Tu1D-2

Ku/K-Band Low Power Dual-Channel LNAs With Less Than 1.4dB NF for SATCOM Phased Array Applications

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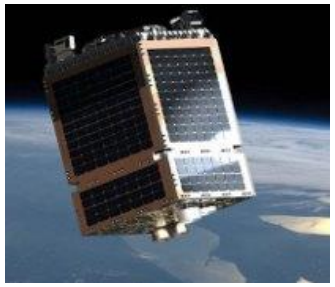
RENESAS

RACE FOR SATCOM

- **Higher thruput makes SATCOM extremely desirable for next generation of communication system.**
- **Lower latency, path loss and cost makes LEO a better choice.**
  - **Needs phased arrays!**

STARLINK

OneWeb



TELESAT

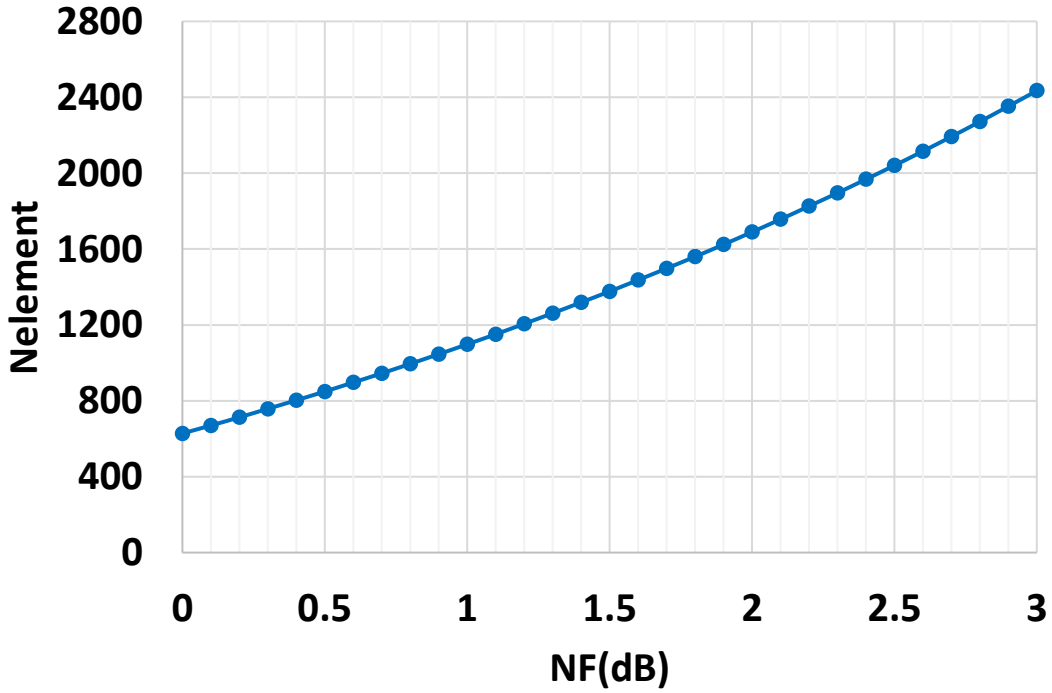
amazon

OUTLINE

- Introduction
- LNAs for SATCOM applications
- Design of the Low Noise Amplifier
- Measurement Results
- Summary

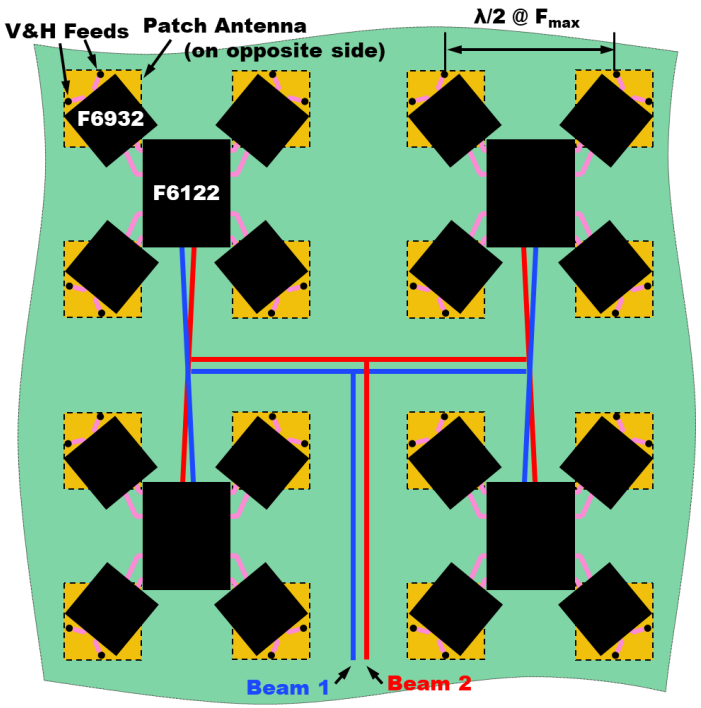
RX NF Effect on Array Implementation

- G/T is a crucial metric for link budget.
- For a desired G/T, antenna gain, and directivity receiver NF sets the required number of elements.



