

LNA design examples for differential antenna structures

Jan Geralt Bij de Vaate
Roel Witvers
Juergen Morawietz
Bert Woestenburg
Bernard Enthoven
Roberto García García



Outline..

- Motivation
- Technology
- Design
- Characterization
- Design examples
- Conclusion



Motivation

Radiating element	Freq Bandwidth	Principle connection
Patch	Narrow	Unbalanced
Slot / Waveguide	Medium	Unbalanced
Ring	Narrow	Unbalanced
Spiral	Wide	Balanced
Bow-Tie, Fat dipole	Wide	Balanced
Vivaldi	Wide	Balanced
Log periodic	Wide	Balanced
Yagi	Medium	Balanced

✓ Narrow: <30%, Medium: <Octave, Wide: multiple octaves

3

Motivation

- Active or passive balun always needed
 - Active balun: differential LNA
- Differential LNA:
 - Lower costs (see Eloys talk today..)
 - Higher freq bandwidth possible
 - Higher performance
 - Improved IP2

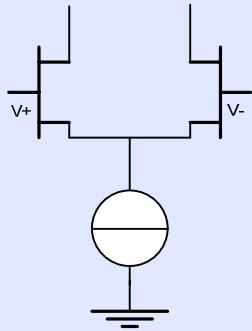
Motivation

- Differential Receiver:
 - Less inference sensitivity (IP2 improvements possible)
 - Power supply noise suppression
 - Common mode susceptibility improved
 - Balanced mixer's for LO suppression
- ----- The only way to build System On Chip!

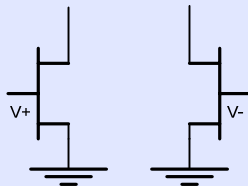
Motivation

- Differential LNA:
 - (little) Higher chip cost
 - Testing / design complexity
 - Higher power consumption

Design



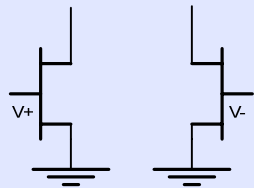
- Differential Amp
 - Common mode suppression



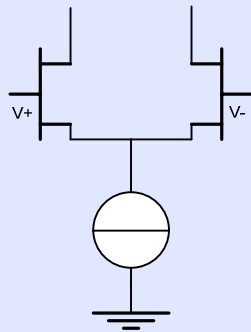
- (just) Two amps
 - Easier design / implementation
 - Used in many (antenna) systems

