Low Area Dual-band LNA with Active Inductor for GSM applications

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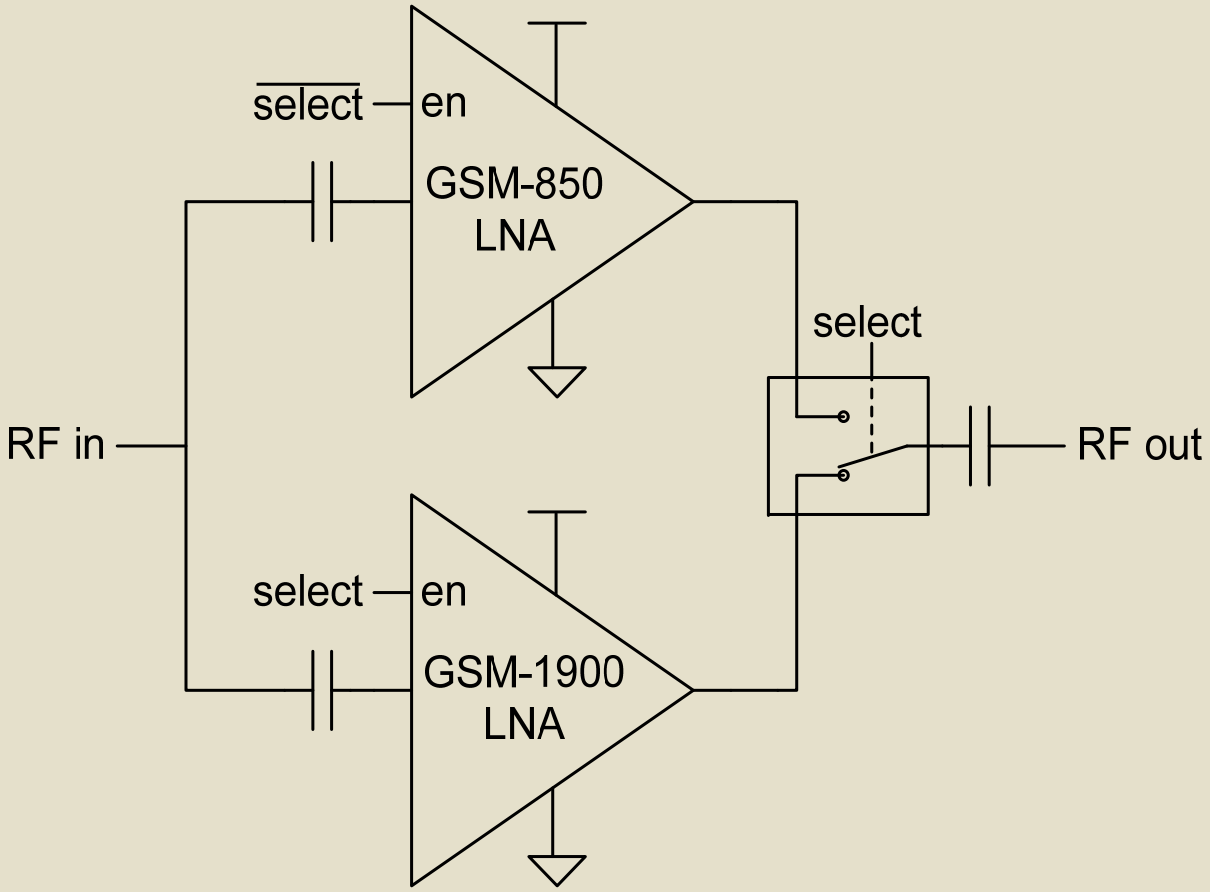
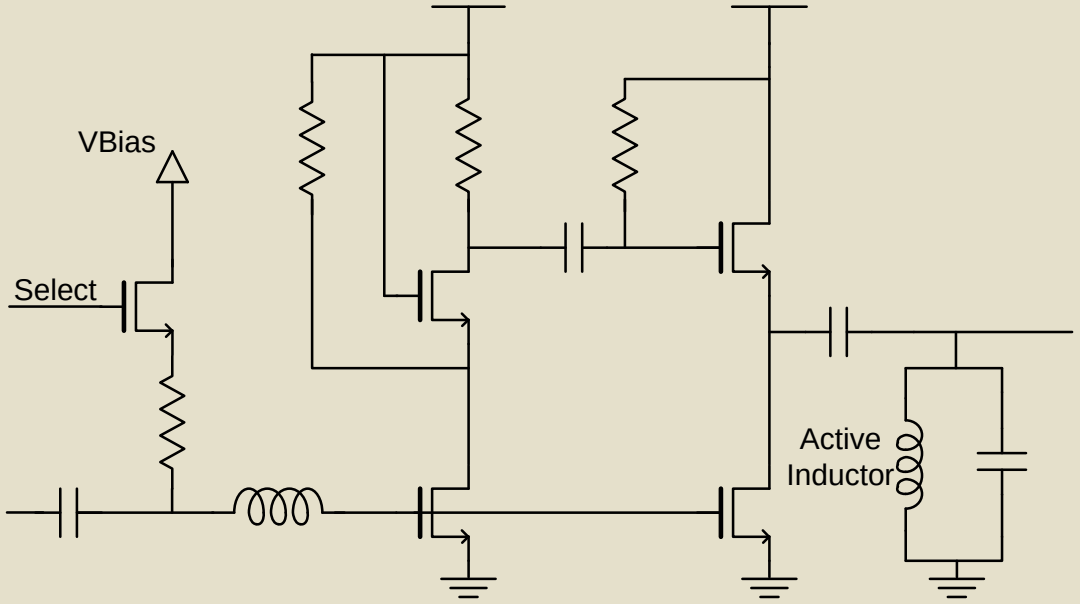
Motivation & Application