Optimized Array for Improved NF

- **Multi-channel beamformers are used to reduced the required number of Ics.**
  - **This adds extra routing which results in extra loss!**
- **One solution: Add LNAs right at the antenna**
  - **Requires dual-channel LNAs**



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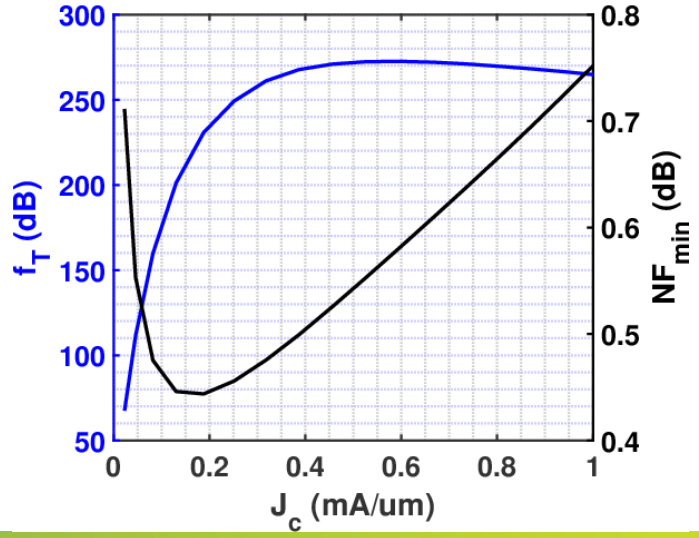
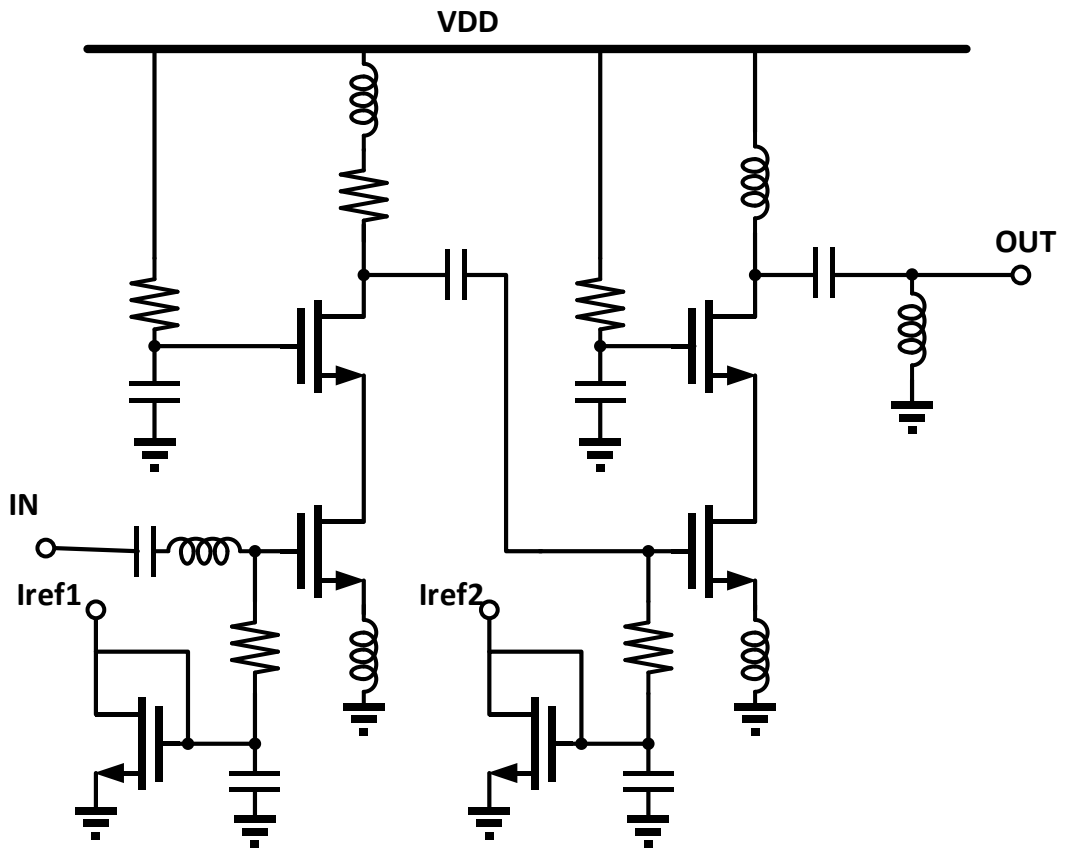
LNA IMPLEMENTATION

- **Ku (10.7GHz-12.7GHz) and K (17.4GHz-21.4GHz) band are most commonly used for SATCOM RX.**
- **Goal: Design dual channel LNAs for both bands**
  - **Large numbers are used in arrays so P_{dc} is a key factor.**
  - **SOI Technology is a great choice due to low NF_{min} and high interconnect Q.**