Design

- After the second stage gain / phase 'matching' not required for noise



✓ 1st stage



✓ 2nd stage

- 1st order approximation
- Still required for IP2 etc.
- Assume 20dB CMRR



Technology

- GaAs PsHEMT / mHEMT

$$F_{MIN} = 1 + \frac{f}{f_T} \times \sqrt{g_m (r_g + r_s)}$$

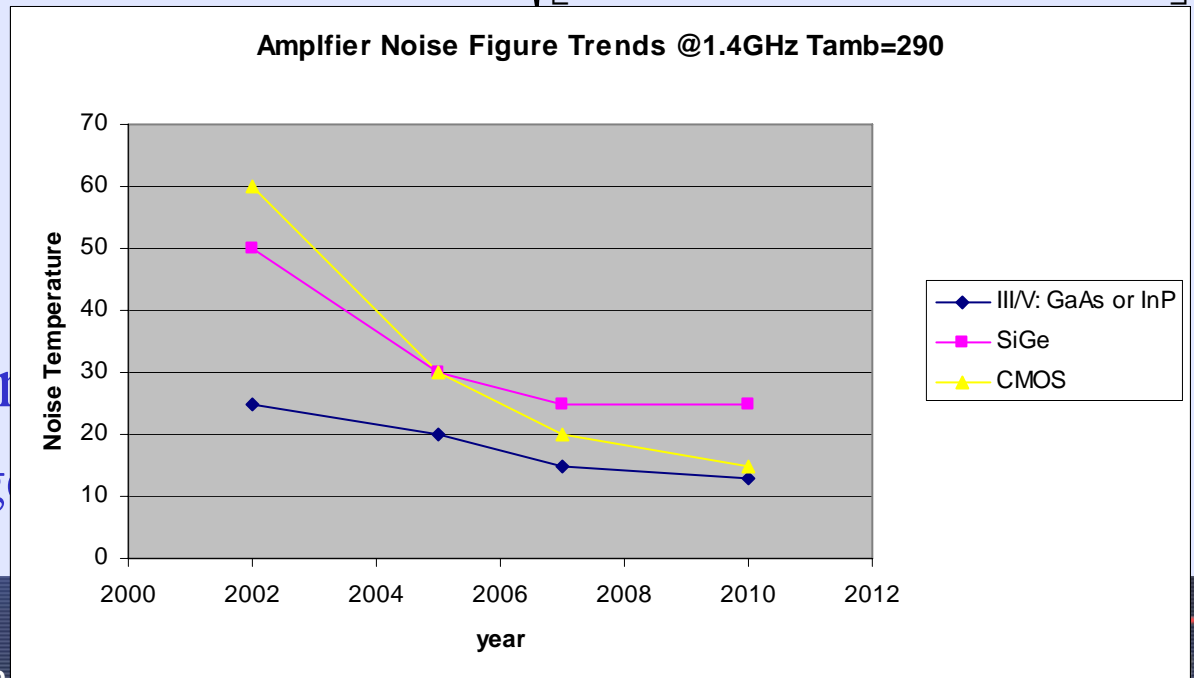
- SiGe BJT

$$F_{MIN} = 1 + \frac{n}{\beta_0} + \frac{f}{f_T} \times \sqrt{\left[\frac{2I_C}{V_T} (r_E + r_B) \left(1 + \frac{f_T^2}{\beta_0 f^2}\right) + \frac{n^2 f_T^2}{\beta_0 f^2} \right]}$$

- with $b_0 = 100$:

- CMOS

- In principle similar to CMOS
 - Gate leakage

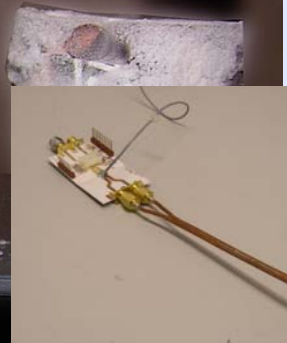
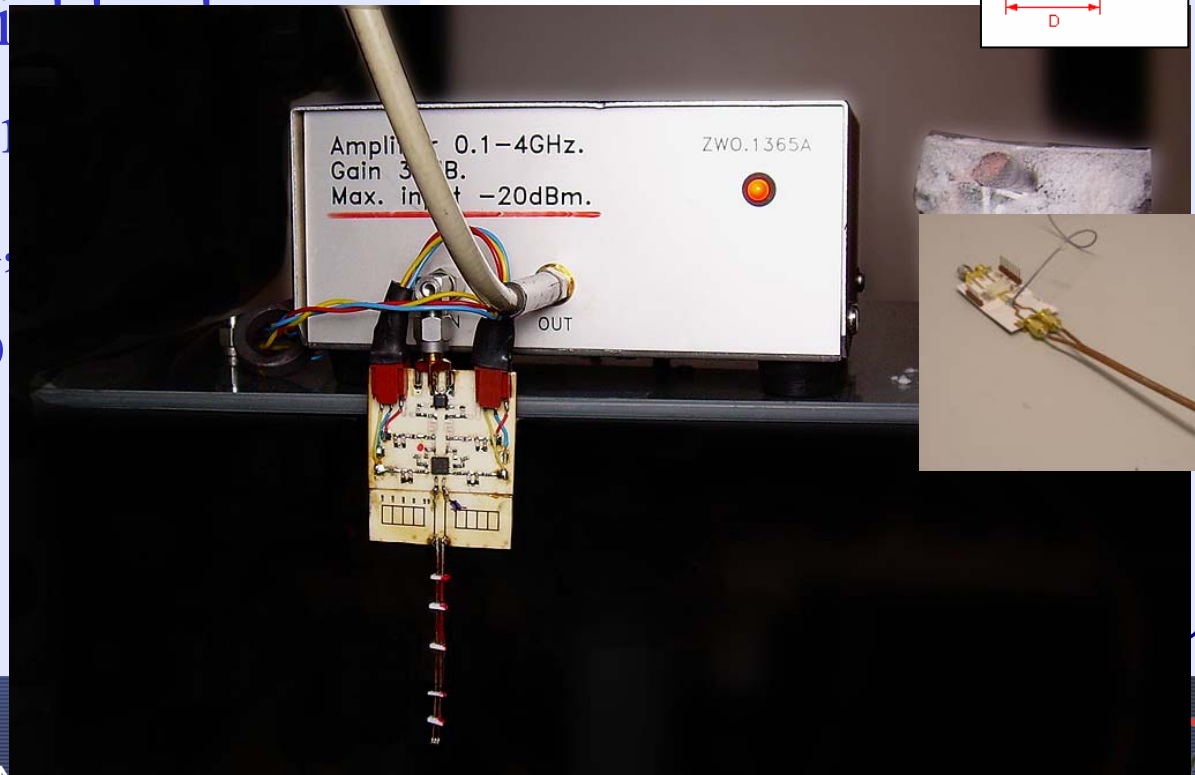
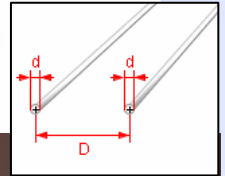
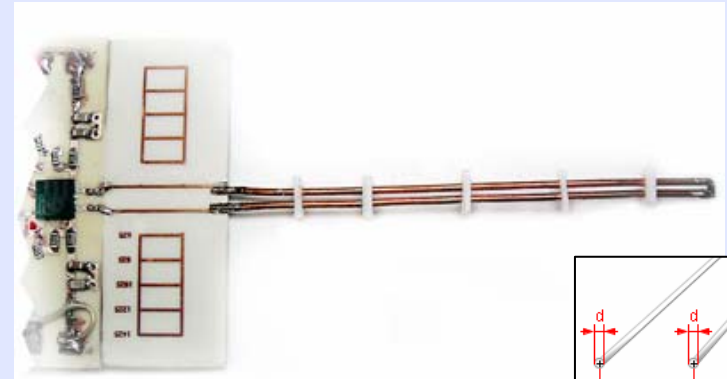