- Different cell phone bands are used over countries
  - GSM-850: 880MHz, 25MHz bandwidth
  - GSM-1900: 1.96GHz, 60MHz bandwidth
  - Dual band LNA for device compatibility
- Inductors consume large area on analog chip
  - Bad for yield on wafer, increases unit cost
  - Try to reduce number of inductors

Design Overview

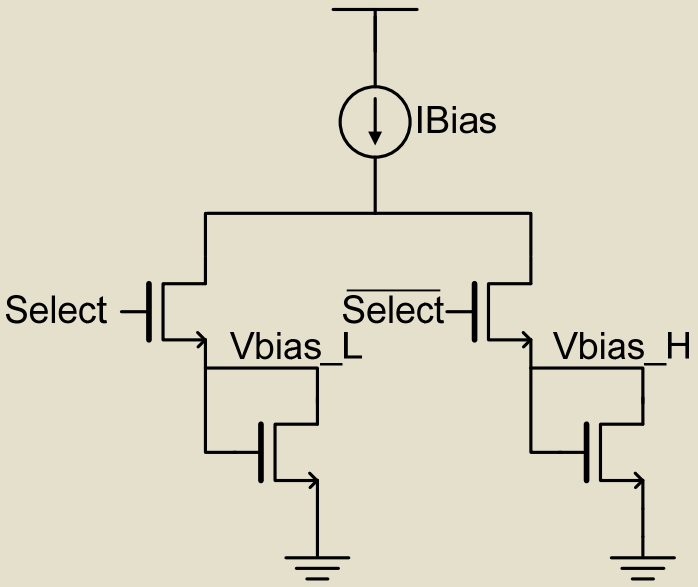


1.96GHz-Band Schematic

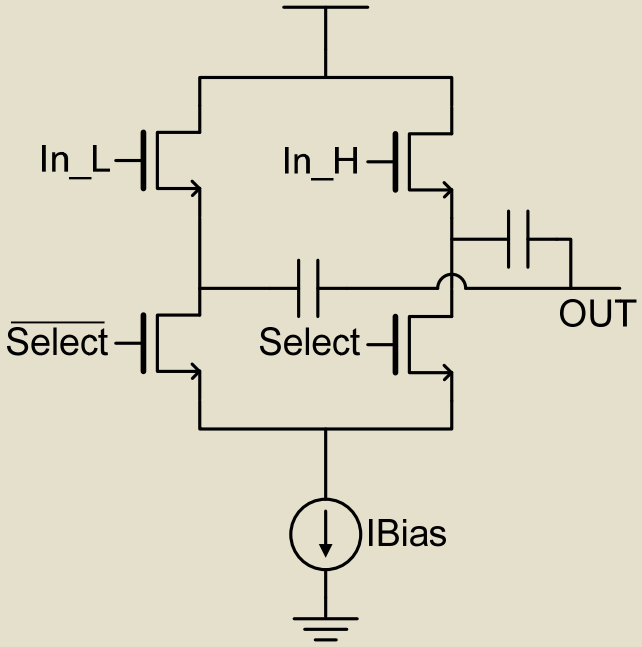


- Two stage for isolation
- Active inductor at load
- Select = 1

Band Selection



Bias voltage control at LNA input



Output gating for isolation

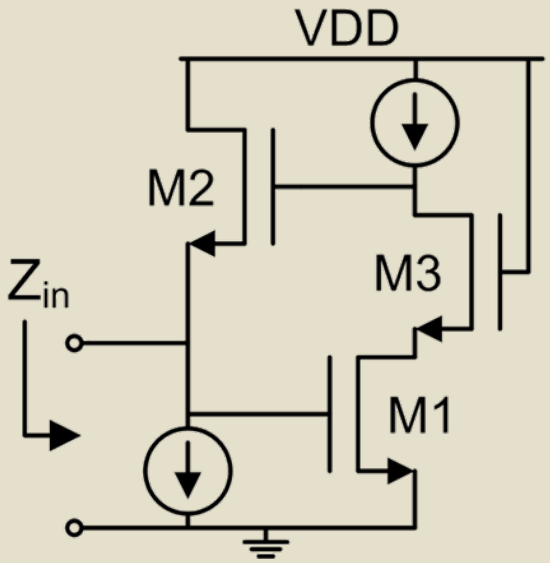
Inductor Options

Type	Inductance	Area	Quality Factor	Repeatability	Noise
None	0	Small	N/A	Good	Good
On-chip spiral	0.2 to 50nH	Large	20	Good	Fair
External discrete	1 to 150nH	Large	150	Fair	Fair
Bond-wire	0.5 to 5nH	Small	150	Poor	Fair
On-chip active	1 to 200nH	Small	0-600, tunable	Good	Poor

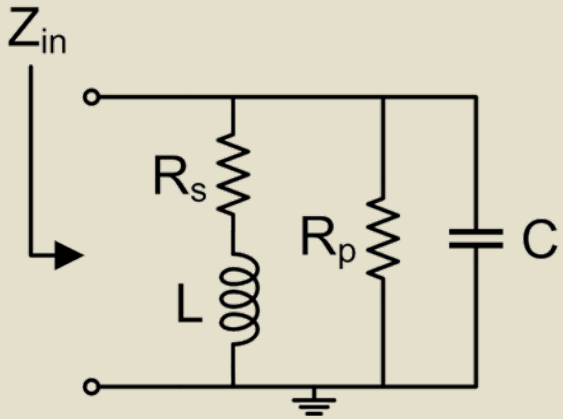
(Values for f < 2GHz)