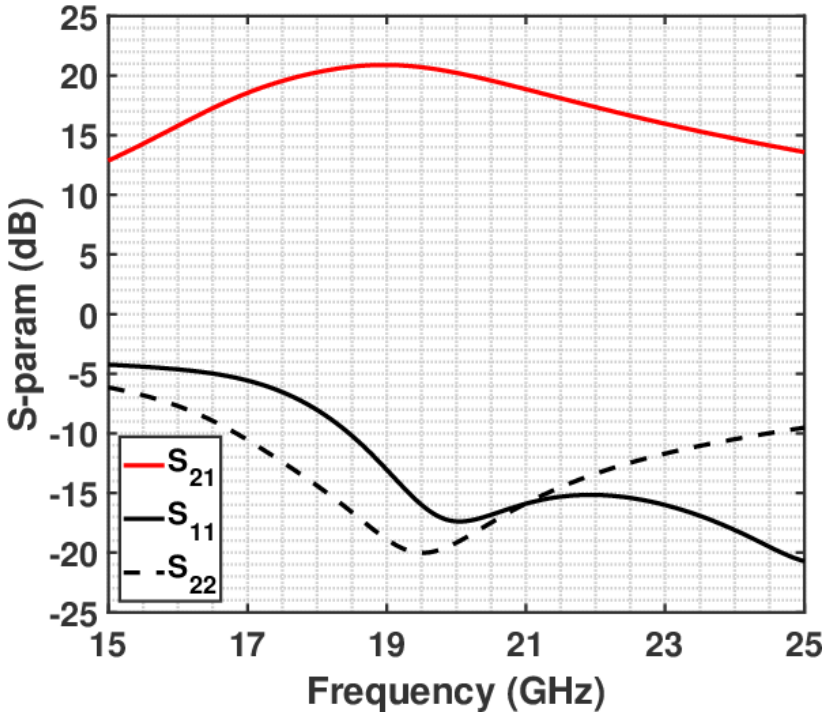
LNA TOPOLOGY

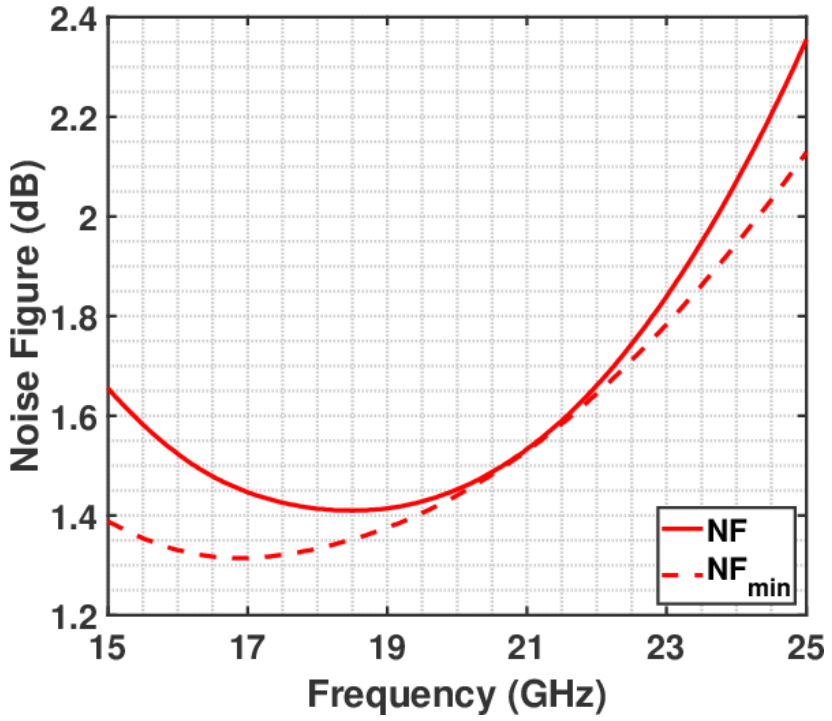
- **Two-Stage cascode topology is chosen**
  - **Provide high gain and low NF**
  - **Better stability**
  - **ESD protection thru:**
    - **Output shunt inductor**
    - **Input on-package shunt inductor**
- **Floating body device provides better NF.**
- **Two-sided gate contact is used to reduce Rg.**