Characterization

- No IEEE definition for multiple input and output ports for noise figure
- J Randa, MTT transactions, 2001:
 - Based on noise matrixes, characterization of differential LNAs is possible with a series of hot-cold measurements
 - $\Gamma=0$, all ports terminated with matched loads
 - 9 noise parameters

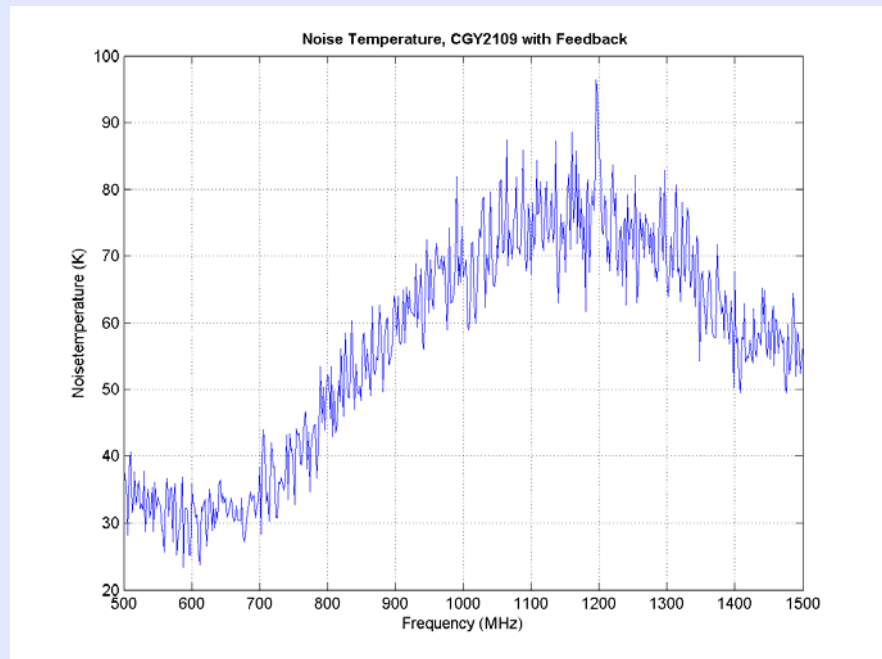
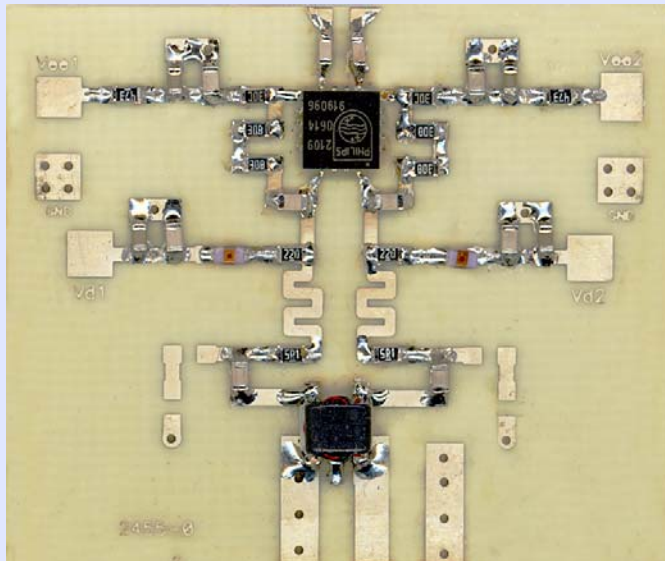
Characterization

- (differential) hot-cold:
 - The differential temperature
 - Arbitrary input
 - 290 kelvin
 - LNA temperature