Active Inductor Design

Active Inductor



Equivalent Circuit

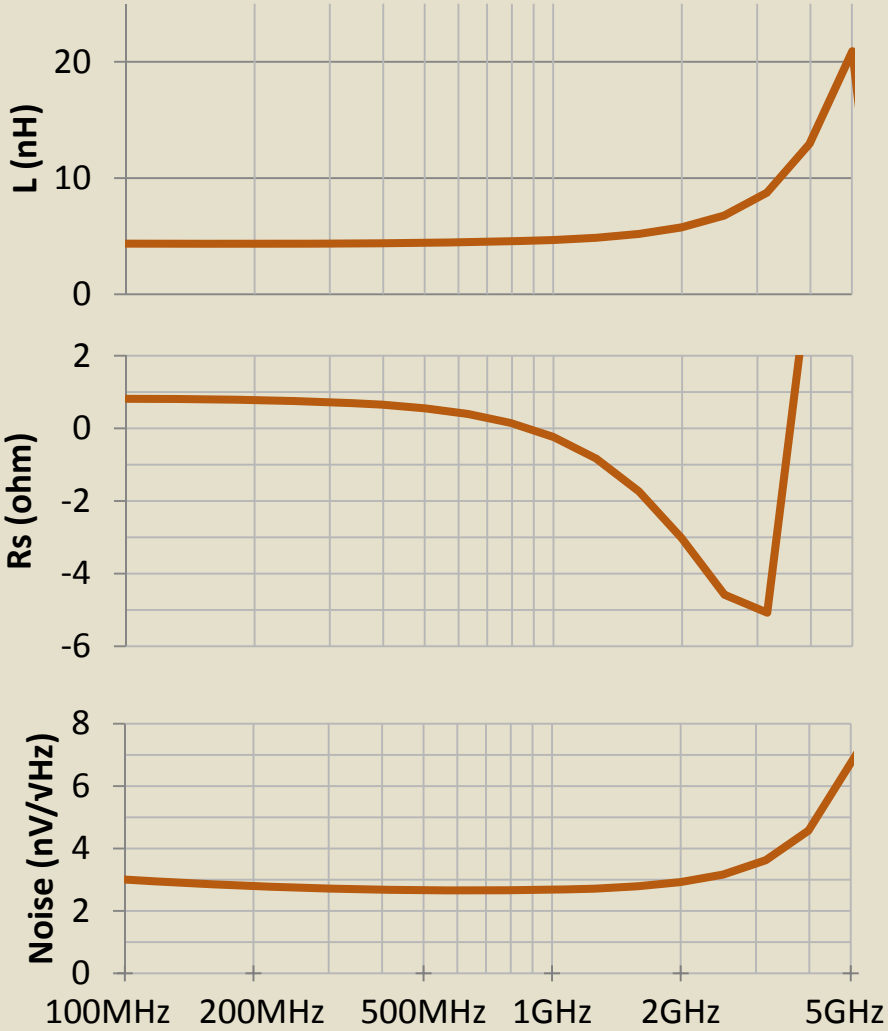


$$Z_{in} = \frac{1}{sC_{gs1}} \parallel \frac{1 + sC_{gs2}r_{o1}}{(1 + g_{m1}r_{o1})(g_{m2} + sC_{gs2})}$$

