Reconfigurable CMOS LNA for Software Defined Radio Using Variable Inductor

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Background

Wireless Communication Circuits

Si CMOS Technology provide
- high density integration
- high frequency performance
- Low fabrication cost

➡ Realization of Si CMOS RF circuits

Wireless Standards

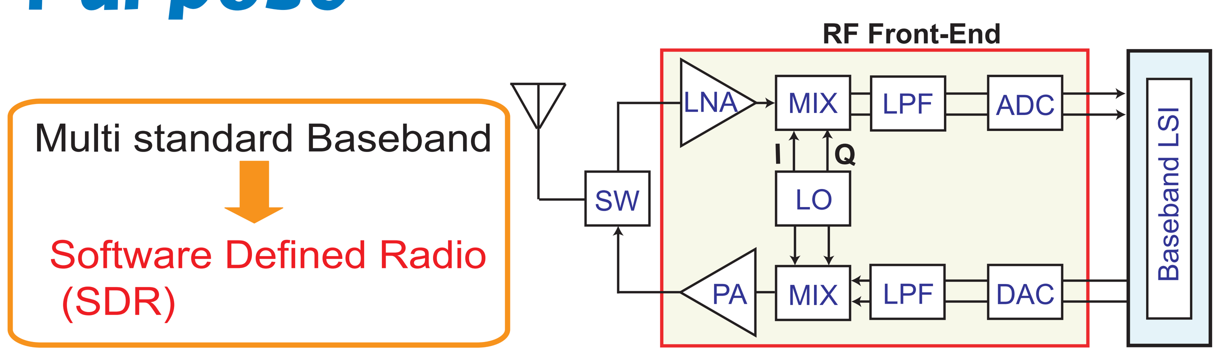
- Mobile phone 900MHz, 1.5GHz, 2GHz (+ 800MHz, 1.7GHz, 1.9GHz for the new system) (+ 800MHz, 900MHz, 1.8GHz, 1.9GHz for GSM)
- WLAN 802.11b/g, Bluetooth 2.4GHz
- WLAN 802.11a/n 5GHz
- GPS 1.2GHz/1.5GHz
- DTV 470 MHz～770 MHz

Wireless communication standards use several frequency bands.

400 MHz-6 GHz

Purpose

To realize Multi-band RF front-end



It is necessary for global roaming using SDR to realize Multi-band RF front-end

Reconfigurable RF Circuit

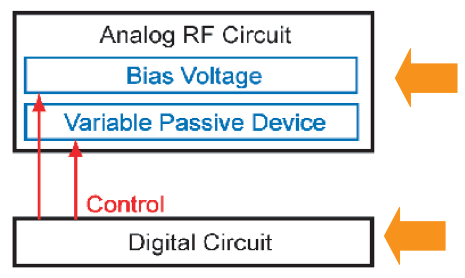
Proposed Concept

Reconfigurable RF Circuit Design K. Okada, *et al.*, in *ASP-DAC*, Jan. 2005, pp.683-686.

Multi-function ➡ To provide multiple functions to circuits
A multi-band/mode circuit for wireless communication chips

Self-compensation ➡ To provide a compensating mechanism
Process variations, Modeling error, Temperature *etc.*

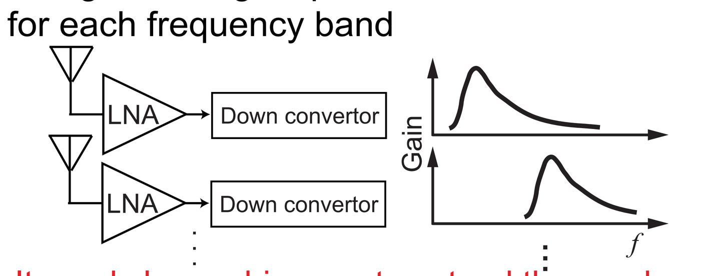
Architecture



●RF circuit is controlled by digital circuit

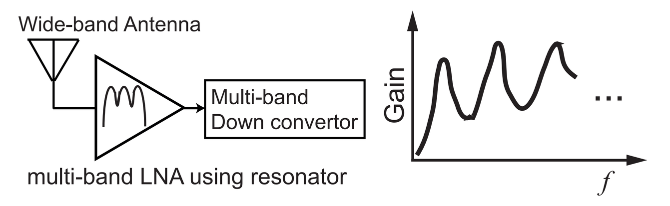
Multi-band RF front-end Architectures

Using some signal paths for each frequency band



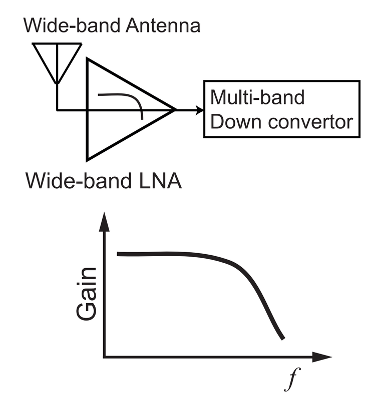
It needs large chip area to extend the number of communication standards.

