AA-lo AA-mid LNA Designs

Saswata Bhaumik

PDRA of:

Dr. Danielle George

The University of Manchester

Overview

- **Important considerations for SKA LNA**
  - Temperature Stability
  - Power Consumption
  - Noise
  - Design Aspects
  - Physical Dimension and Integration
  - Single ended and Differential LNAs
- **Pseudo-Differential LNA**
- **MMIC process considerations**

List of Measured HEMT Samples

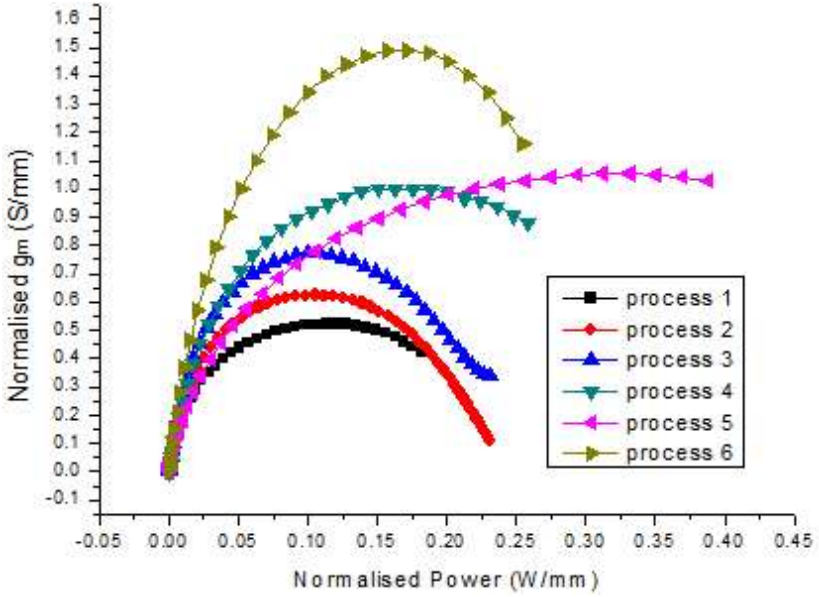
Process Sizes	Different samples	S-parameter Samples	Noise Samples	Details
1	8	8x4	7x2	150nm GaAs pHEMT
2	9	9x4	5x2	150nm GaAs mHEMT
3	4	4x4	4x2	150nm GaAs pHEMT
4	7	7x4	4x2	100nm InP pHEMT
5	8	8x3	8x2	130nm GaAs mHEMT
6	6	6x3	3x2	70nm GaAs mHEMT
7	1	1x6	-	150nm GaAs pHEMT
8	1	1x6	-	100nm InP pHEMT
9	3	3x6	-	100nm GaAs pHEMT
Total	**52**	**190**	**54**	**9 types**

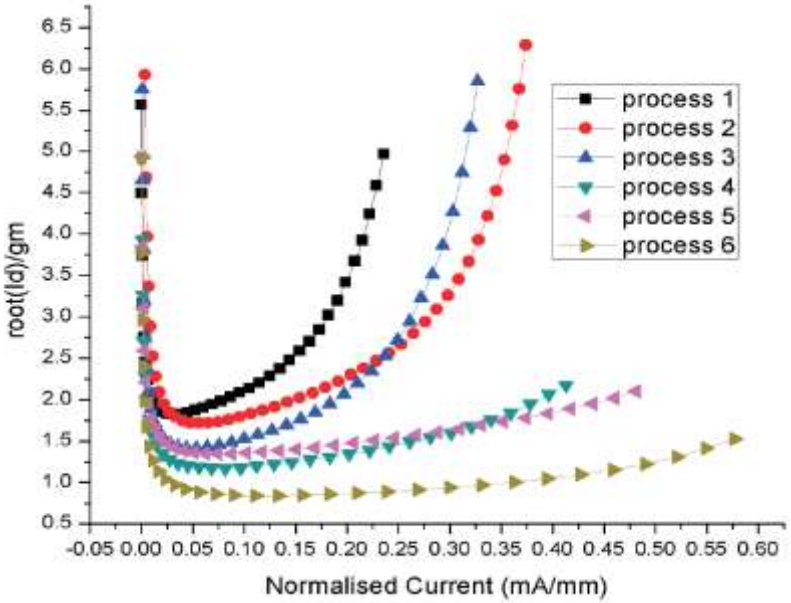
Important primary parameters of MMIC for LNAs:

