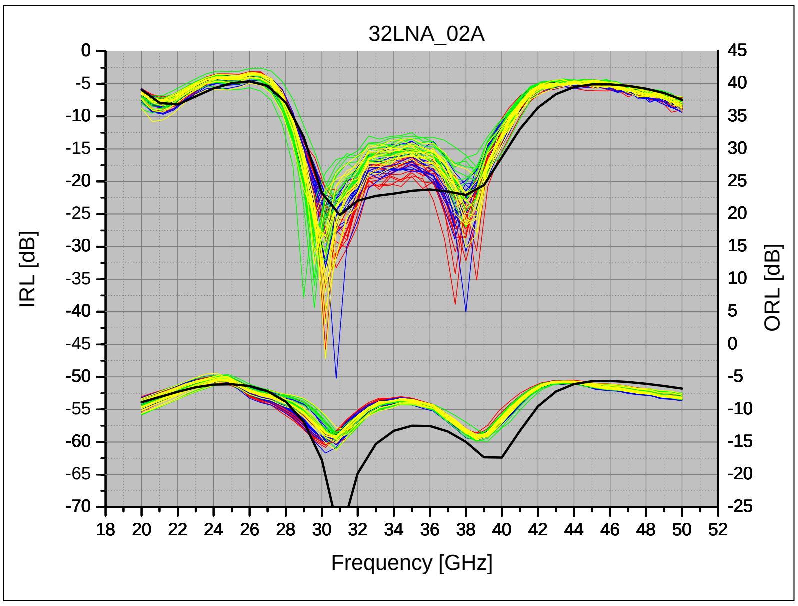


Fig 5.5.2 – 32LNA_02A IRL & ORL

4245-013	4245-016
4245-018	4245-019

The LNA has a gain which is, on average, 3dB higher than the simulations. This depends by a NGC foundry process maturation which involve the entire wafer-run. They probably provide a more accurate gain alignment. Devices have lower losses and consequently higher gain. These results come after the library publications. The first two wafer of CSR18 run named 4245-013 and 4245-016 provide, as shown in fig 5.5.1, lower noise and gain higher than the other wafers.

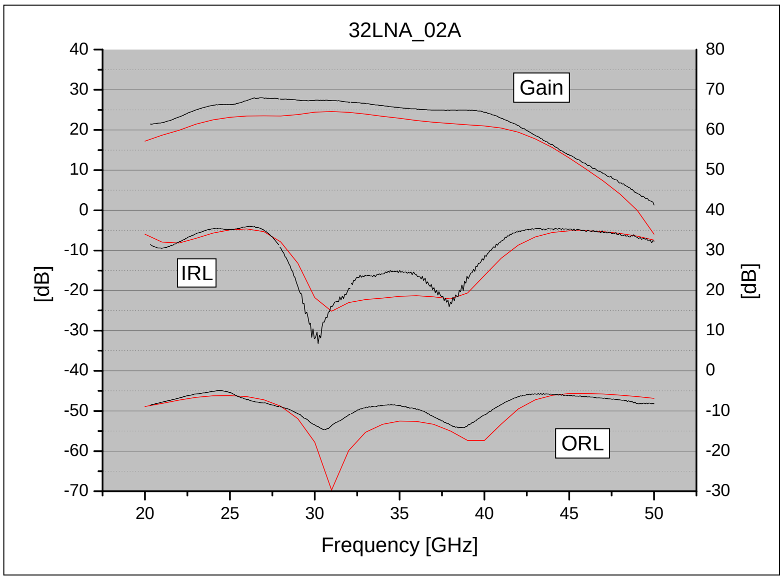


Fig 5.5.3 – 32LNA_02A Hi Resolution Gain & IRL & ORL

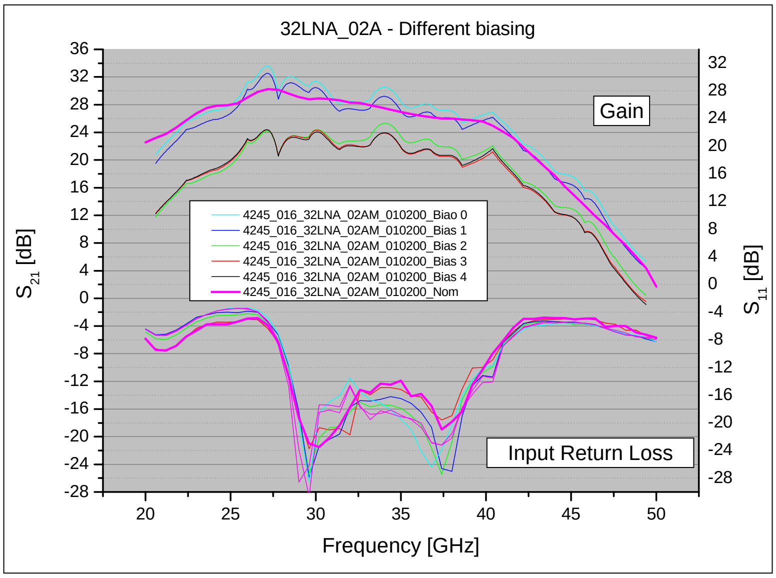


Fig 5.5.4 – 32LNA_02A IRL & Gain with several different biasing conditions

Fig. 5.5.4 and data listed in table 5.5.1 show how is possible to reduce the bias currents Id and also the power consumption, while having a sufficient gain to mask the receiver noise. We have to remember that , when we cool down to 20 K, the LNA increase the gain, about of 1-1.5 dB per Stage. IRL result excellent also varying the bias. We must verify the noise response according to the bias condition listed in table 5.5.1