Using some input resonators



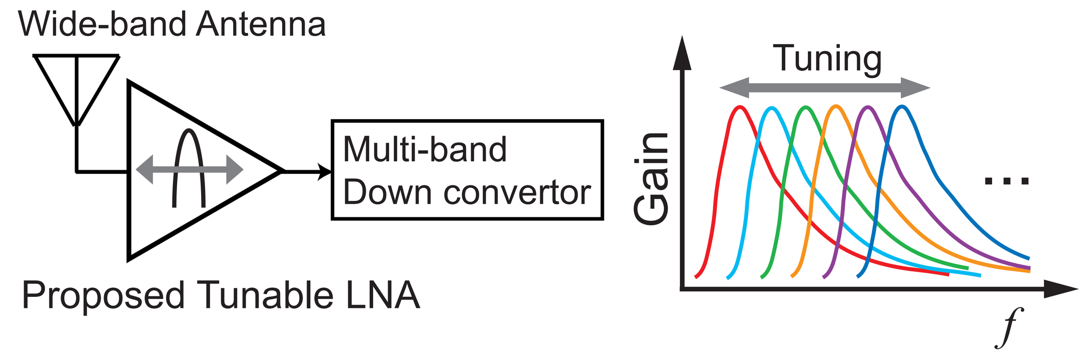
The approach require large chip area due to many resonators.

Using Distribute amplifier



Distributed amplifier needs large chip area and power consumption.

Proposed Architecture

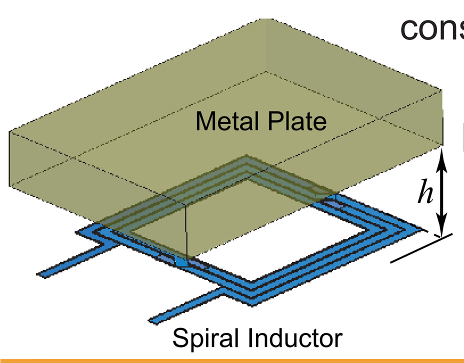


Wide-tunable CMOS LNA is realized by the variable inductor.

The proposed LNA achieves wide-tuning range with narrow-band gain and can be used for reconfigurable RF front-end.

Variable Inductor

Variable Inductor



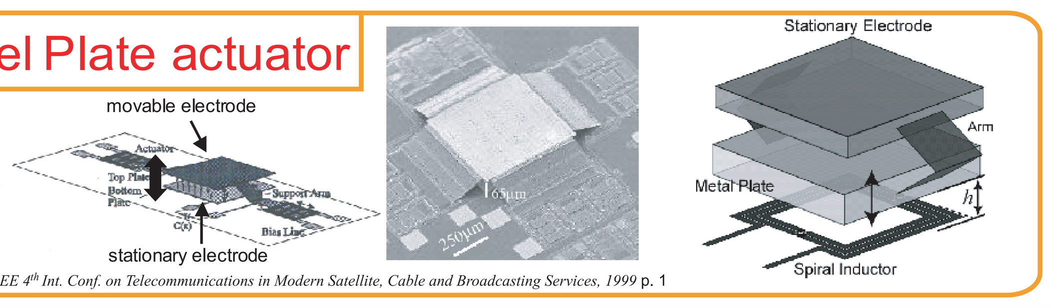
consists of a planar-type spiral inductor and a metal plate.

The metal plate shields the magnetic flux which penetrate the inductor.

The inductance continuously varies depending on the position of the metal plate.