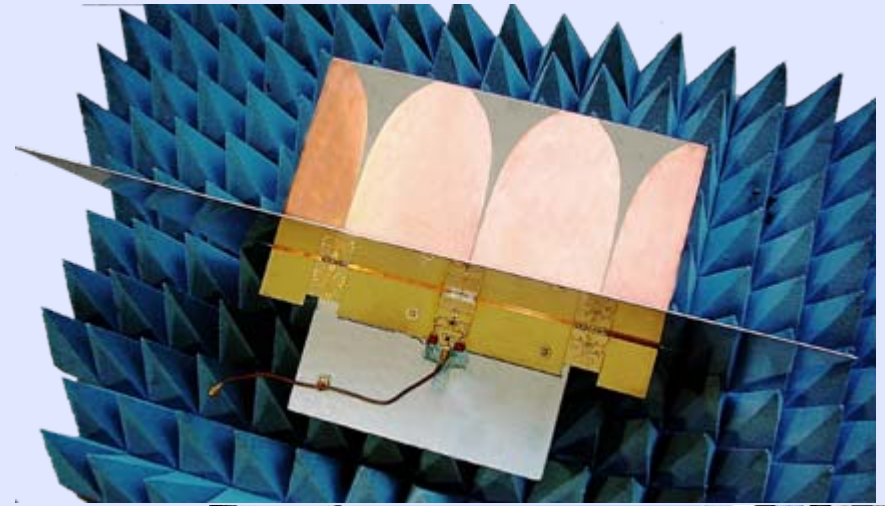
Characterization

- OMMIC COTS LNA



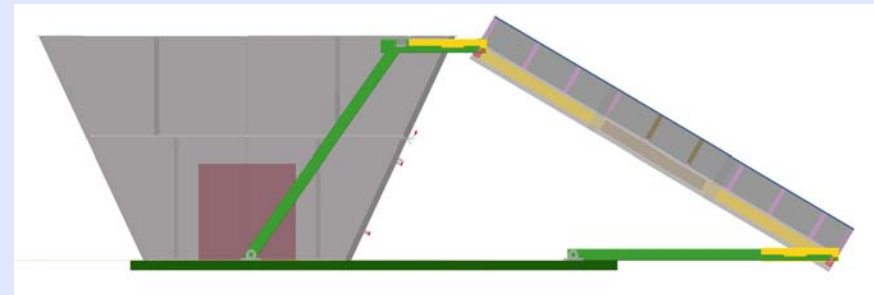
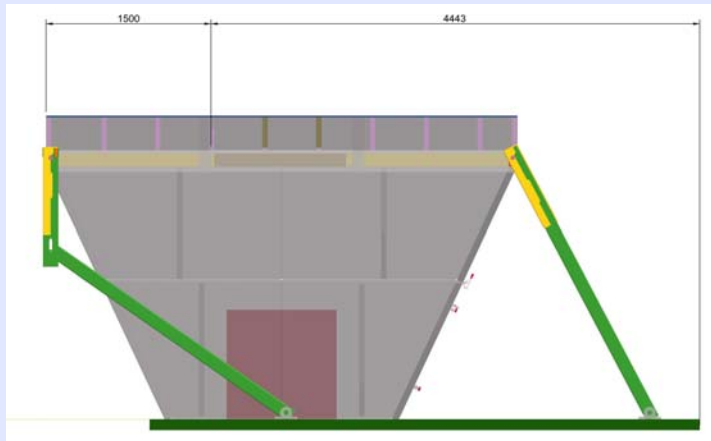
Characterization: Active antenna

- Hot cold test
 - 290 kelvin, 8 kelvin
 - Requires ground shield
 - RFI issues

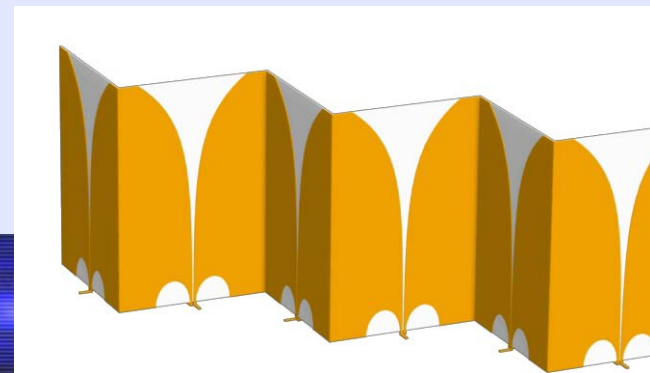
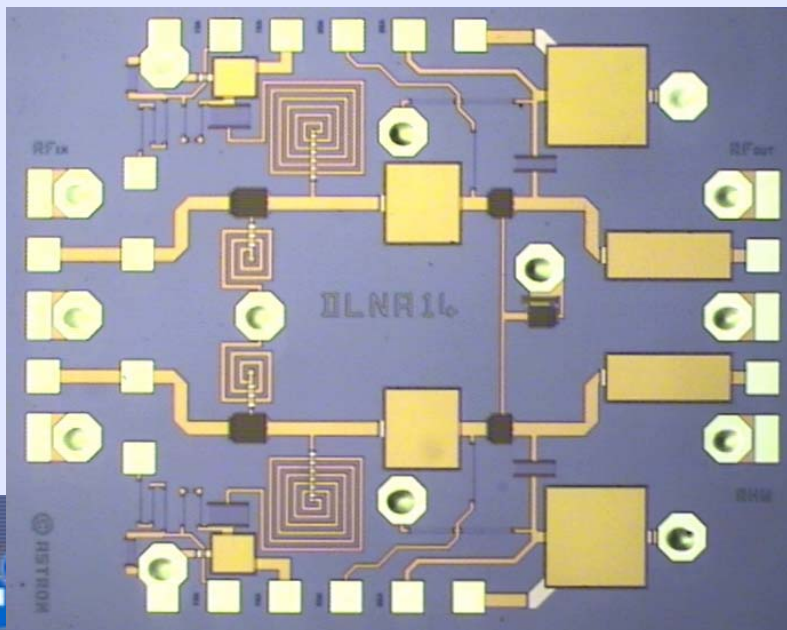
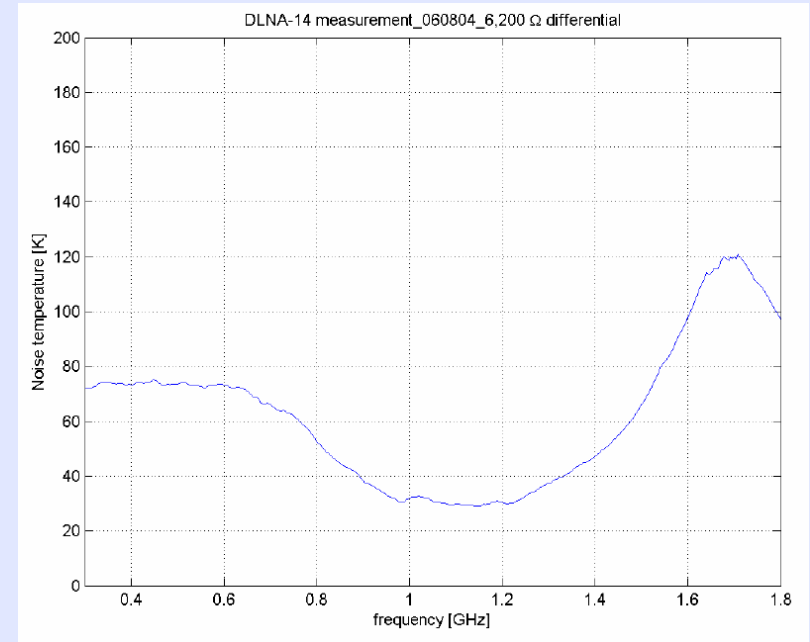