$$L = \frac{C_{gs2}}{g_{m1}g_{m2}}$$

$$R_s = \frac{1}{g_{m1}g_{m2}r_{o1}r_{o2}g_{m3}}$$

Active Inductor Results



L = 4.59nH at 880MHz

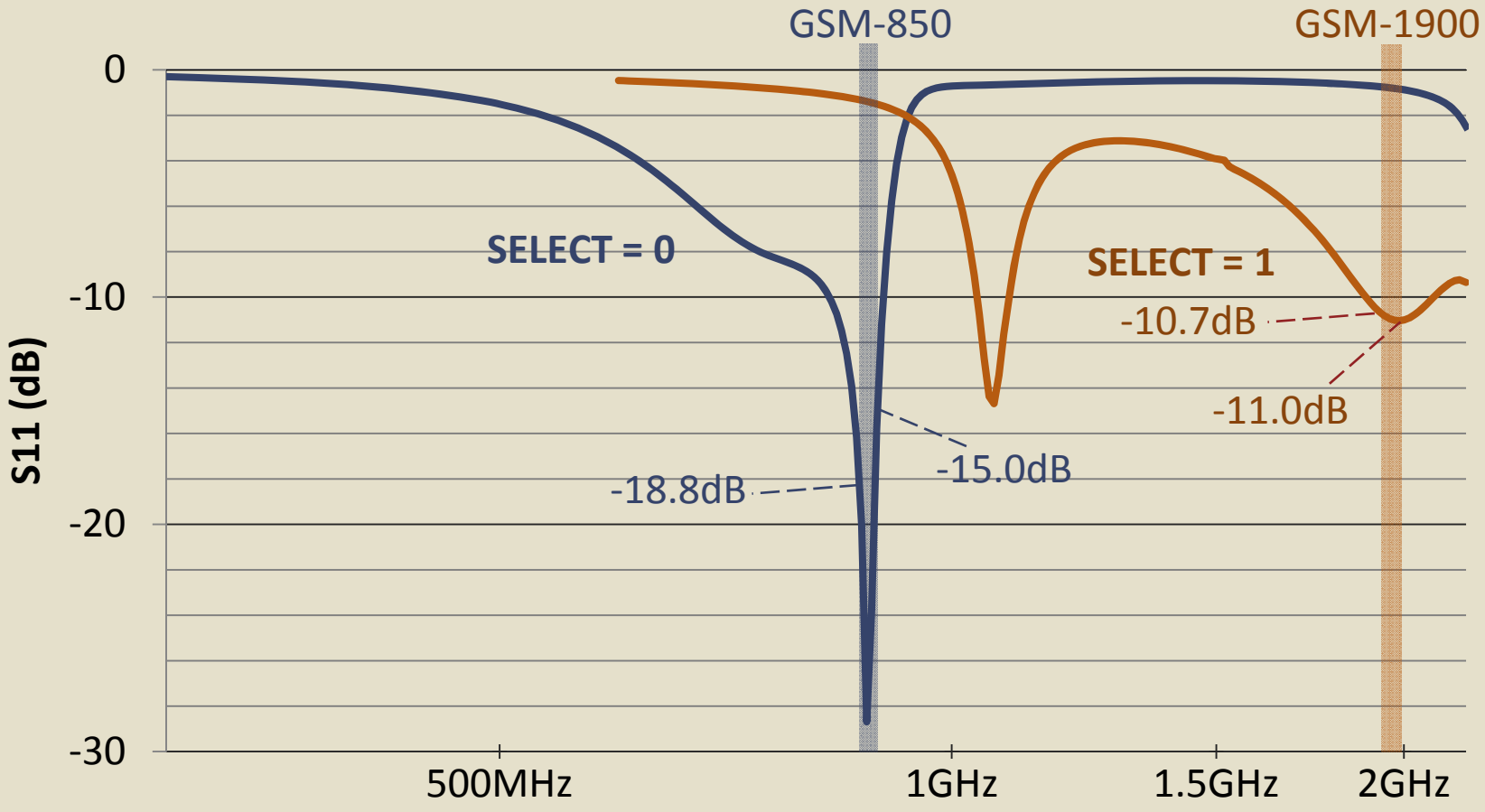