Measurement Name	D1		D2		D3		D4	
	Vd [V]	Id [mA]	Vd [V]	Id mA	Vd [V]	Id mA	Vd [V]	Id mA
CSR18_32LNA_02A_Nom	1,08	12	X	x	1,08	12	1,08	12
CSR18_32LNA_02A_Bias 0	1,08	6	X	x	1,08	12	1,08	12
CSR18_32LNA_02A_Bias 1	1,08	6	X	x	1,08	6	1,08	12
CSR18_32LNA_02A_Bias 2	1,08	6	X	x	1,08	6	1,08	2
CSR18_32LNA_02A_Bias 3	1,08	6	X	x	1,08	6	0,3	2
CSR18_32LNA_02A_Bias 4	1,08	6	X	x	0,8	6	0,3	2

Table 5.5.1 – 32LNA_02A biasing

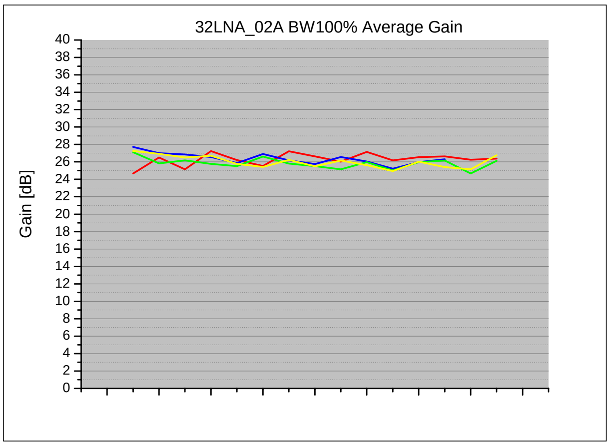


Fig 5.5.5 – 32LNA_02A BW100% Average Gain

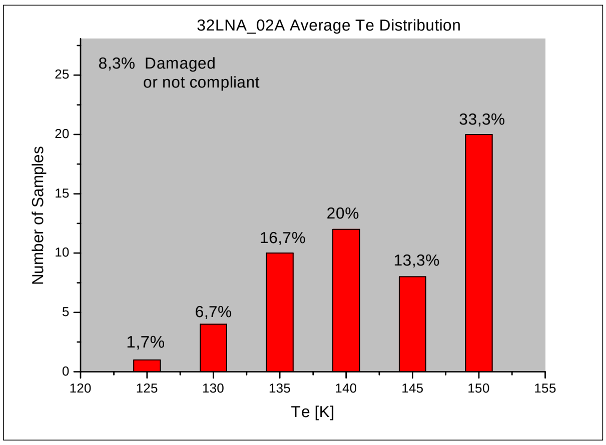


Fig 5.5.6 – 132NA_02A Average Te distribution

Figure 5.5.5 show the average gain of each device in the frequency range between 26 to 40 GHz. The typical value is 26 dB. Figure 5.5.6 gives a distribution of the average Te, in the working bandwidth of this device, on the wafer-run. IRL has an excellent response, better than 15dB over 90%BW which become superb, better than 20dB over 88%BW of some selected sample. The ORL is worst if compared with the simulation. We will try to recover it when we will design the Waveguide output probe. Causes of these discrepancy haven’t been yet investigated. they probably depend by some unwanted mutual coupling of the output circuits