Characterization

- Hot cold test facility
 - Metal container (funnel) with removable load

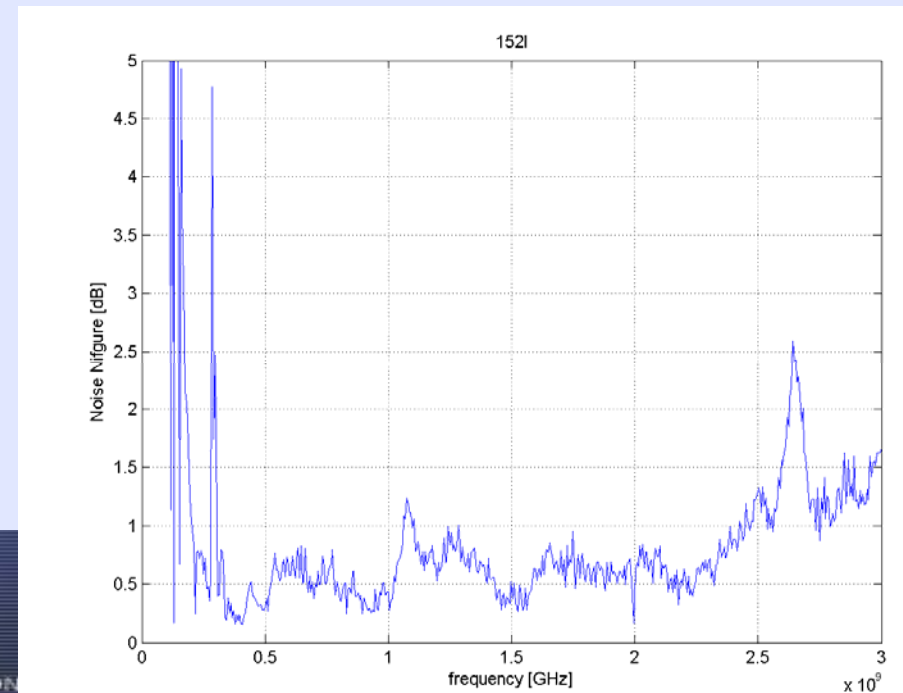
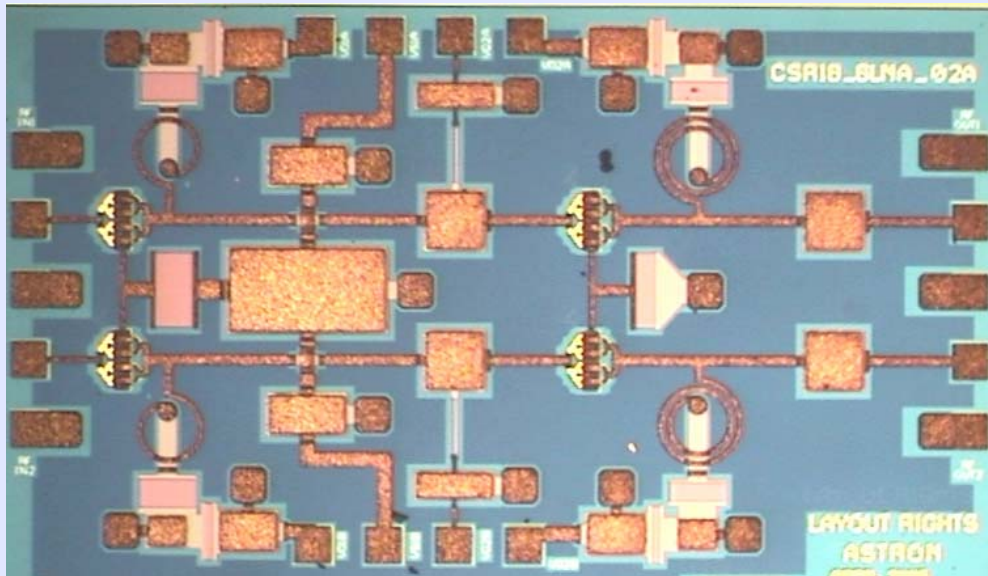