Rs = -24.06mΩ

Compensate by adding external series resistance

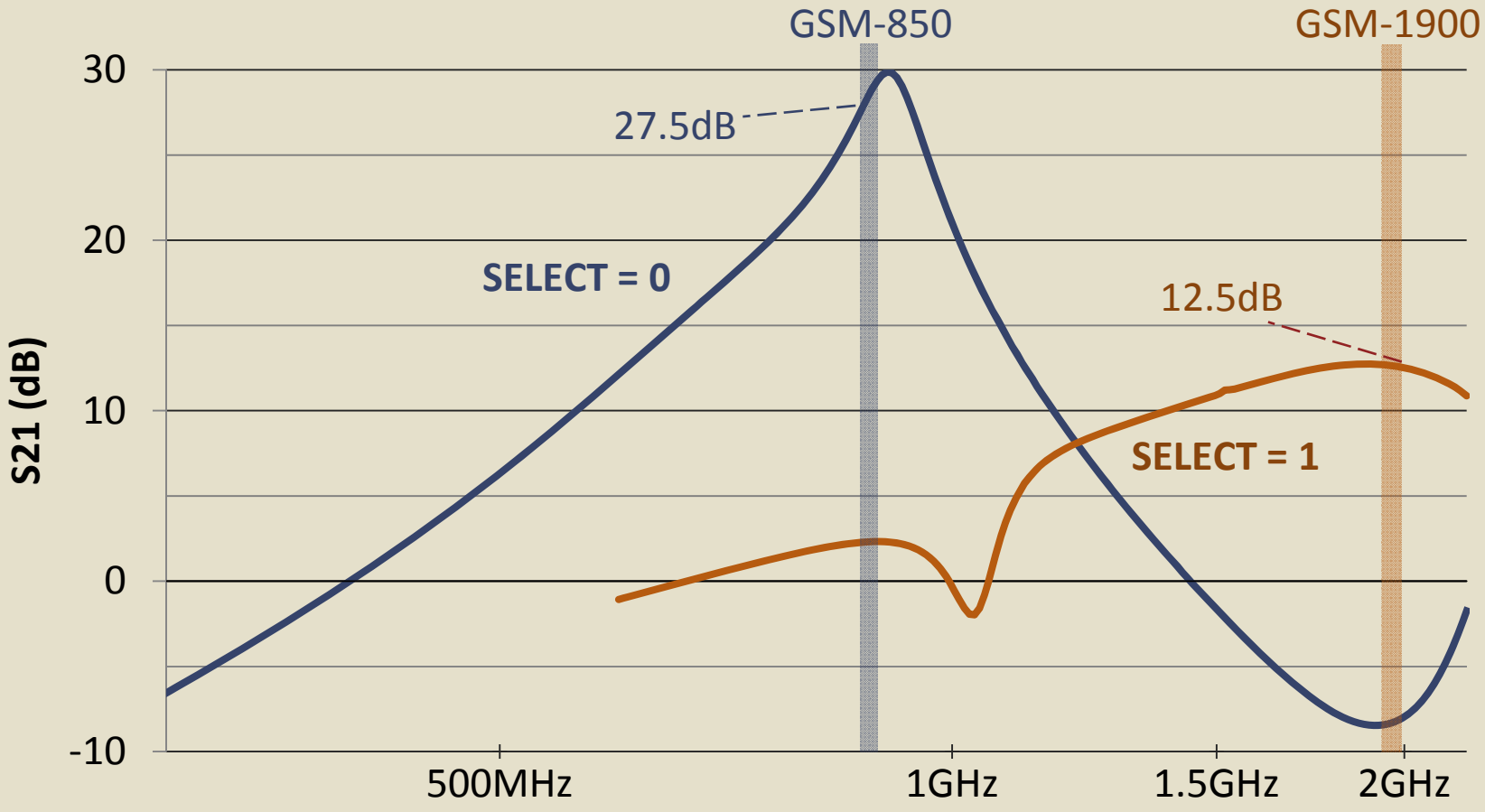
Noise voltage = 2.67nV/$\sqrt{\text{Hz}}$