K-Band LNA Simulation Results

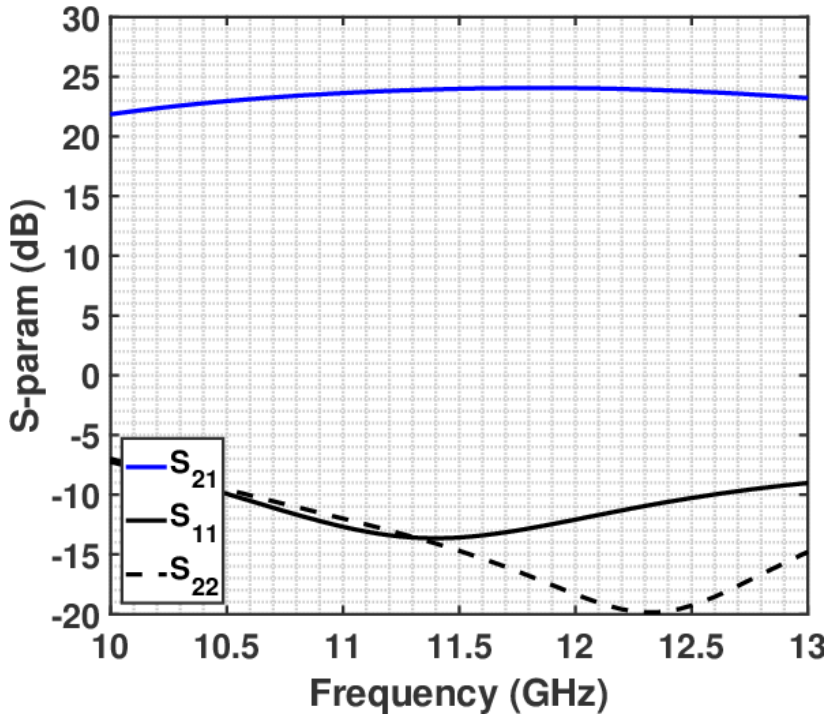
- **Simulation Methodology:**
  - **EMX software is used for EM simulation of all interconnects above fourth metal layer.**
  - **All other interconnects including the cores are extracted with Calibre RCCC**
- **Two-Stages burn 14mA from a 1.3V VDD.**