5.6– 43LNA_01A

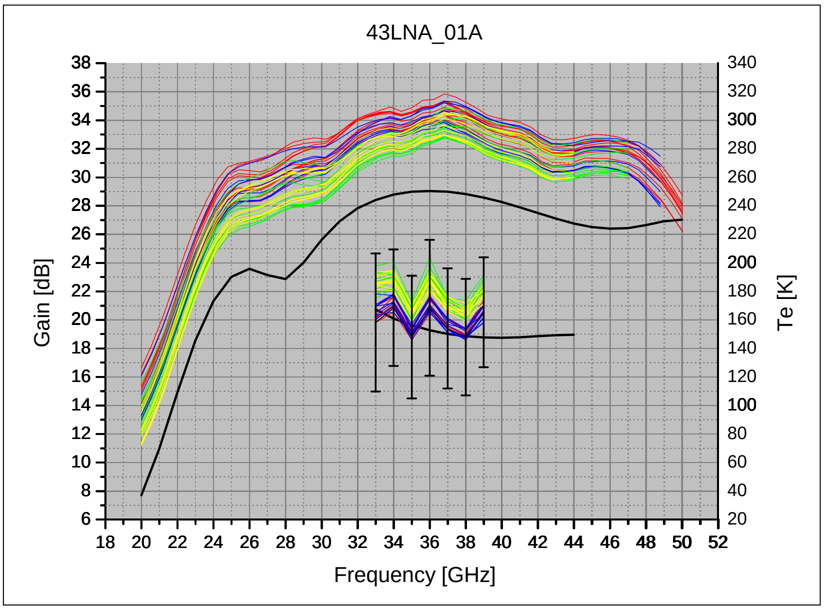


Fig 5.6.1 – 43LNA_01A Gain & Te

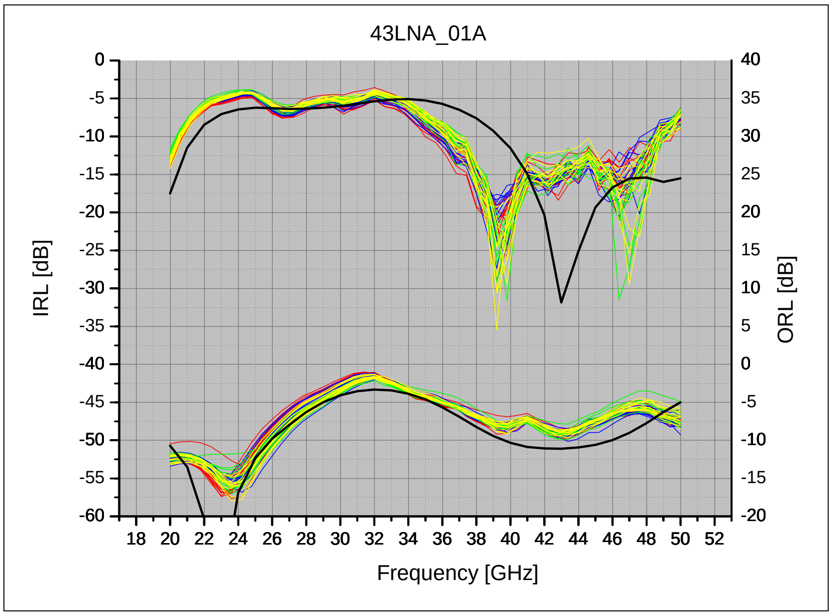


Fig 5.6.2 – 43LNA_01A IRL & ORL

■ 4245-013 ■ 4245-016
■ 4245-018 ■ 4245-019

Also this LNA provide higher gain than expected. In order to define a “rule of thumb” we can assert that foundry process improvements allows extra gain of 1,2-1,5 dB per stage compared to the library. It depends also by the operating frequency. From the fig.5.6.5-6 we observe that the tipical gain value is around 31.5 dB.