1. Reliability
2. Repeatability
3. High Yield
4. Noise Measure
5. **Position of Gamma Opt in Smith Chart**

Power Efficiency

Process Investigation based on power efficiency

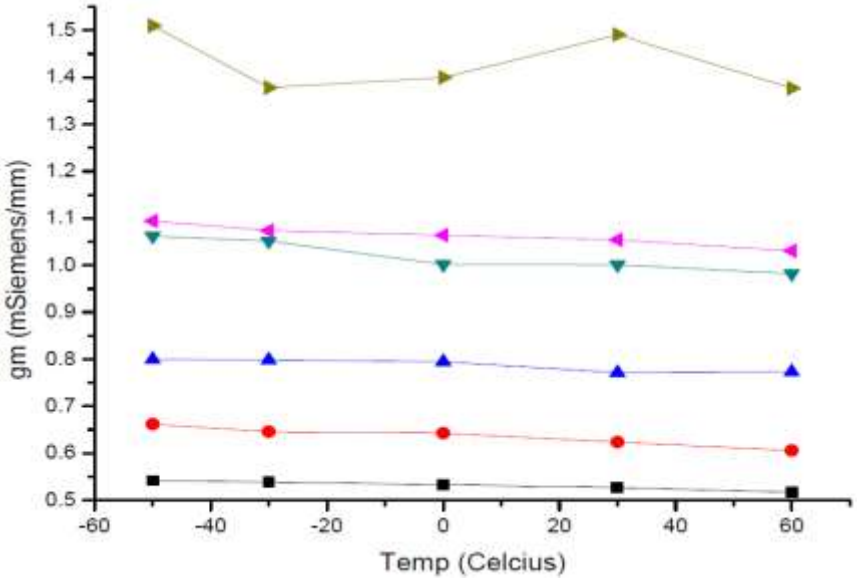


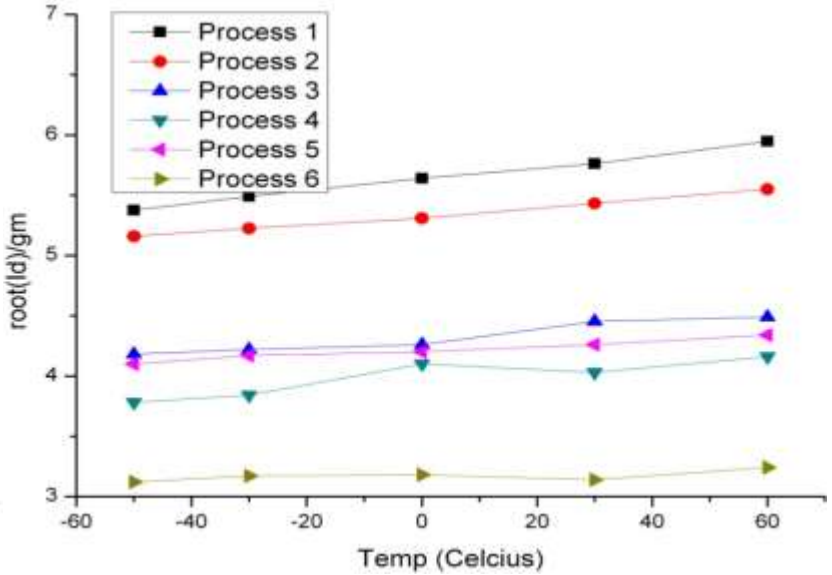


1. Millions of LNAs to be used in SKA
2. HEMT (InP and GaAs) technology studied here
3. Cost efficiency of different technologies
4. Power is traded-off with lower noise and higher gain