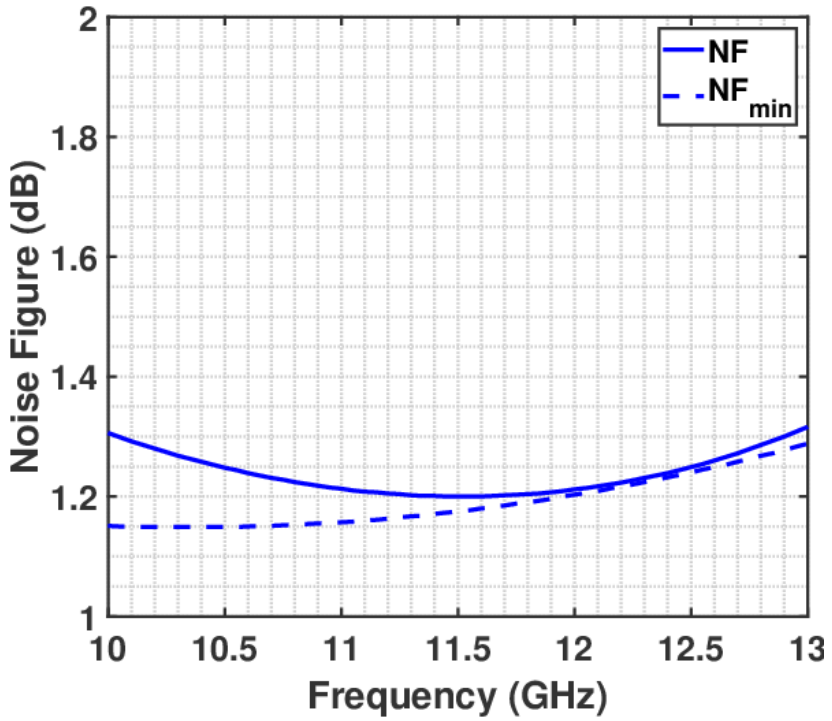




Ku-Band LNA Simulation Results

- **Two-Stages burn a total of 9mA from a 1.3V supply.**





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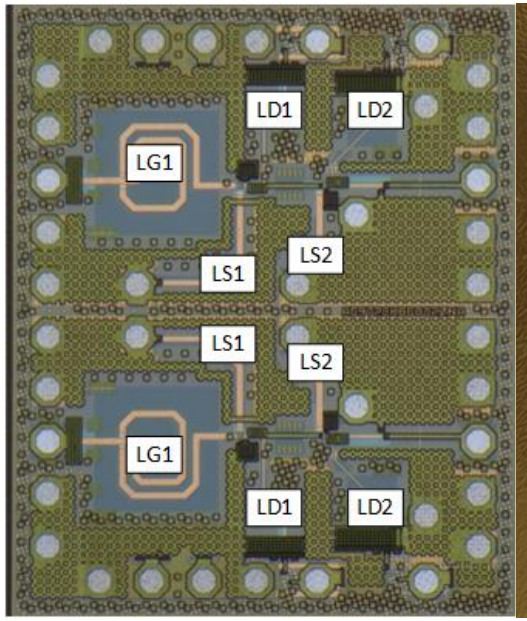
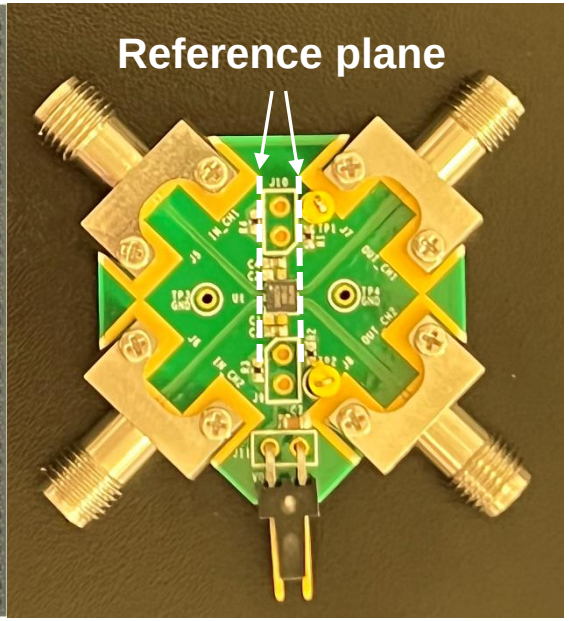
Measurement Setup

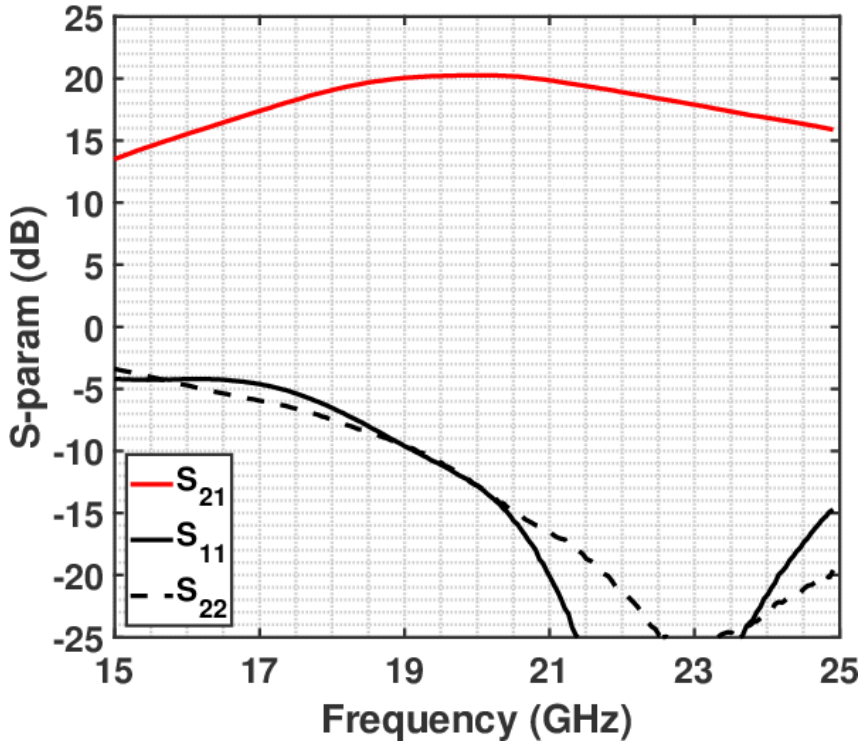
- **Chip was fabricated in GF 45RFSOI technology.**
- **Flip-Chip-Chip-Scale (FCCS) is used to package the part.**
- **Part is measured through a Keysight PNA-X.**
  - **Measurement reference plane is moved to the IC pin using AFR.**