Tolerable when active inductor is at LNA output

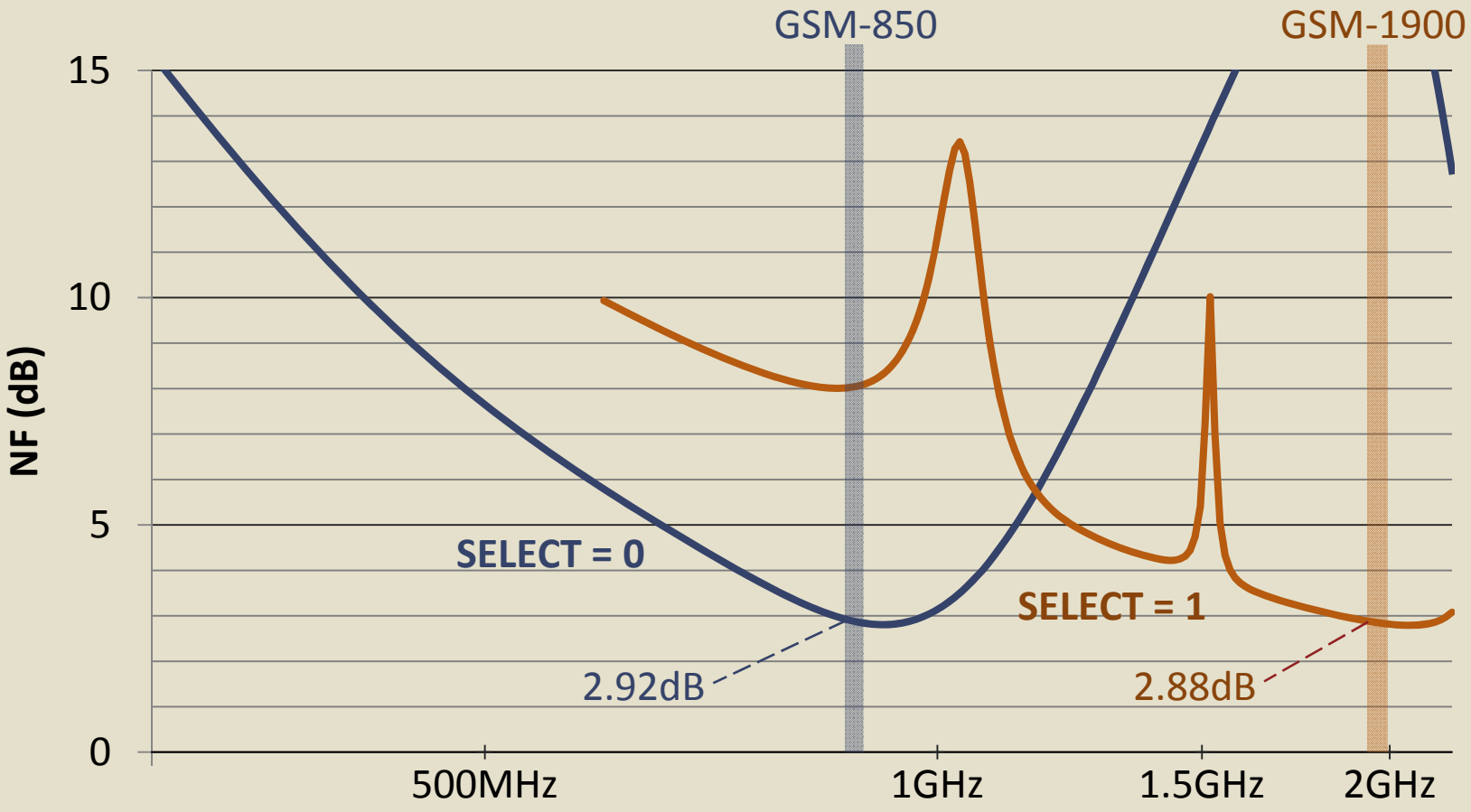
Input Matching (S_{11})