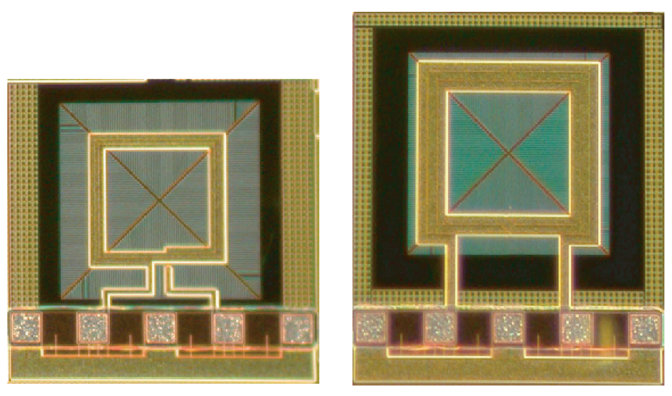
MEMS Parallel Plate actuator

Moving system is realized to use MEMS actuator

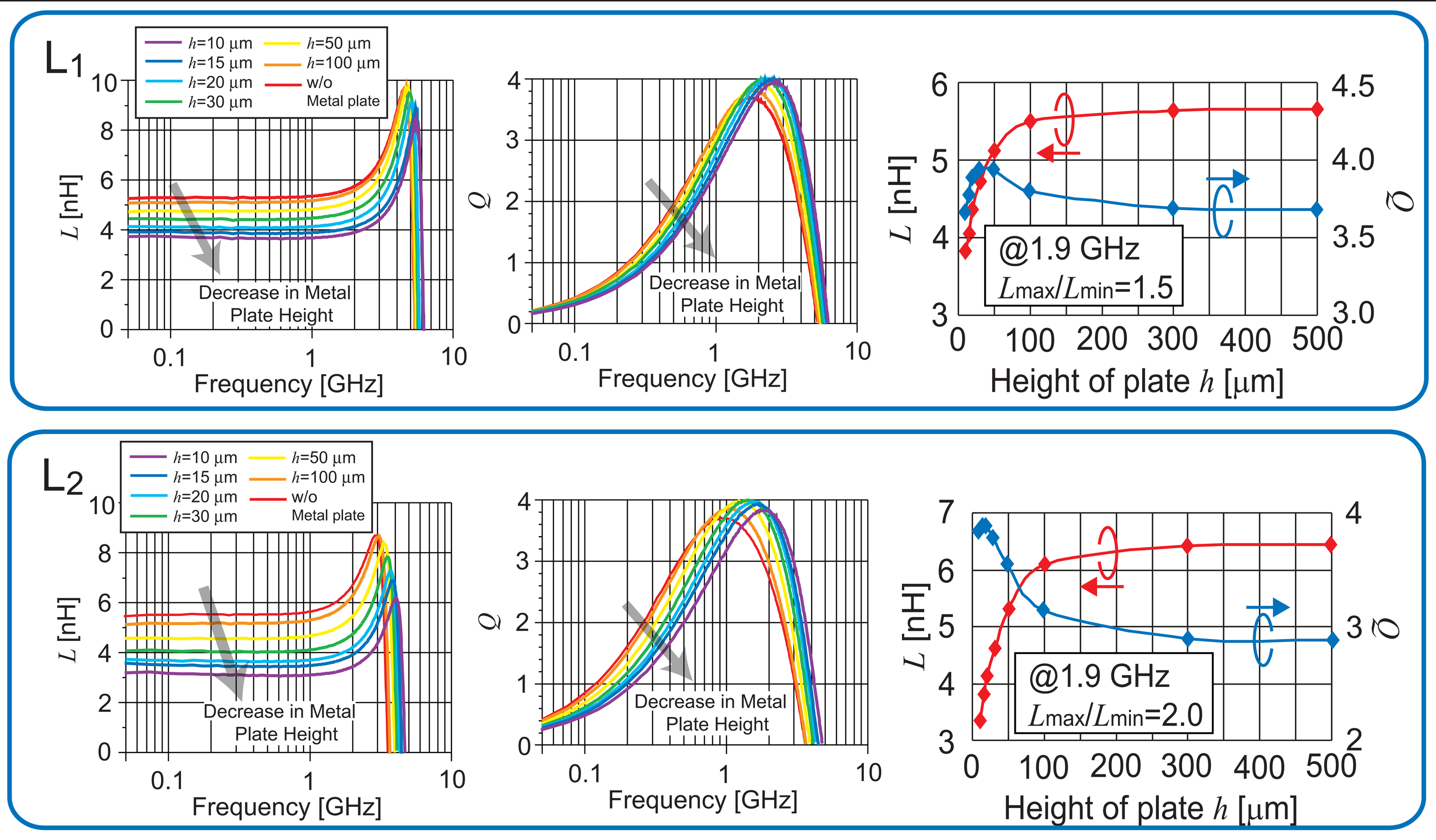


V. M. Lubecke, and J. -C. Chiao: *The IEEE 4th Int. Conf. on Telecommunications in Modern Satellite, Cable and Broadcasting Services*, 1999 p. 1