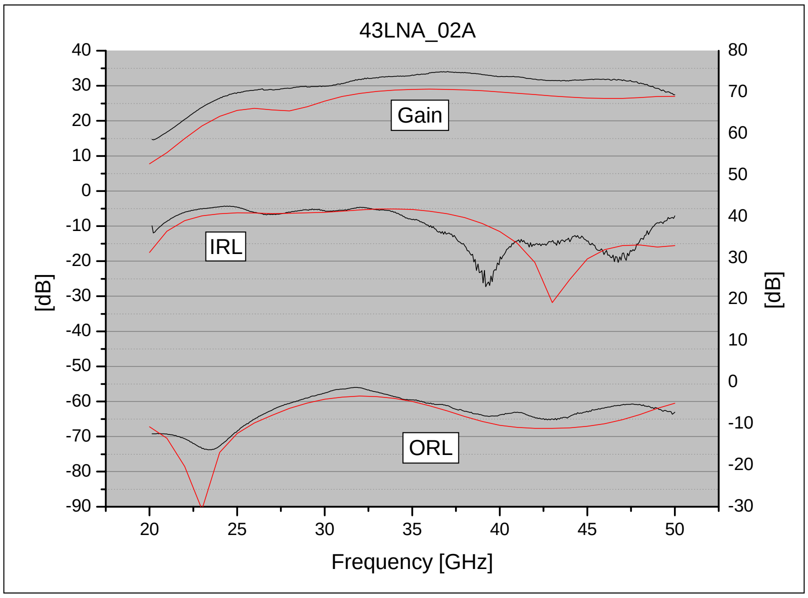


Fig 5.6.3 – 43LNA_01A Hi Resolution Gain & IRL & ORL

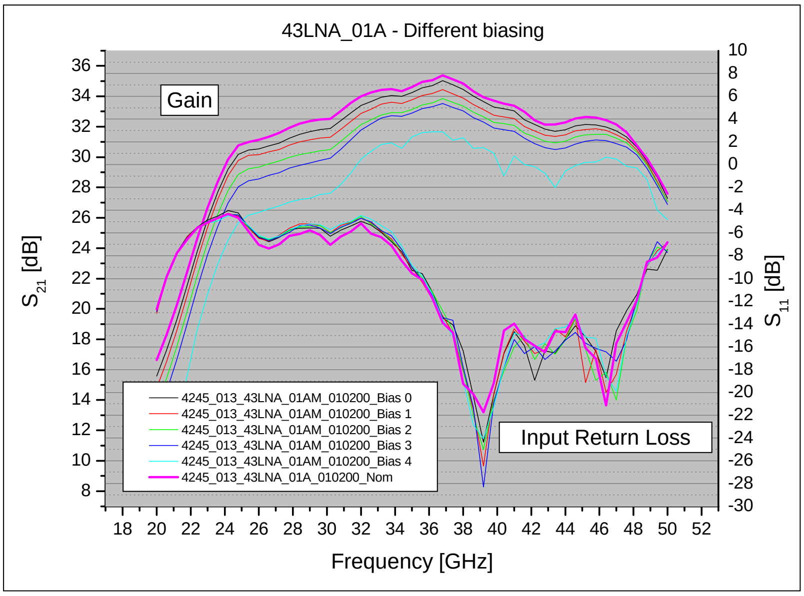
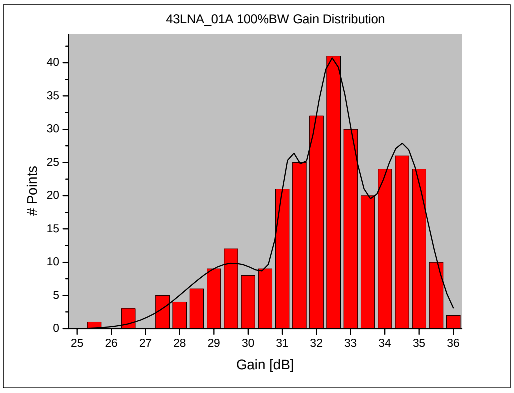


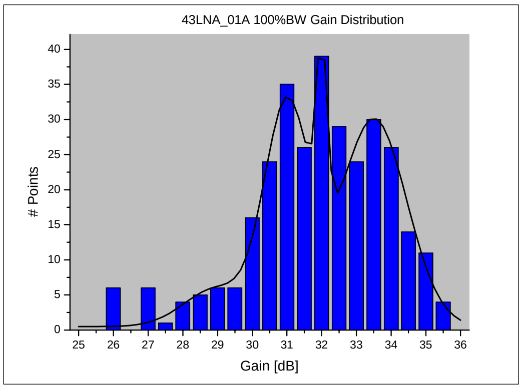
Fig 5.6.4 – 43LNA_01A IRL & Gain with several different biasing conditions

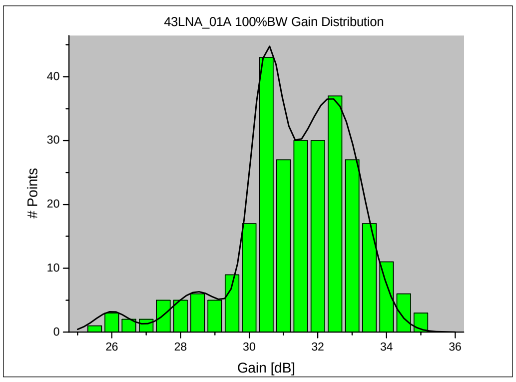
Measurement Name	D1		D2		D3		D4	
	Vd [V]	Id [mA]	Vd [V]	Id mA	Vd [V]	Id mA	Vd [V]	Id mA
CSR18_43LNA_01A_Nom	1,08	12	1,08	12	1,08	12	1,08	12
CSR18_43LNA_01A_Bias 0	1,08	8	1,08	12	1,08	12	1,08	12
CSR18_43LNA_01A_Bias 1	1,08	8	1,08	8	1,08	12	1,08	12
CSR18_43LNA_01A_Bias 2	1,08	8	1,08	8	1,08	8	1,08	12
CSR18_43LNA_01A_Bias 3	1,08	8	1,08	8	1,08	8	1,08	8
CSR18_43LNA_01A_Bias 4	1,08	8	1,08	6	1,08	6	1,08	6

Table 5.6.1 – 43LNA_01A biasing

Gain response looks similar to the simulation but some flexes must be investigated. IRL is better than expected. It appears frequency shifted providing a match better than 15 dB over 50% BW. The upper part of BW has poor IRL which we try to improve when we design the waveguide input probe. ORL appear more similar to the simulation and this will focus the designer attention on the first two stages, during a reverse engineering activity, in order to discover discrepancy reasons.