GaAs PsHEMT LNA



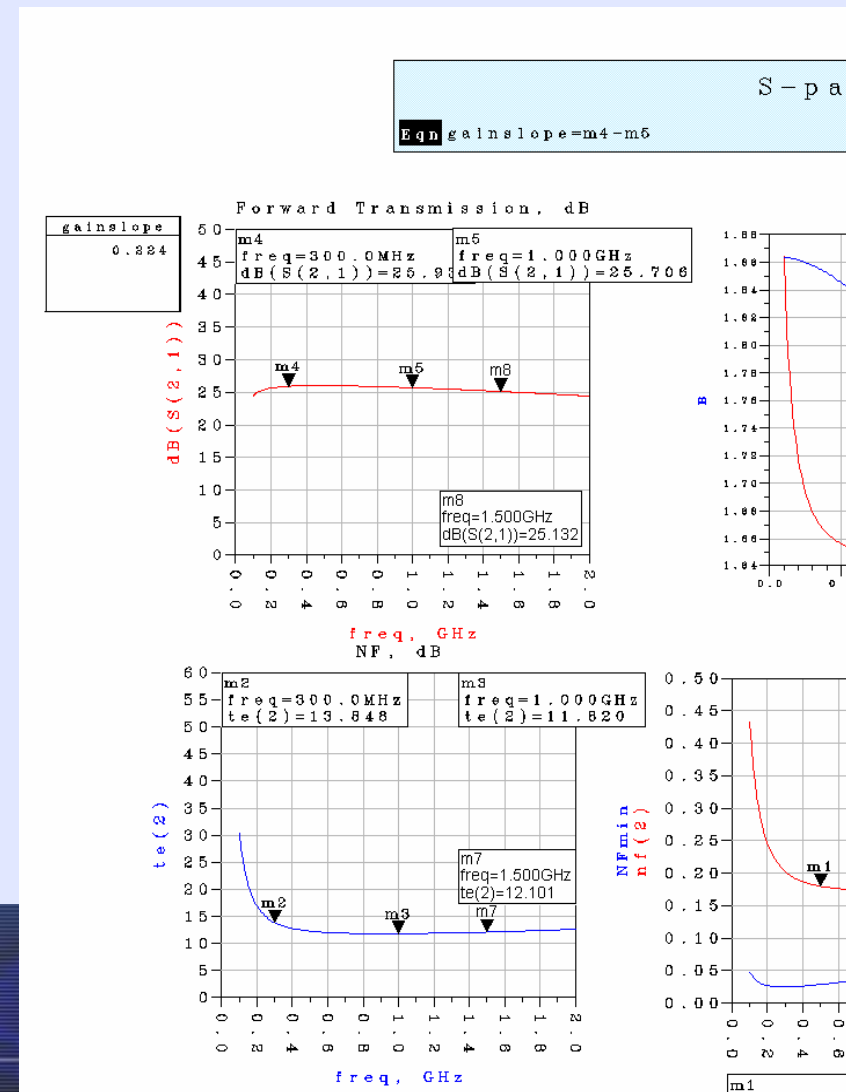
InP LNA

- NGST

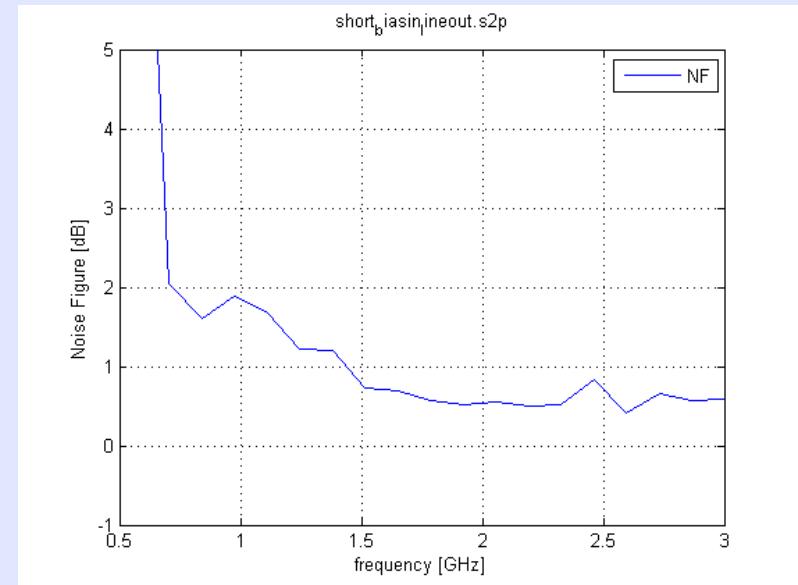
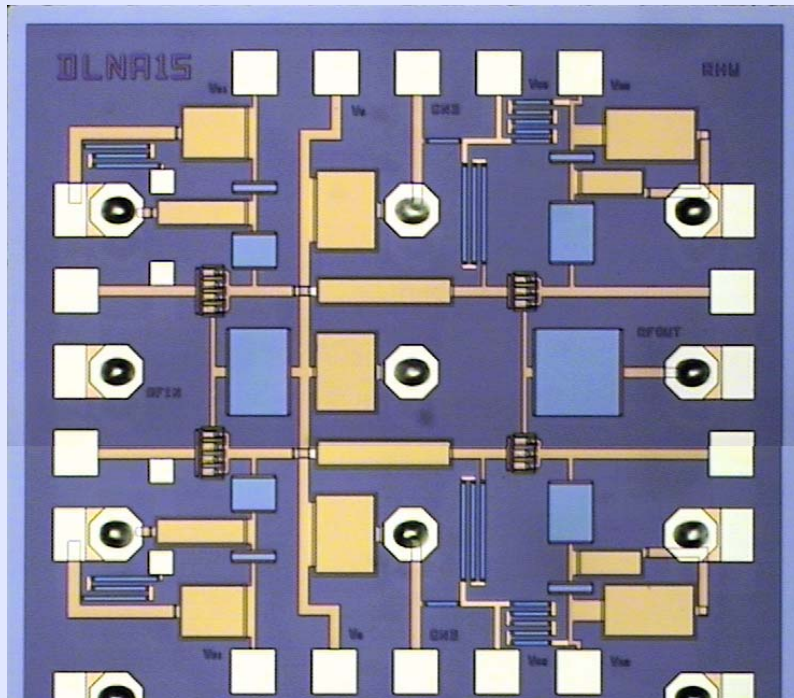


GaAs mHEMT LNA