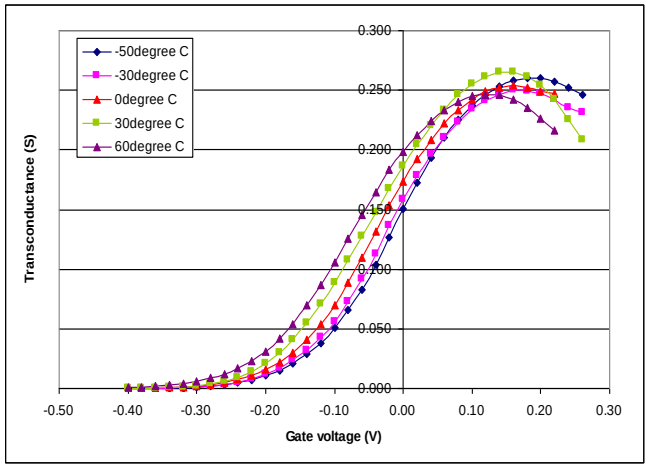
Temperature Dependency

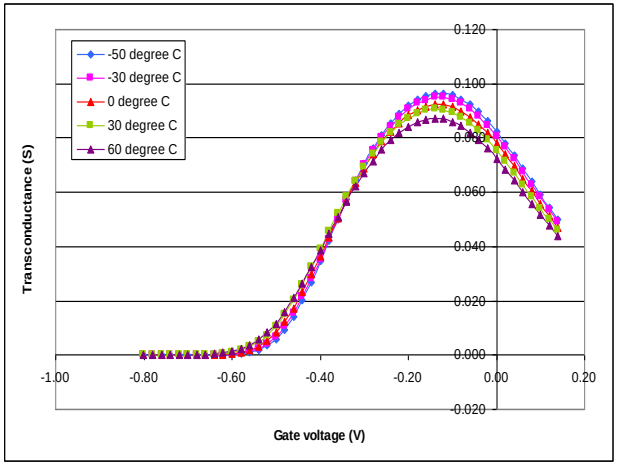
Process Investigation based on temperature dependency