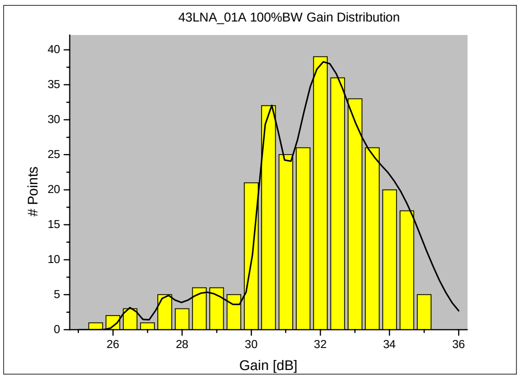


Fig 5.6.5 – 43LNA_01A Gain distribution

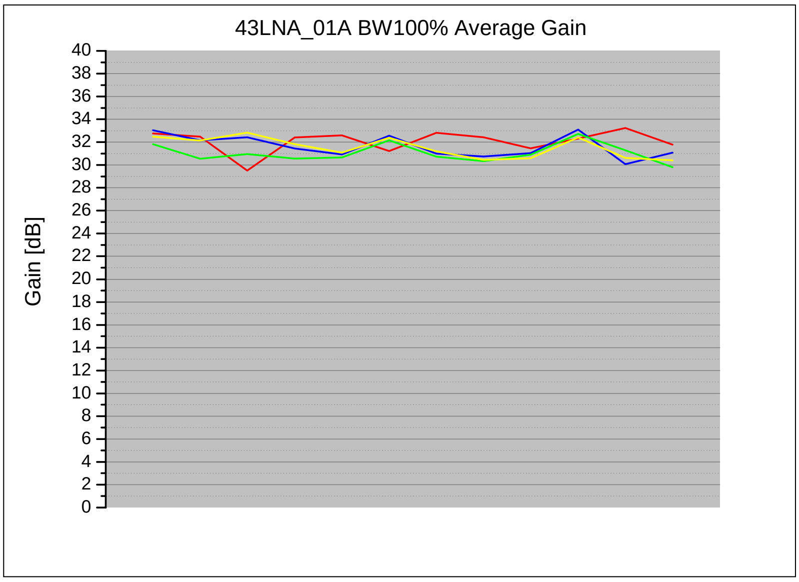


Fig 5.6.6 – 43LNA_01A BW100% Average Gain

4245-013 4245-016
4245-018 4245-019

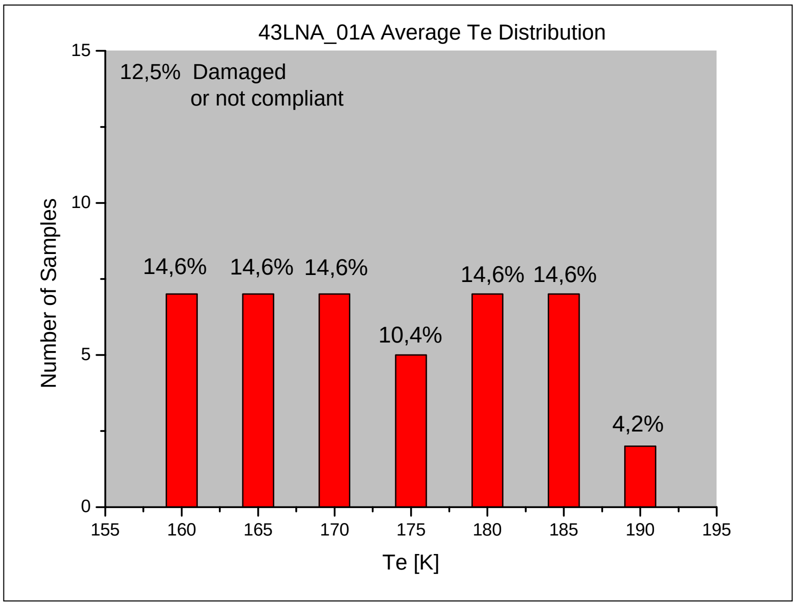


Fig 5.6.7 – 43LNA_01A Average Te distribution

5.7– 86LNA_01A

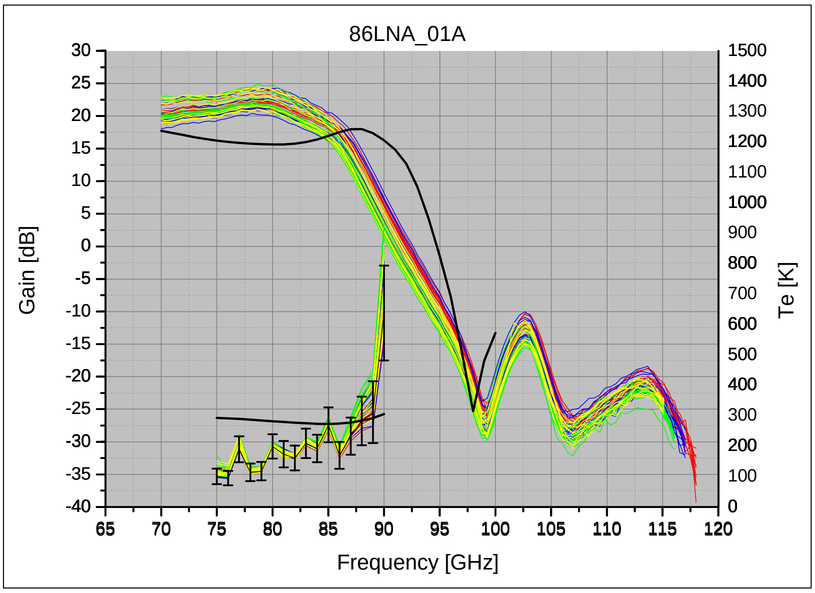


Fig 5.7.1 – 86LNA_01A Gain & Te

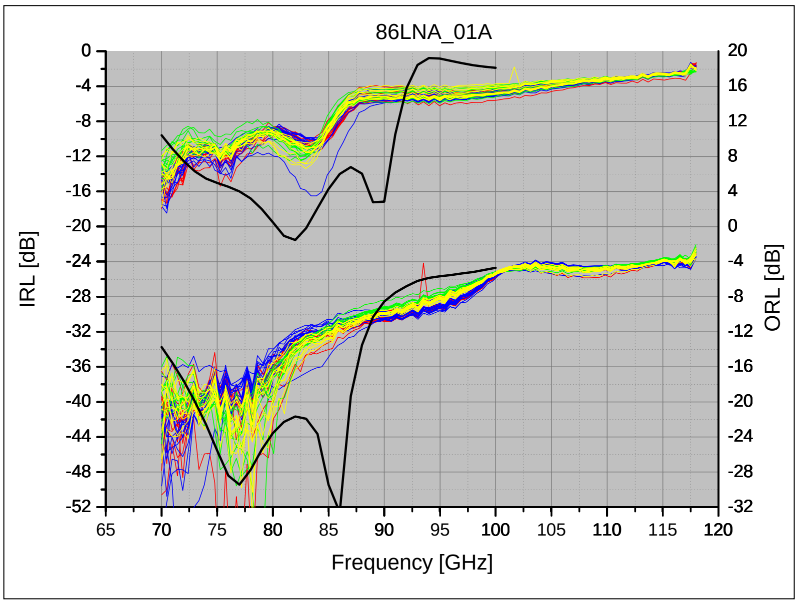


Fig 5.7.2 – 86LNA_01A IRL & ORL

4245-013	4245-016
4245-018	4245-019

If we observe the LNA response, it appears to be clearly narrower than expected from the simulation. Fractional bandwidth is about 19%. Gain flatness is about 3dB between 