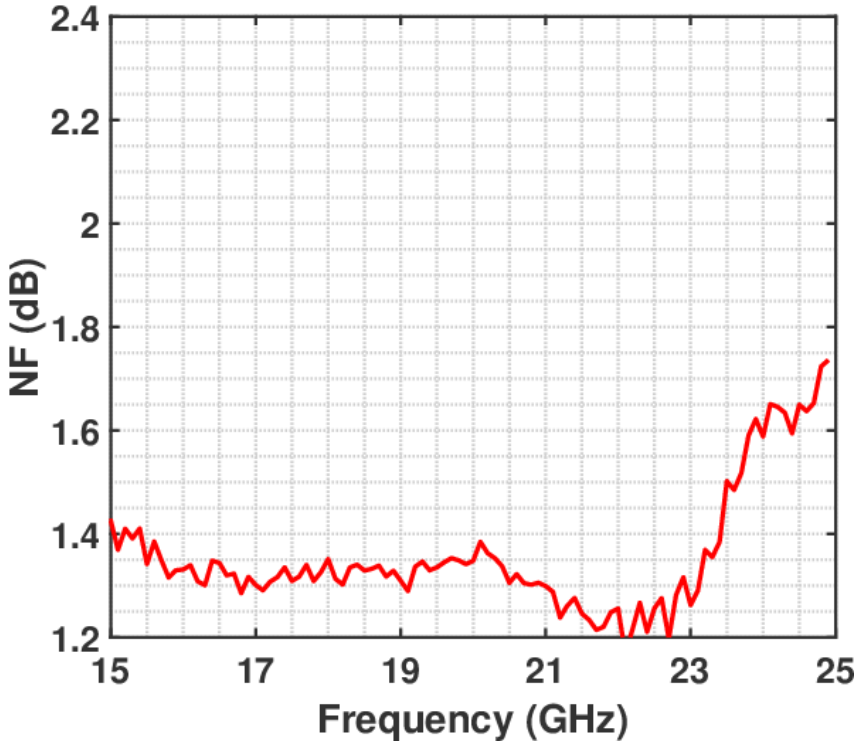




K-Band LNA Measurement Results

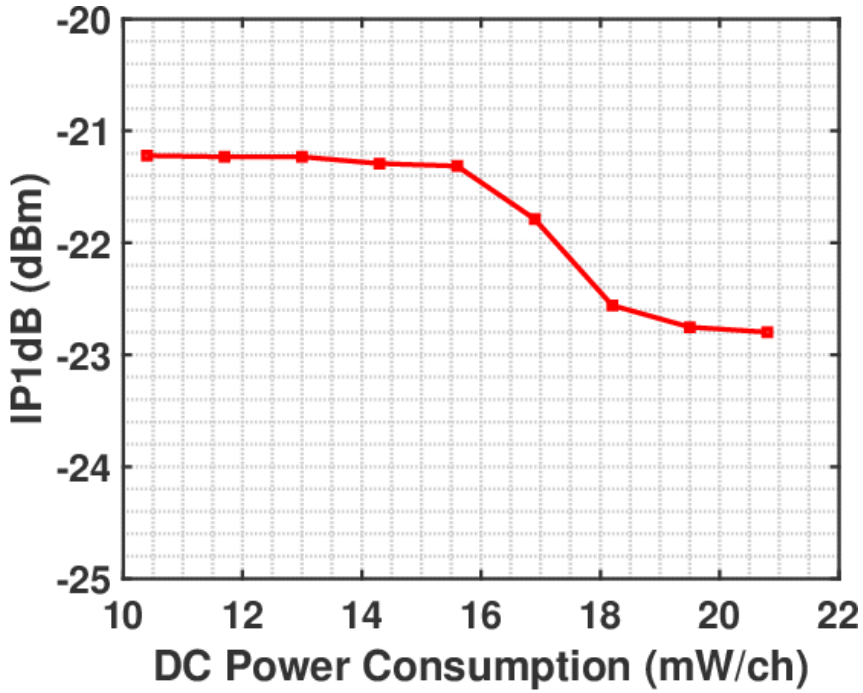
- **Biasing the LNA at 1.3V VDD and 14mA/ch current consumption.**