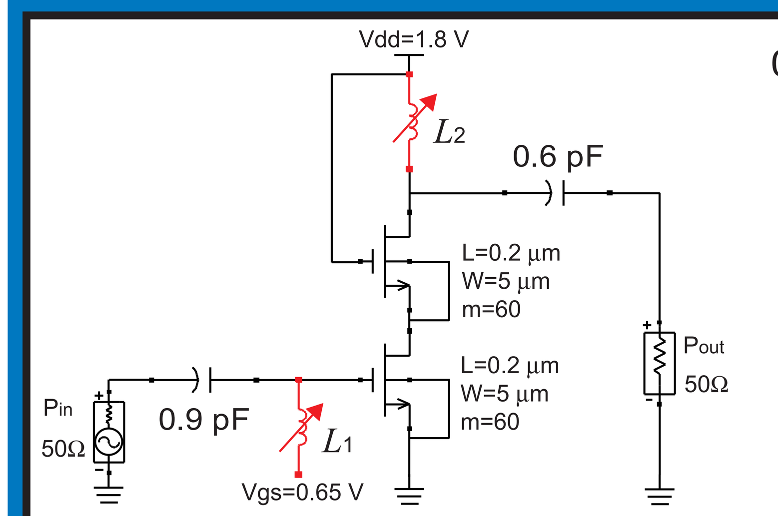
Measurement



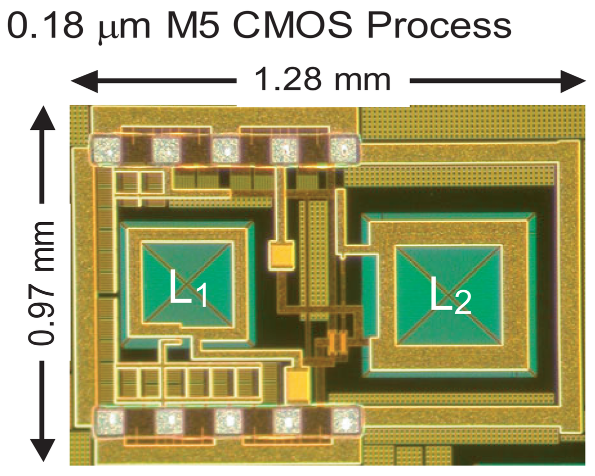
	L_1	L_2
Turns	3	3
Line width	10 μm	20 μm
Line space	1.2 μm	1.2 μm
Outer diameter	300 μm	400 μm