70 to 85 GHz, with a typical gain value of 21dB (Fig. 5.7.4). It could rise up to 25 at 20K. We haven't any information regarding Gain and Noise frequency response below 70 GHz, because WR-10 measurement test set were frequency limited. We could measure the device in Tor Vergata up to 50 GHz, but we haven't facilities which allow us to test these devices between 50 to 70 GHz. If necessary could be possible extend the frequency range of this device using 2 cascaded LNA's followed by an equaliser in order to obtain 21db Gain flat from 70 to 88 GHz, extending the bandwidth up to 23%.

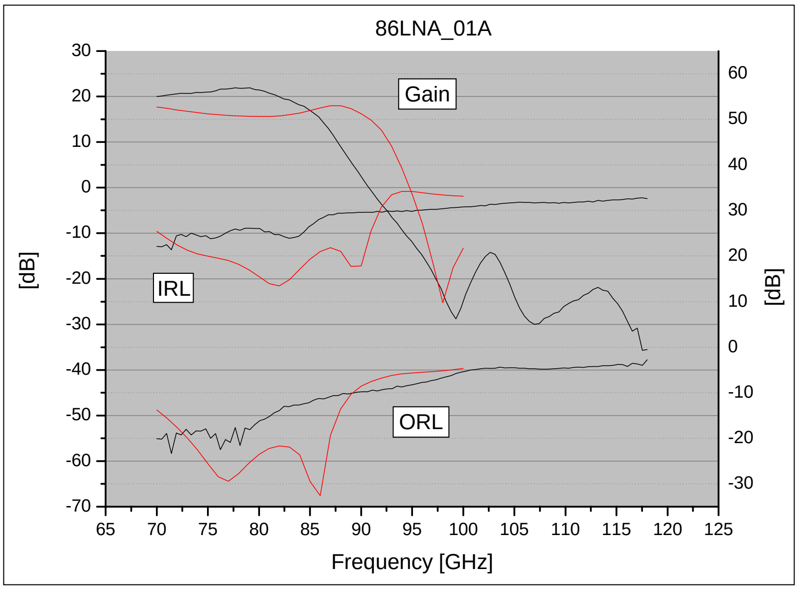
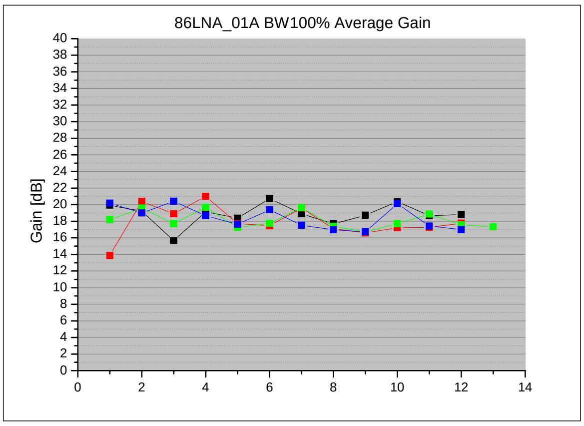