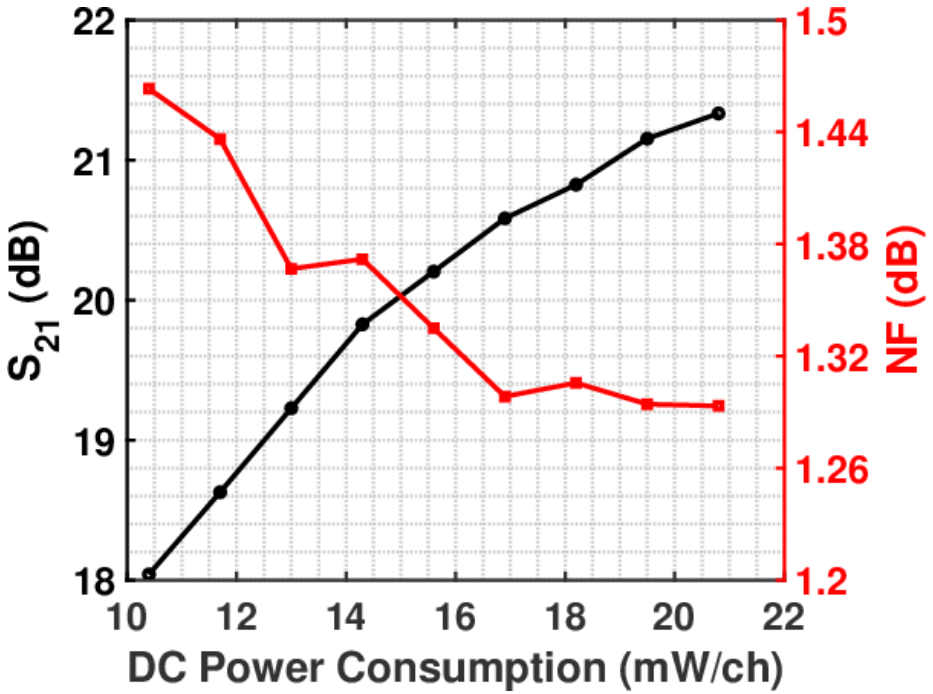




K-Band LNA Measurement Results

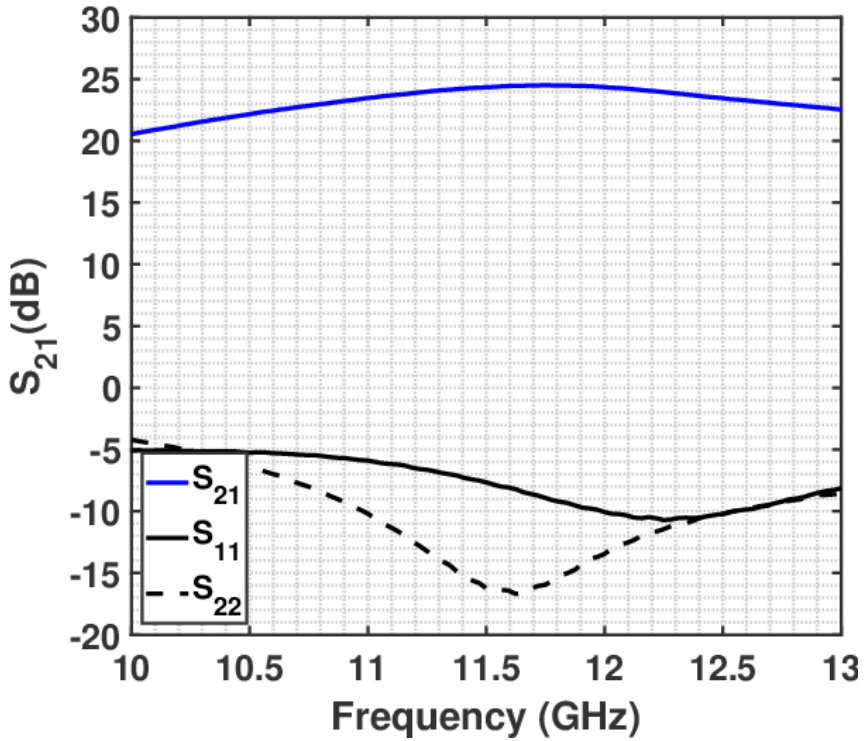
- **Sweeping the reference current demonstrates the trade-off between Pdc and RF performance.**