- 70nm OMMIC technology
 - 250GHz fT
 - 150 Ohm input impedance



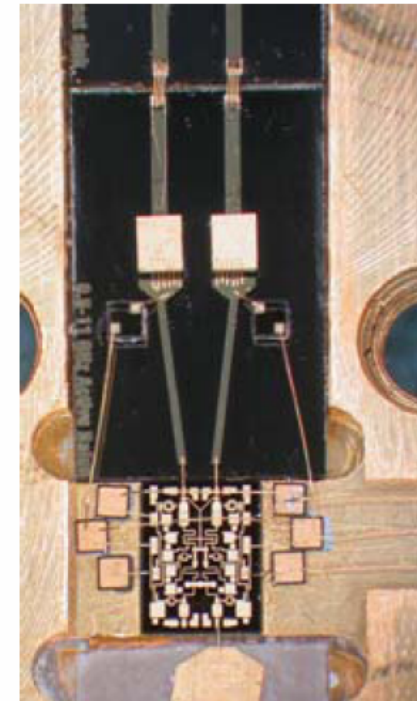
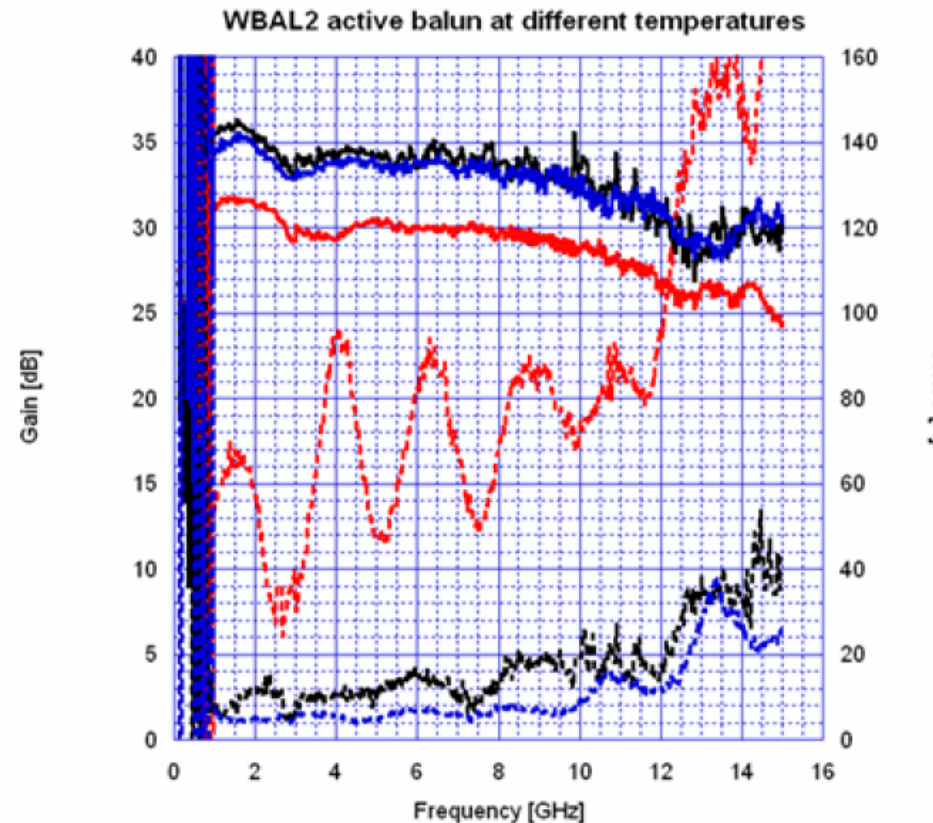
mHEMT LNA