Fig 5.7.4 – 86LNA_01A Hi Resolution Gain & IRL & ORL



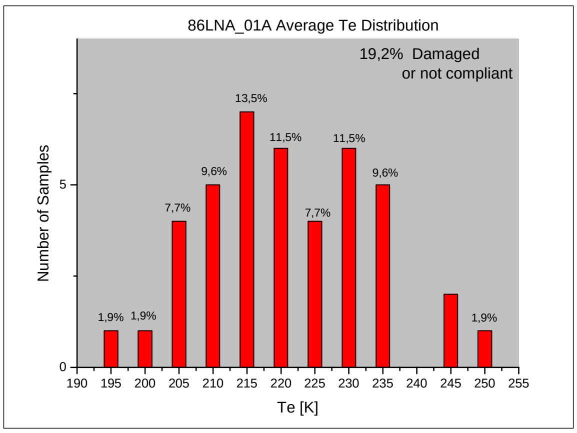


Fig 5.7.4 – 86LNA_01A BW100% Average Gain

Fig 5.7.5 – 86LNA_01A Average Te distribution

5.8– 100LNA_01A

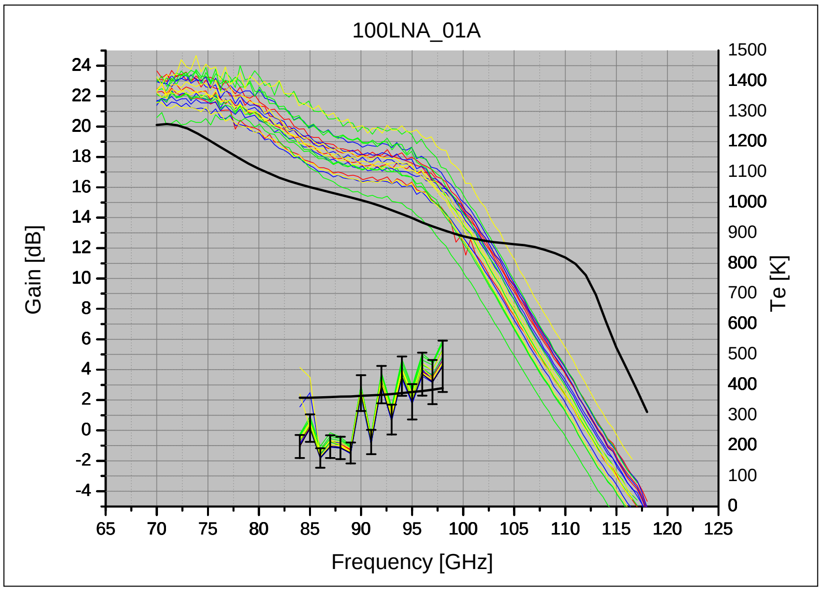


Fig 5.8.1 – 100LNA_01A Gain & Te

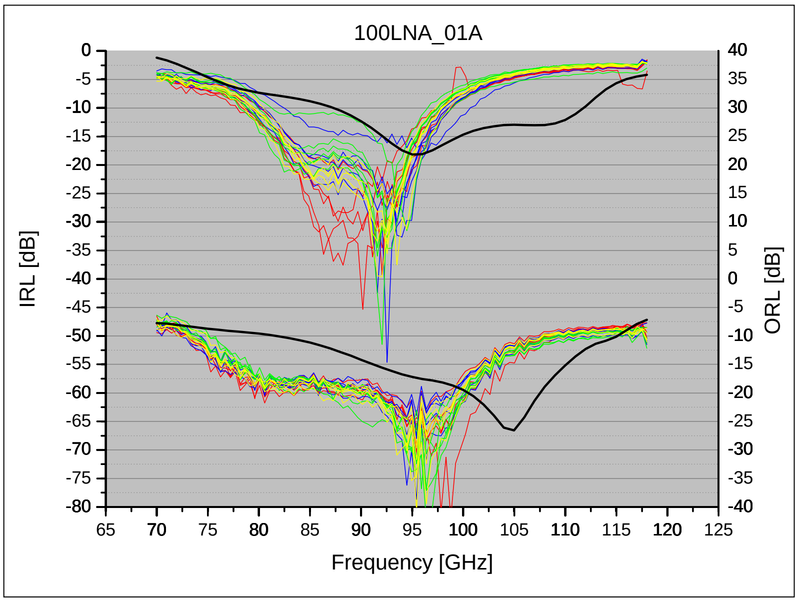


Fig 5.8.2 – 100LNA_01A IRL & ORL

■ 4245-013 ■ 4245-016

■ 4245-018 ■ 4245-019

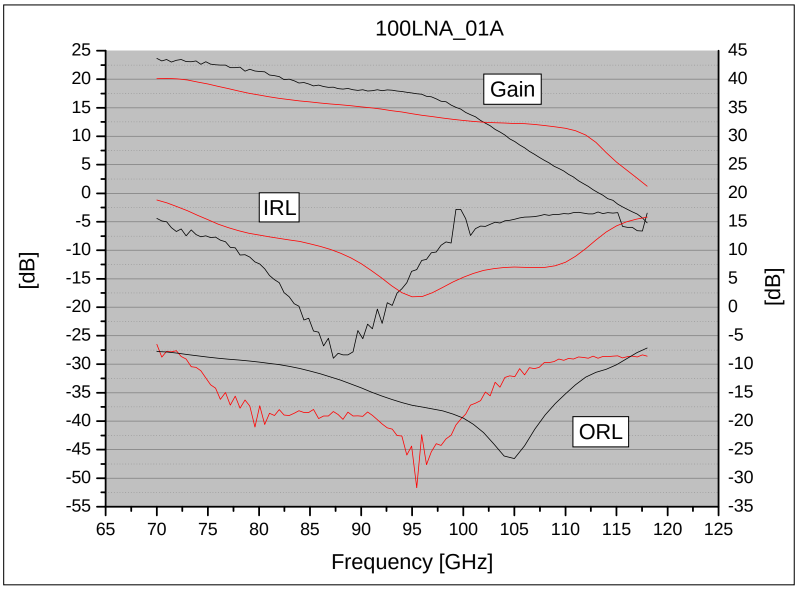
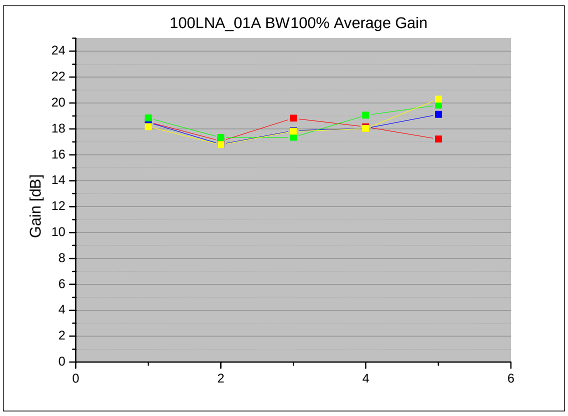


Fig 5.8.3 – 100LNA_01A Hi Resolution Gain & IRL & ORL

As described for 86LNA_01A, this device provides a narrower bandwidth than expected. Reasons could lies in devices model, which would be adjusted to work better in a different frequency range, or with higher probability, unwanted microstrip coupling at this frequencies, change too much the matching circuit behaviour. Reverse Engineering EM investigation activity will give more exhaustive explanation. This MMIC could be used between 70 to 90 GHz, accepting a 4dB slope, providing a typical gain of 20 dB. To extend the range up to 95 GHz the acceptable slope must be 5dB. Using two cascaded MMIC followed by an equaliser, we would use the resulting device up to 107 GHz providing a cooled flat gain of 25 dB.



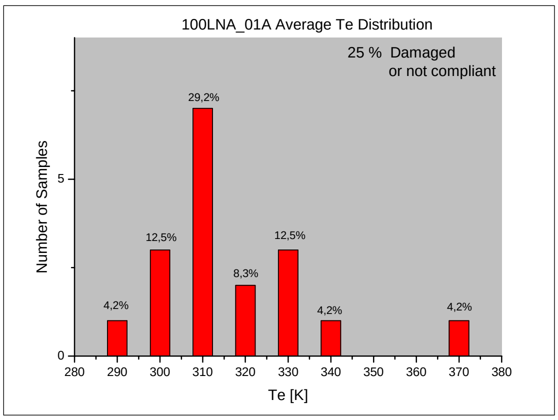


Fig 5.8.4 –100LNA_01A BW100% Average Gain

Fig 5.8.5 – 100LNA_01A Average Te distribution

6 – Conclusion