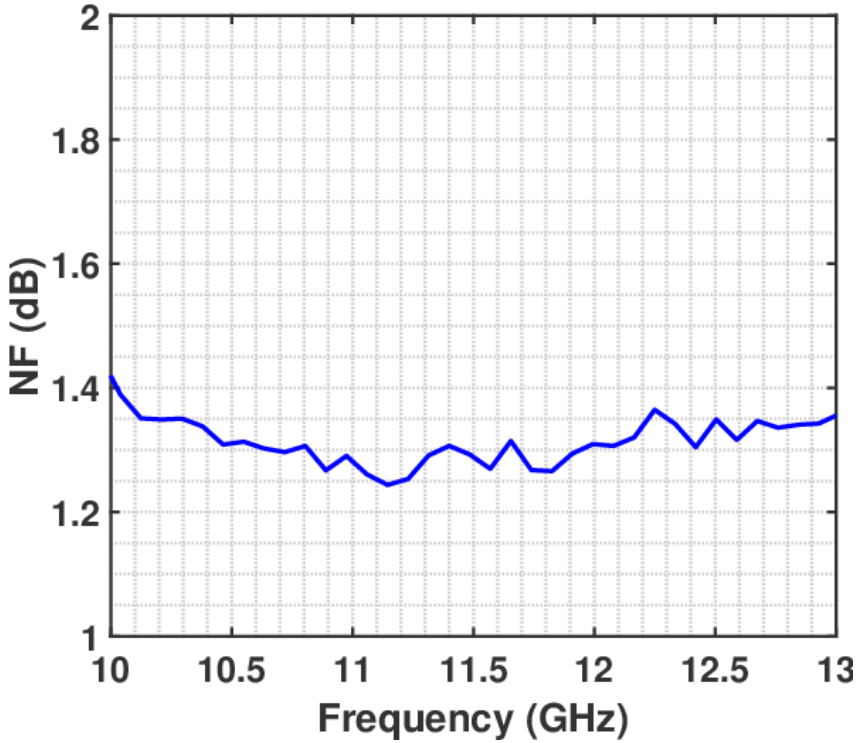




Ku-Band LNA Measurement Results

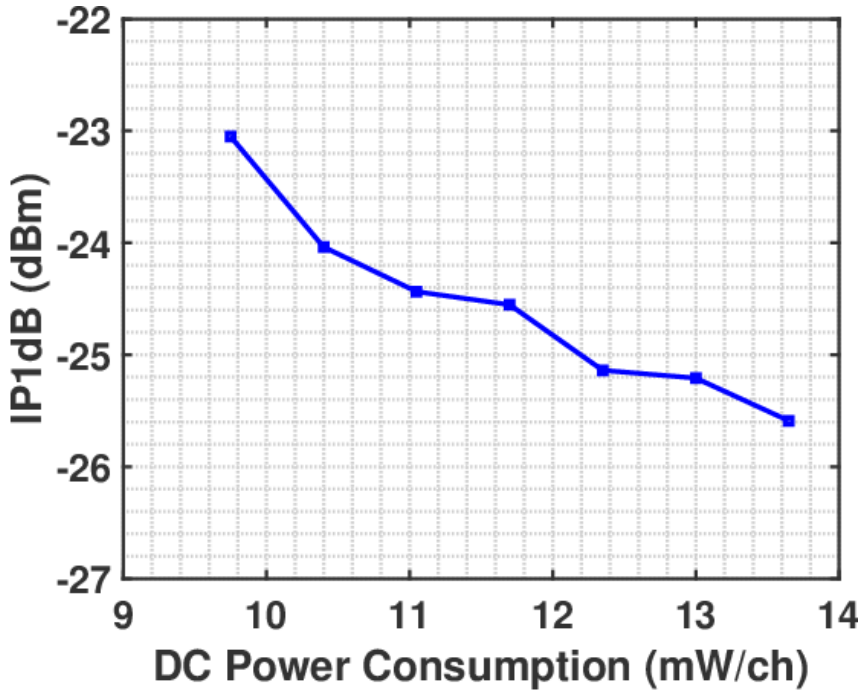
- **Biasing the LNA at 1.3V VDD and 7.5mA/ch current consumption.**

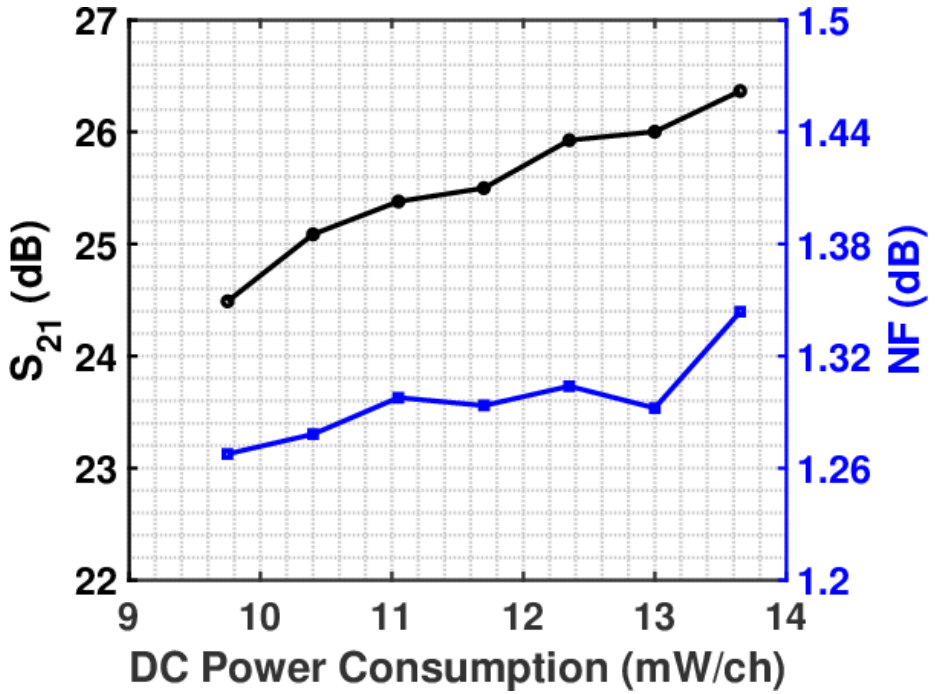




Ku-Band LNA Measurement Results

- **Lower current benefits NF and IP1dB at the price of less gain.**





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State-of-the-Art Comparison

Reference	This Work		[1] IMS 2019	[2] IMS 2018
Frequency (GHz)	10.7-12.7	17.4-21.4	13.9-22	24-28
Peak Gain (dB)	23	21	23.1	14
Min NF (dB)	1.3	1.35	1.5	1.4
DC Con. (mW)	9.5	15	12.5	15
IP1dB (dBm)	-21	-22	-21.6	-4.6
Package	FCCSP	FCCSP	FC	On-Wafer
Die Area (mm^2/ch)	0.84	0.84	0.7	0.3

SUMMARY

- Dual channel LNAs for Ku and K band LNAs for SATCOM applications are presented.
- Packaged LNAs achieve better than 1.4dB noise figure with low power consumption.
- This work paves the way for more efficient RX antenna array by reducing the number of elements and power consumption.
- Future work should focus on further improvement in NF while achieving better power match.

References

- [1] A. H. Aljuhani and G. M. Rebeiz, “A 12.5 mW Packaged K-band CMOS SOI LNA with 1.5 dB NF,” IMS 2019.
- [2] C. Li, O. El-Aassar, A. Kumar, M. Boenke and G. M. Rebeiz, “LNA Design with CMOS SOI Process-l.4dB NF K/Ka band LNA”. IMS 2018.

Thank you for your attention!

Back-up Slides