InP LNA

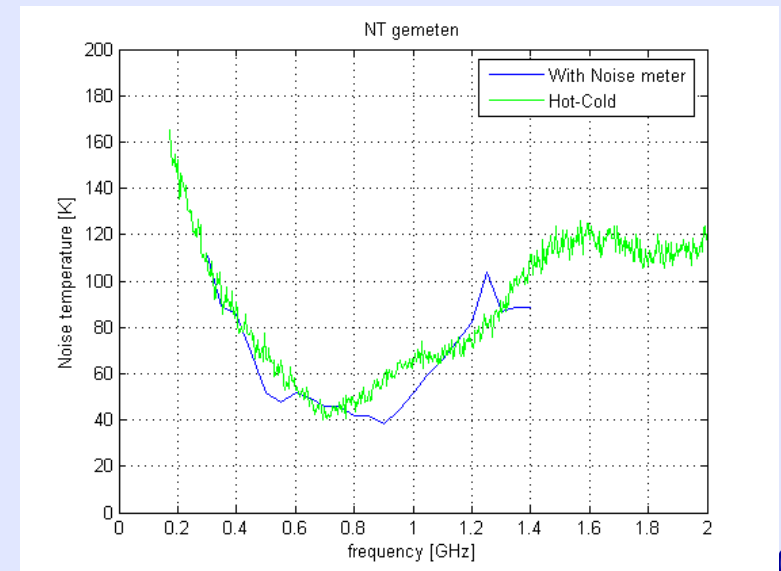
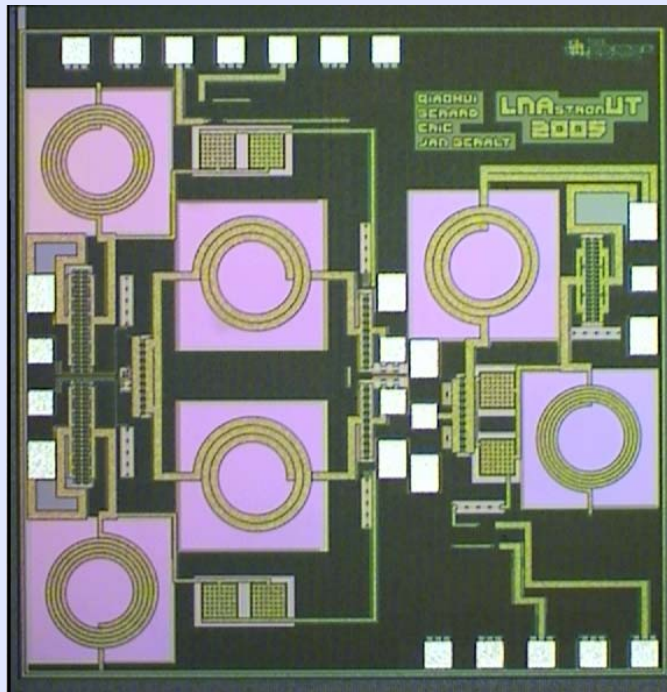
S Weinreb

Status 1.2 to 11 GHz - An active balun MMIC using NGST InP transistors has been developed at Caltech [8] with measured results at 3 temperatures shown in Figure 6 below:



CMOS

- 0,18 μm UMC



_0

Conclusion

- Differential LNAs essential for SKA
- Work to be done on design
- Work to be done on characterization
- Diff. noise parameters required?

FIVE DAYS ■ FOUR CONFERENCES ■ ONE EXHIBITION



**EUROPEAN
MICROWAVE
WEEK**
Amsterdam
27-31 October 2008
www.eumweek.com

EuMA

European Microwave
Association

Co-sponsored by:



Endorsed by:



Supported by:



an Institution of the IET

Organised by:



Official Publication:



CALL FOR PAPERS

Europe's Premier Microwave, RF, Wireless
and Radar Event

**Amsterdam RAI
Amsterdam, The Netherlands**

The 11th European Microwave Week combines:

- Four Major Conferences
- Associated Workshops
- Tailored Courses and Seminars
for industrial participants and scientists
- Leading International Trade Show