In this report we have described an intense on wafer MMIC measurement campaign. Moreover we explained measurement methods and the preliminary consideration in order to estimate the uncertainty. This aspect is necessary especially for the Noise which is more critical than Network test and defining the uncertainty helps data interpretations. All the collected values had been analysed and cross referenced in order to obtain a precise datasheet set to describe, briefly but entirely, LNAs behaviour and characteristics. More detailed results explanation follow the datasheet set in this document. In order to conclude, we can assert that CSR18 had been a successful Wafer run. Devices are mostly suitable for radio astronomical cryogenic application in state of the art receiver system or for noise testing facilities. they are a milestone for our capability to realise receiver up to 100 GHz and an excellent starting point for future design adventure.

7 – Bibliography

Duncan Boyd – Calculate the uncertainty of NF Measurements

Patrick Robbins – Looking into Noise Figure Measurements Uncertainty

8 – Tables Index

9 – Figure Index

10 - Acronym List

InP	Indium Phosphide
NGST	Northrop Grumman Space Tecnology
NGC	Northrop Grumman Company
HEMT	High Electron Mobility Transistor
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ATNF	Australia Telescope National Facility
FARADAY	**F**ocal plane **AR**r**A**y **D**esign **A**ccess and **Y**eld
IRA	Istituto di Radioastronomia
C-TIP	CSIRO Division of Telecommunications and Industrial Physics
MMIC	Monolithic Microwave Integrated Circuit
LNA	Low Noise Amplifier
IRL	Input Return Loss
ORL	Output Return Loss
NFM	Noise Figure Meter
NS	Noise Source
ENR	Excess Noise Ratio
IL	Insertion Loss
G_{AV}	Available Gain
HTS	High Temperature Superconductor

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