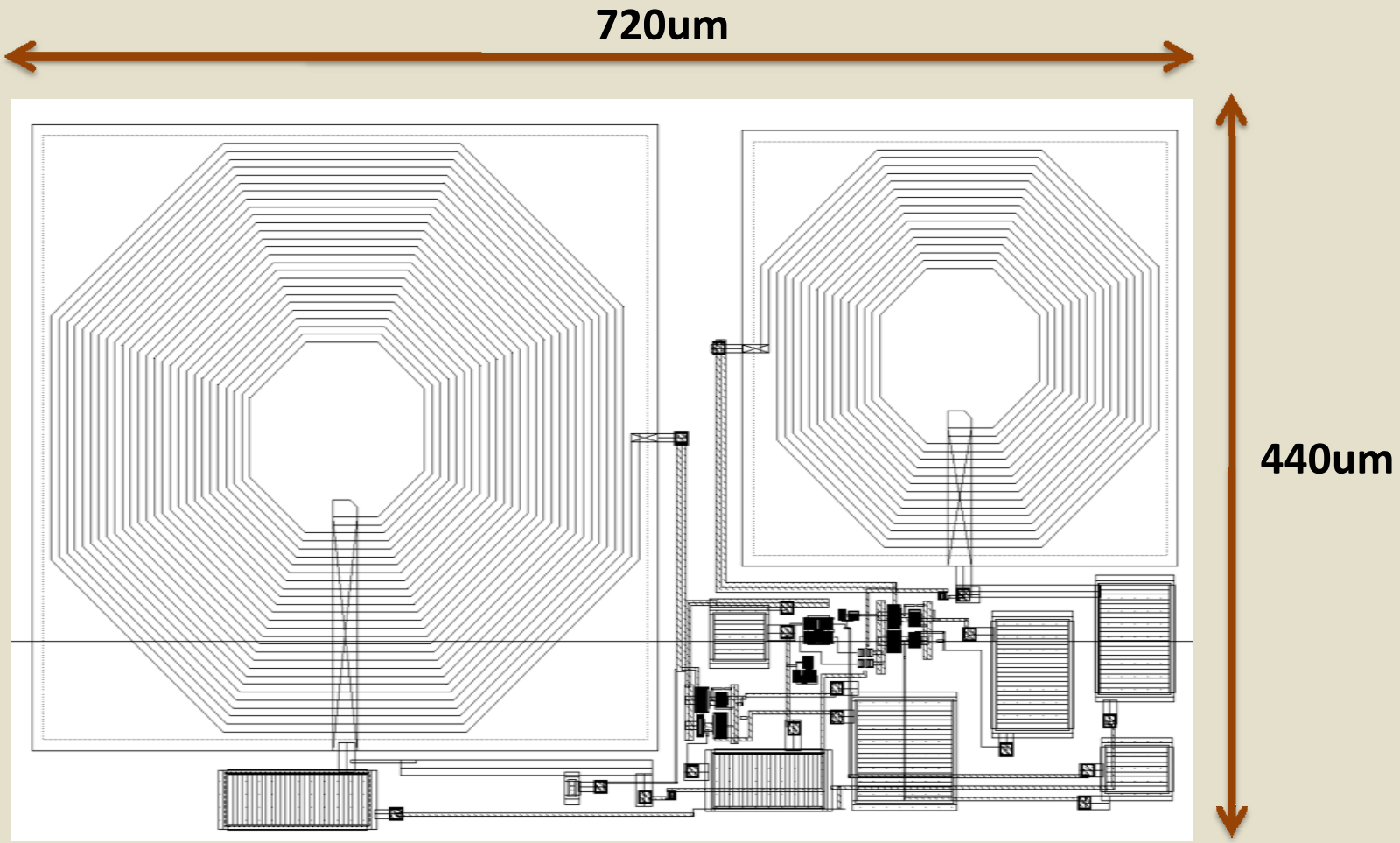
Gain (S_{21})


GSM-850
GSM-1900
30
20
10
0
-10
S21 (dB)
27.5dB
SELECT = 0
12.5dB
SELECT = 1
500MHz
1GHz
1.5GHz
2GHz

Noise Figure



Layout



Results Summary

Parameter	Select GSM-850	Select GSM-1900
Center freq.	906.1 MHz	1888Mhz
S11	-15.0dB	-10.69dB
S21	29.86dB	12.74dB
NF	2.92dB	2.88dB
3dB-BW	85.2MHz	905MHz
P1dB	-0.5dBm	1.995dBm
IIP3	-12.71dBm	-14.0dBm
Power	13.27mW	12.97mW
Area	0.301 mm^2	

Summary

- Switched dual band LNA for GSM 850/1900 bands is presented.
- Active inductors can replace passive inductors
  - Reduce unit cost
  - Power and noise disadvantage
- Still needs passive inductor at input port for high Q and reasonable noise figure

Questions?

References

- Active inductor quality factor: Grozing, M.; Pascht, A.; Berroth, M., "A 2.5 V CMOS differential active inductor with tunable L and Q for frequencies up to 5 GHz," *Radio Frequency Integrated Circuits (RFIC) Symposium, 2001. Digest of Papers. 2001 IEEE* , vol., no., pp.271-274, 2001
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