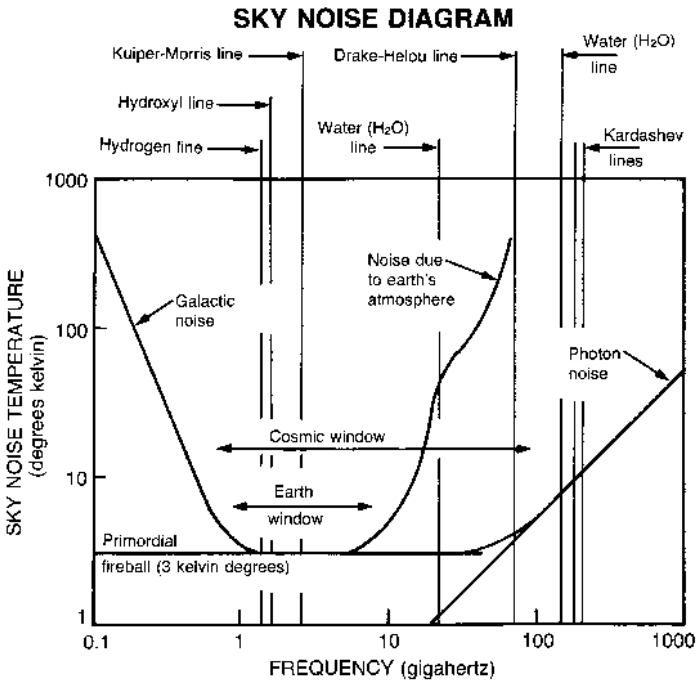


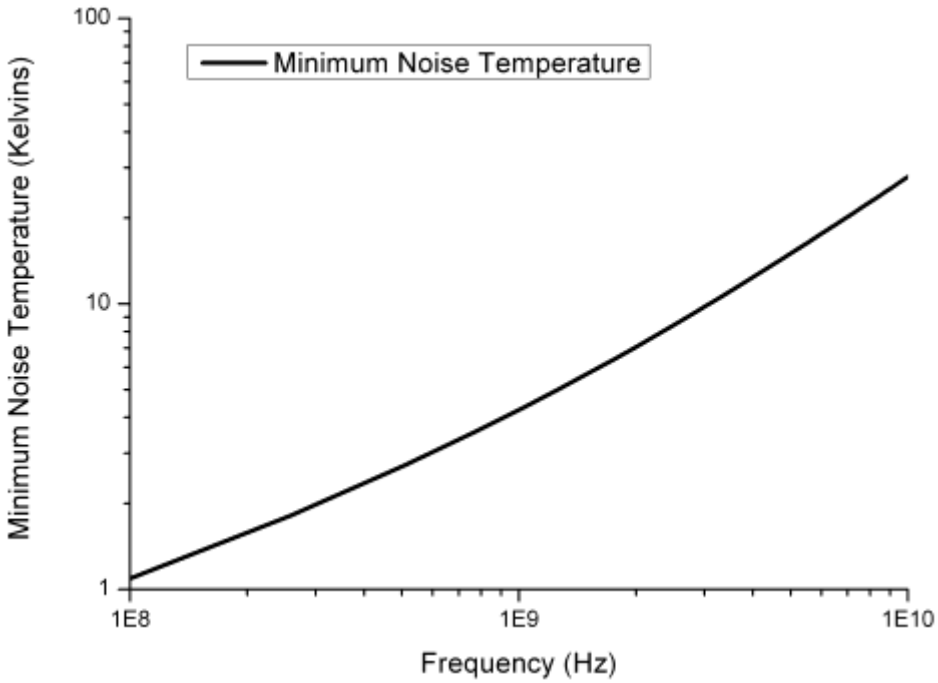
1. Temperature fluctuation varies gain and NT
2. Temperature stabilisation is vital for long observations
3. Optimum biases change with temperature
4. Temperature stabilisation?





