Paper ID: 93

Design of a Multi-Stage Common Source LNA with Enhanced Gain and Noise Performance for SIGINT Applications

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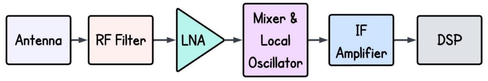
ABSTRACT & INTRODUCTION

This research offers a multi-stage Common-Source Low Noise Amplifier (CS-LNA) with high gain and excellent energy efficiency using 90 nm CMOS technology. The use of a LNA in SIGINT systems has sparked substantial attention due to its ability to enhance weak signals while reducing external noise. Achieving a low noise figure while minimizing power consumption is a significant problem in LNA design for portable devices. The common source arrangement offers optimal performance, simplicity, scalability and CMOS compatibility with source degeneration. A single-stage CS-LNA is simple to develop but has limited gain, stability concerns and inferior noise performance. Multi-stage CS-LNA offers increased tuning freedom, improved impedance matching control, signal integrity, sensitivity and stability. This proposed LNA shows a noise figure (NF_{min}) of 6.21 dB and power gain of 34.43 dB over the frequency range of 7.069 GHz to 7.4588 GHz.



OBJECTIVES

- Design a wide band low noise amplifier for high frequency.
- Design input and output matching network for impedance matching.
- Design an a multi-stage amplifier for higher gain in SIGINT application.
- Analyze the performance of the proposed amplifier for low power consumption.
- Design a stable LNA to avoid parasitic oscillations.
- Add feedback for cancelling out the potential oscillatory signals.

METHODOLOGY

Design Topology

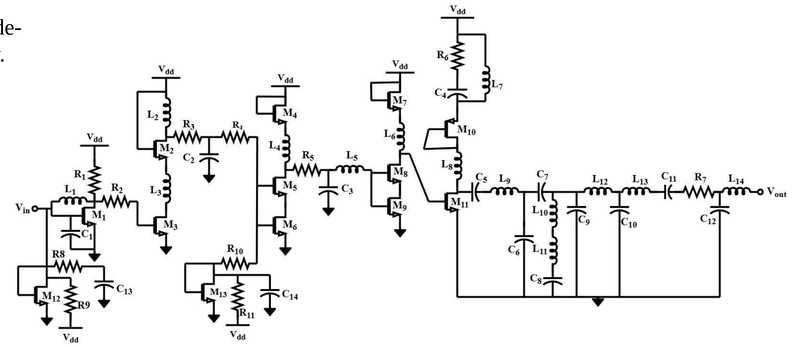
- **Architecture:** 5-stage CS-LNA
- **1st stage:** CS with resistive load.
- **2nd–5th stages**: CS with inductive loads for better high-frequency performance.
- **Matching Network:** Cascaded T, L, and π networks ensure impedance matching to 50 Ω.
- **Biasing:** Current mirror biasing and diode-connected MOS for stability and linearity.

Technology & Tools

- **Process Node:** 90 nm CMOS.
- **Simulation Tool:** Cadence Virtuoso.
- **Application Target:** SIGINT (Signals Intelligence).

Special Design Features

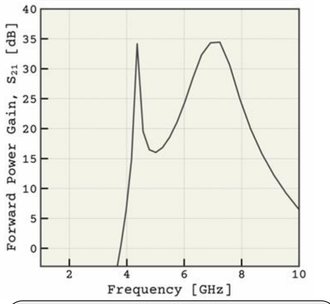
- **Noise Cancellation:** 2nd to 4th stages configured to suppress thermal noise.
- **Source Degeneration:** Inductor used at the source improves stability and linearity.
- **Component Optimization:** Capacitors, inductors, and transistors fine-tuned for target bandwidth.



Schematic Diagram of the proposed LNA

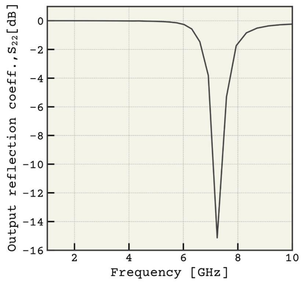
RESULT

Forward Transmission Coefficient



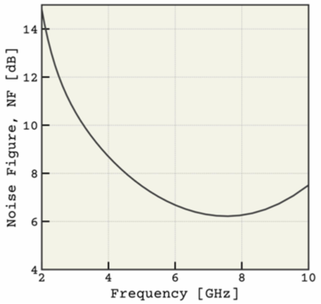
- Indicates larger gain & Strong Amplification.
- Output power is more than 100 times larger than the input power.

Output Reflection Coefficient



- Indicates how well the output is matched to the load.
- Minor amount of output power is reflected back at output port

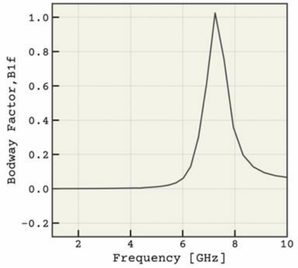
Noise Figure



- Measures how much noise the amplifier adds to the signal.

RESULT

Stability Factor



- Determines if the amplifier is unconditionally stable.
- B1f > 0 indicates unconditional stability.

FUTURE WORK

- Designing the Layout of the proposed Low Noise Amplifier
- Implementation and fabrication of the designed LNA
- Real-World Validation and Expansion

CONCLUSION

The multi-stage designed CS-LNA, achieving 34.43 dB gain and a 6.21 dB noise figure ensures the reduced transmission loss, improved input-output isolation, and moderate noise. These results highlight its potential for compact, high-performance SIGINT receiver applications.

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