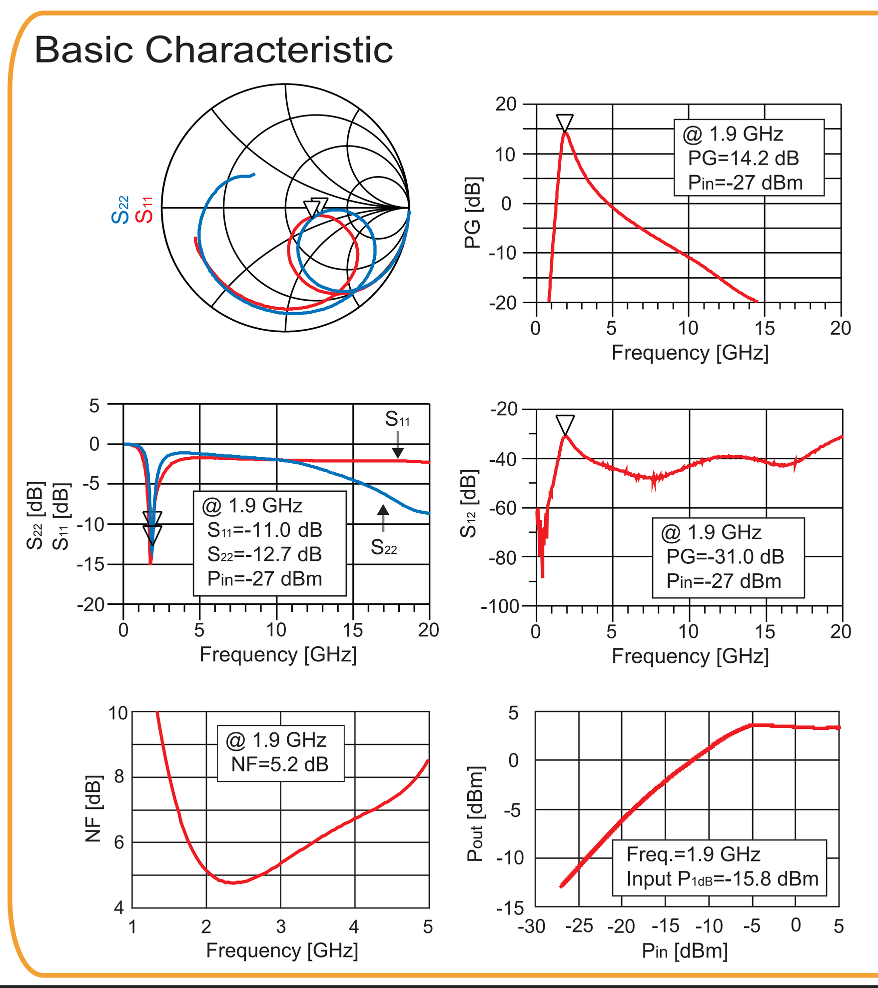
Tunable LNA



0.18 μm M5 CMOS Process



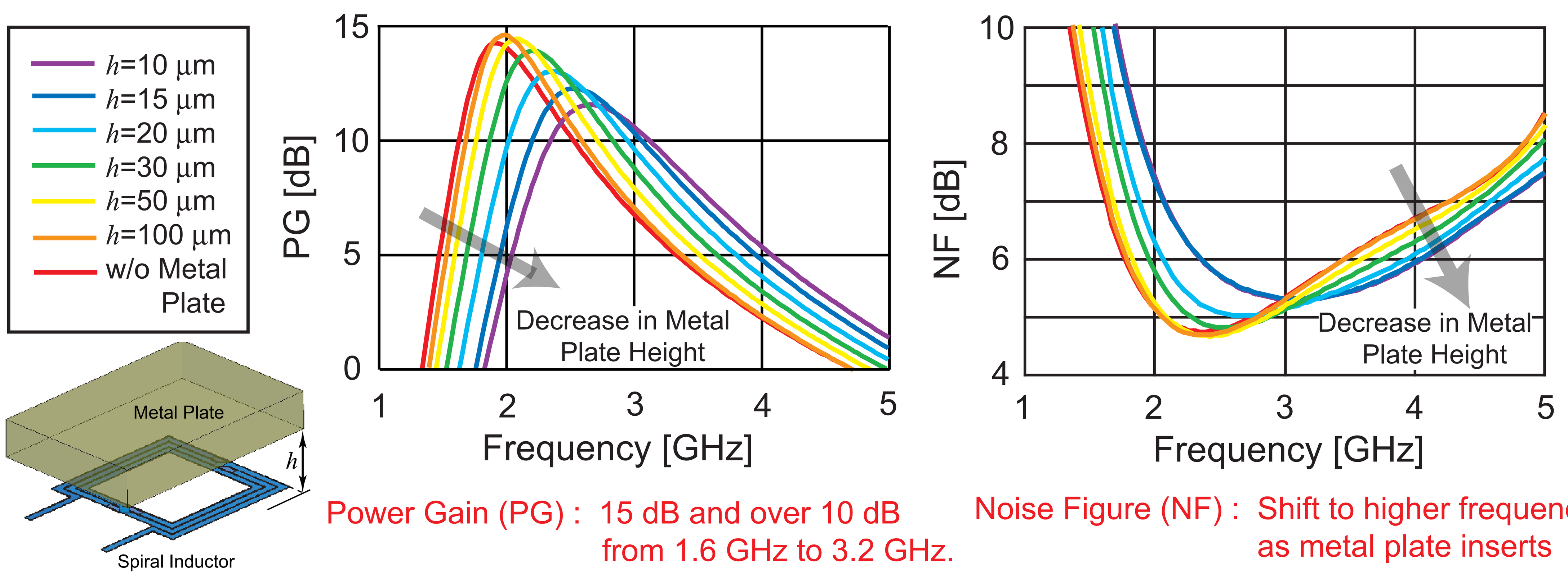
Basic Characteristic



Summary of Performance

Freq. [GHz]	1.9
Vdd [V]	1.8
Vgs [V]	0.65
Idd [mA]	7.4
PG [dB]	14.2
S_{11} [dB]	-11.0
S_{22} [dB]	-12.7
NF [dB]	5.2
Input P_{1dB} [dBm]	-15.8
IIP_3 [dBm]	-7.2

Variable Characteristic



Power Gain (PG) : 15 dB and over 10 dB from 1.6 GHz to 3.2 GHz.

Noise Figure (NF) : Shift to higher frequency as metal plate inserts

Conclusion

Si CMOS Tunable LNA using the on-chip variable inductors for the SDR

- The variable ratios of the variable inductors are over 1.5.
- The proposed LNA achieves PG of over 10 dB from 1.6 GHz to 3.2 GHz.
- The minimum NF is shifted to higher frequency as inductances vary.

This tunable LNA is quite useful for multi-band RF communication system with the reconfigurable RF circuit design.