Noise Aspects

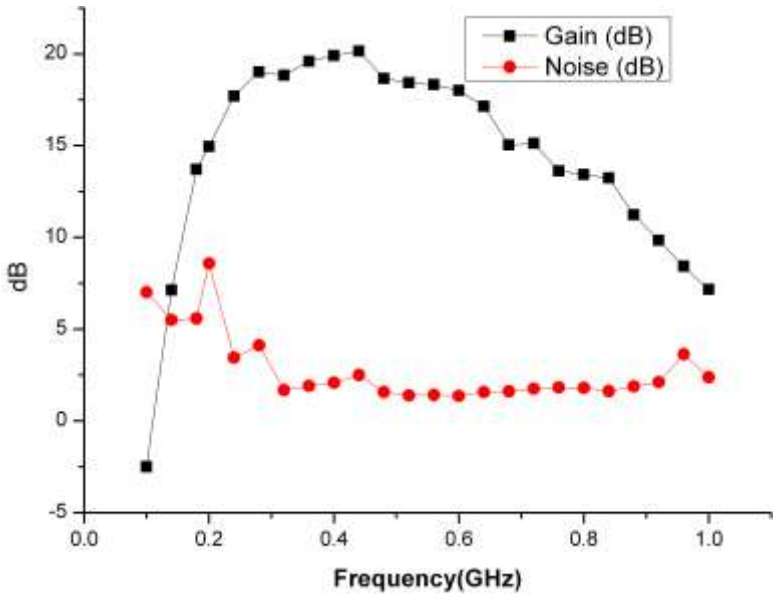


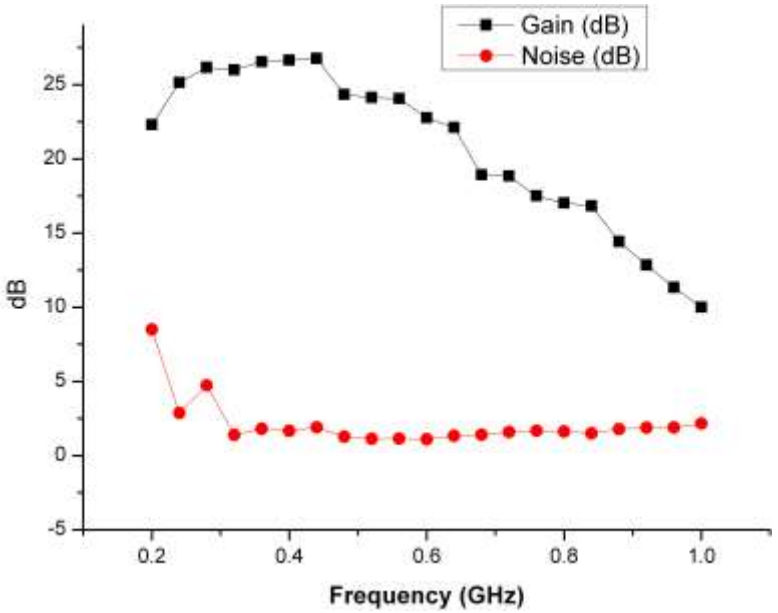


1. Galactic Noise Temperature is very high below 0.3GHz. Design considerations for low frequency SKA.
2. Single ended LNAs require balun. Balun loss is far below galactic NT for low-SKA.
3. Trade-off between NT, dimension of MMIC, fabrication cost.
4. Loss of hybrid passive components lower than equivalent MMIC structure.

AA-mid Pseudo-Differential LNA v1.1

Measured Performance



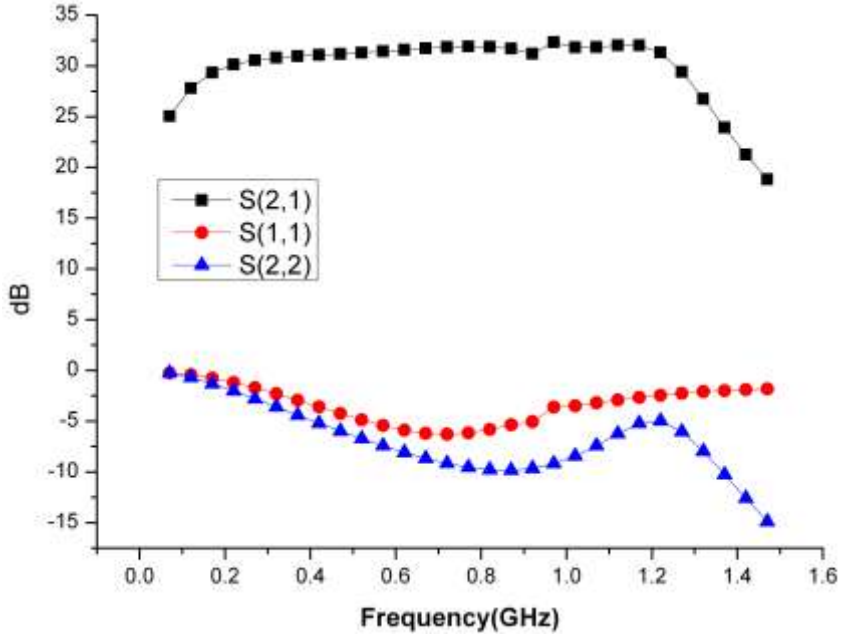


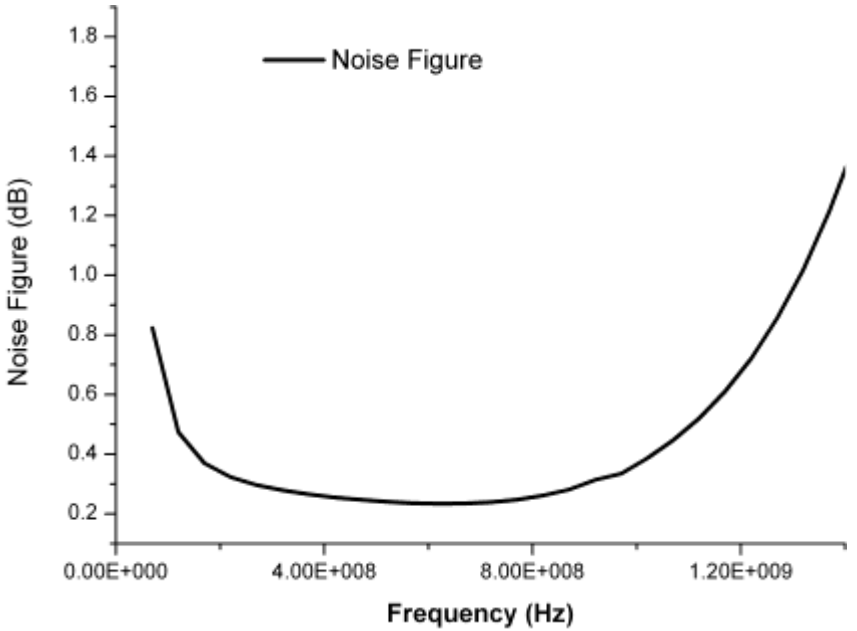
Details:

1. Number of components same as that in single ended LNA
2. Performs differential amplification
3. Power consumption same as single ended
4. No balun required
5. Further measurements required
6. Investigation of possibility of CMRR

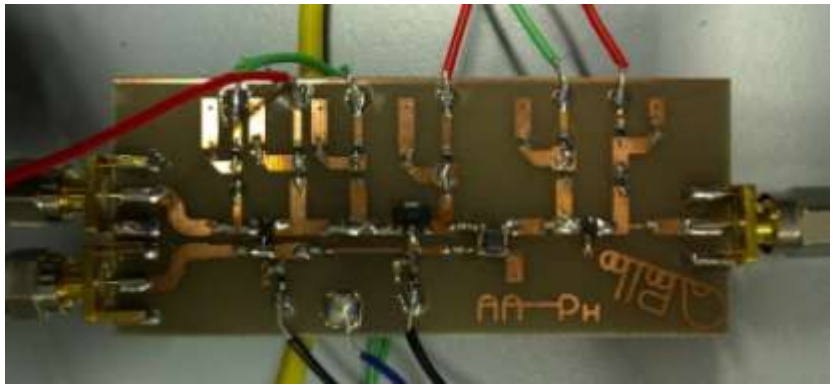
AA-mid Pseudo-Differential LNA v2

Simulated Performance

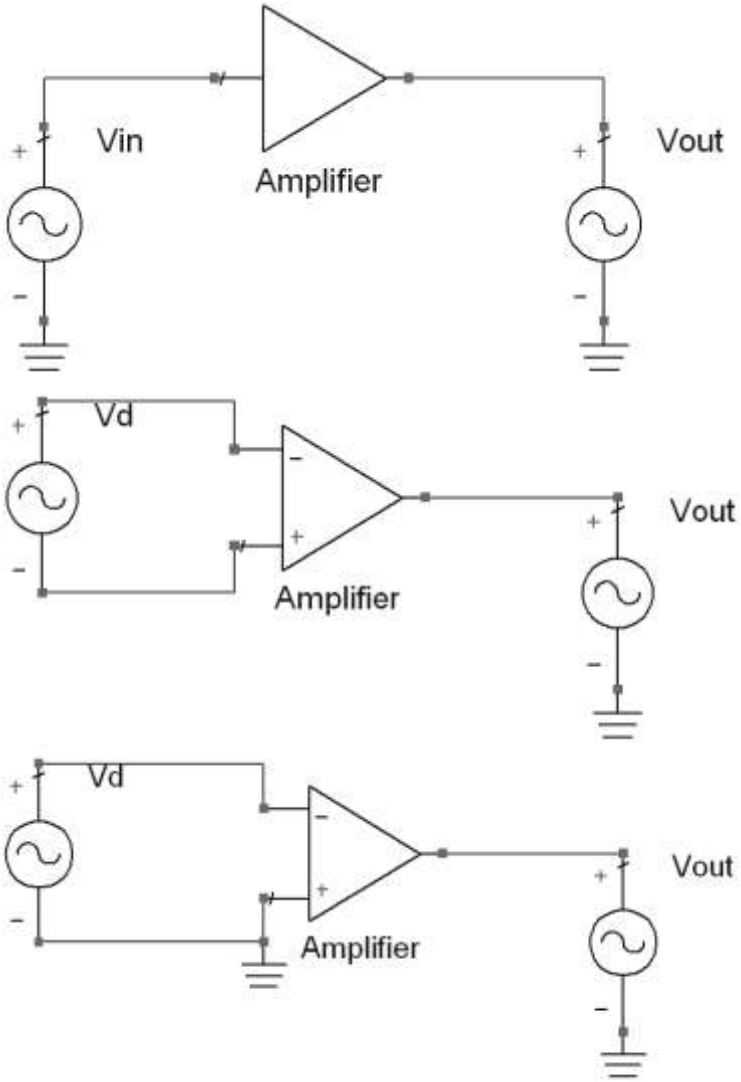




1. 3-stage LNA
2. 4V – 80mA drain bias for 3 stages
3. Enhancement mode pHEMTs of Avago



LNA Topologies



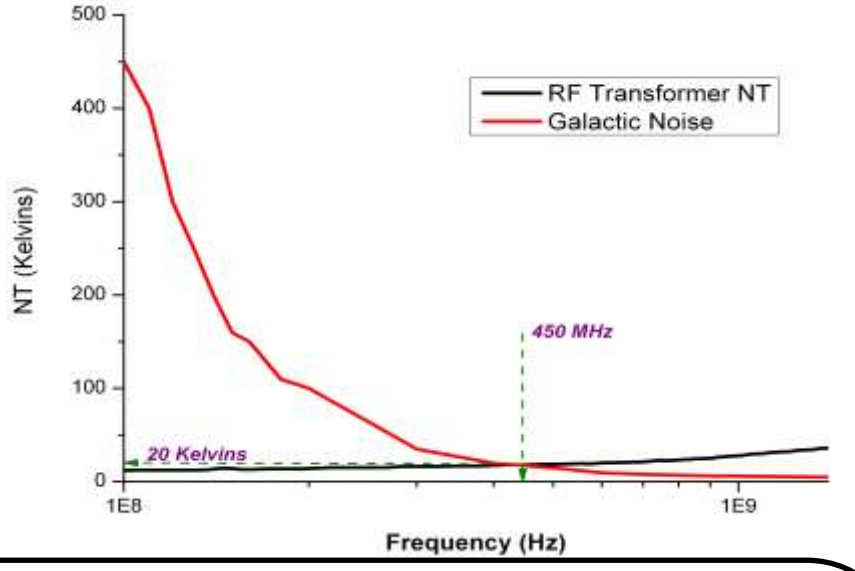
	SE LNA	D LNA	pD LNA
Component number	x	2x	x
Power	x	2x	x
System Noise	System Noise Higher	System Noise Lower	Needs Investigation (theoretically low)
Maturity	Matured	Inter mediate	New
Design Complexity	Simpler	Complex	Complex
Measurement	Well Established	Noise – Complex	Noise - Complex
Cost	Cheaper	Costlier	Cheaper

Table for the comparison of different LNA topologies

AA-lo LNA

AA-lo LNA:

- Pseudo-differential LNA topology can be scaled to 70MHz – 450MHz.
- 2 SE designs using RF transformers have been designed



Simulated results:

1. Two hybrid LNA designs.
2. 2-stage LNAs with differential input and single ended output.
3. Enhancement mode pHEMTs of Avago Technology
4. Operational from 50MHz to 400MHz.

5. LNA1:

- Gain above 25dB.
- NT below 35Kelvin between 100MHz and 450MHz 20Kelvin at 330MHz.
- 4V – 121mA drain bias (at PSU).
- $P1dB_{IN}$ point of -23dBm at 0.4GHz.

6. LNA2:

- Gain above 36.7dB.
- NT below 36Kelvin.
- P1dBIN is -24dBm at 0.4GHz.
- 3V – 60mA drain bias and 0.5V at gate

Conclusions and Further Work

- HEMTs of 9 different low noise processes have been thoroughly investigated – **power, temperature dependency, chip dimension.**
- Processes shortlisted by Manchester will be further investigated from November.
- **Pseudo differential LNA** shows potential.
- Pseudo differential LNA v2 is being measured.
- Low frequency SKA LNA will be measured subsequently.
- MMIC versions of pseudo differential LNA are being designed for wafer run next year.
- Development and production of processes when LNAs will be fabricated.