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A Low-Power Zigbee Receiver using a Self-Oscillating Mixer

Group1

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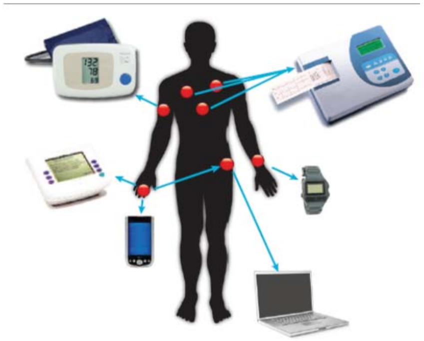
Introduction

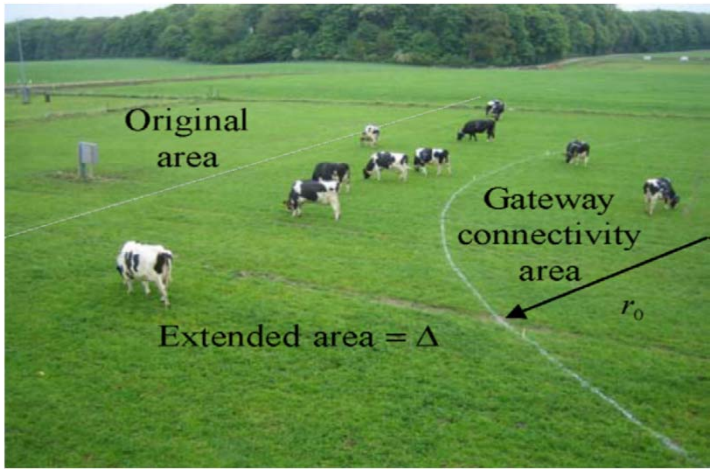
- Zigbee governed by **IEEE 802.15.4** for Wireless Personal Area Networks (WPAN)
  - 2450 MHz band; Channels 11-26 (each 5MHz wide),
  - Data rate of 250kb/s
  - Uses O-QPSK Modulation

- **Advantages**:
  - Low power
  - Small size
  - Mesh networks
  - Ease of deployment

- **Zigbee Applications**:
  - Wireless sensor nodes
  - Home automation
  - Health Care
  - Cattle monitoring

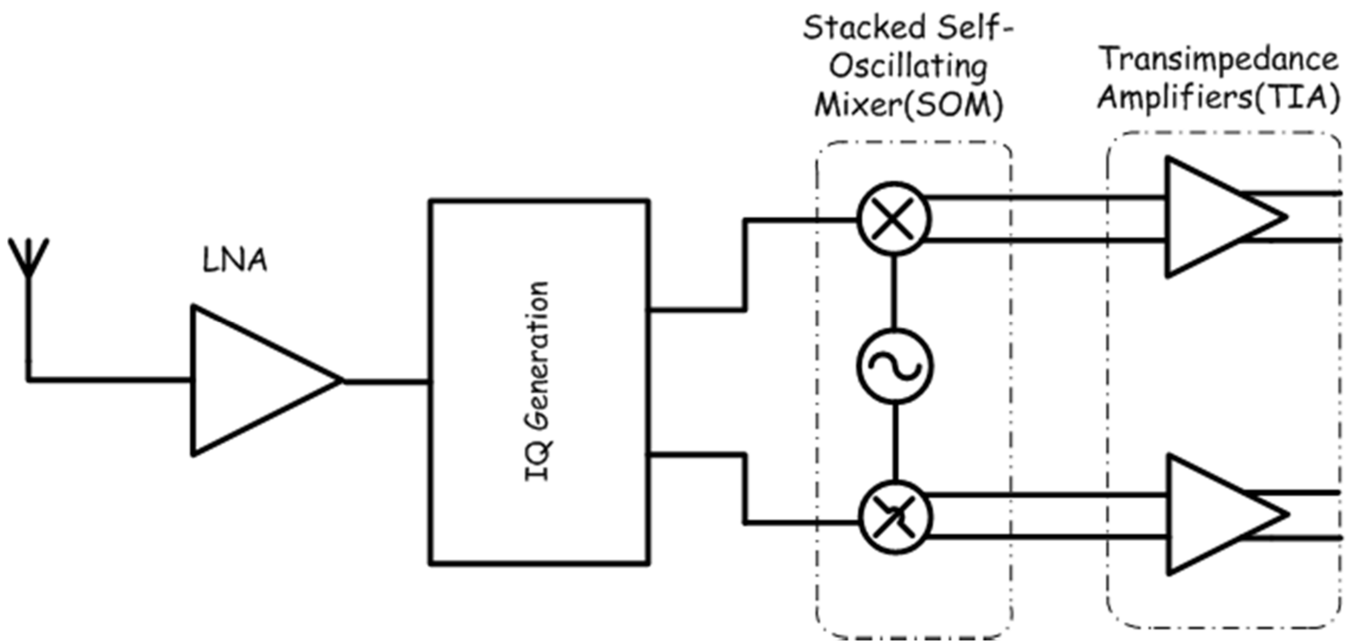


Chronic Disease Monitoring Devices [1]



Pasture time monitoring [2]

System Architecture

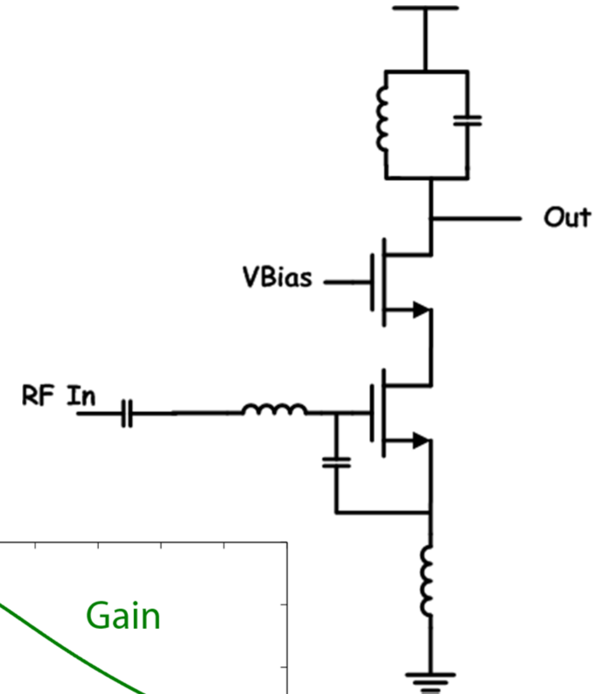


Key Features:

- Stacked oscillator with mixer
- Bond wire inductors : high Q (~30)
- IQ generation in RF Path
- Image rejection with Complex IF Filters (not part of this work)

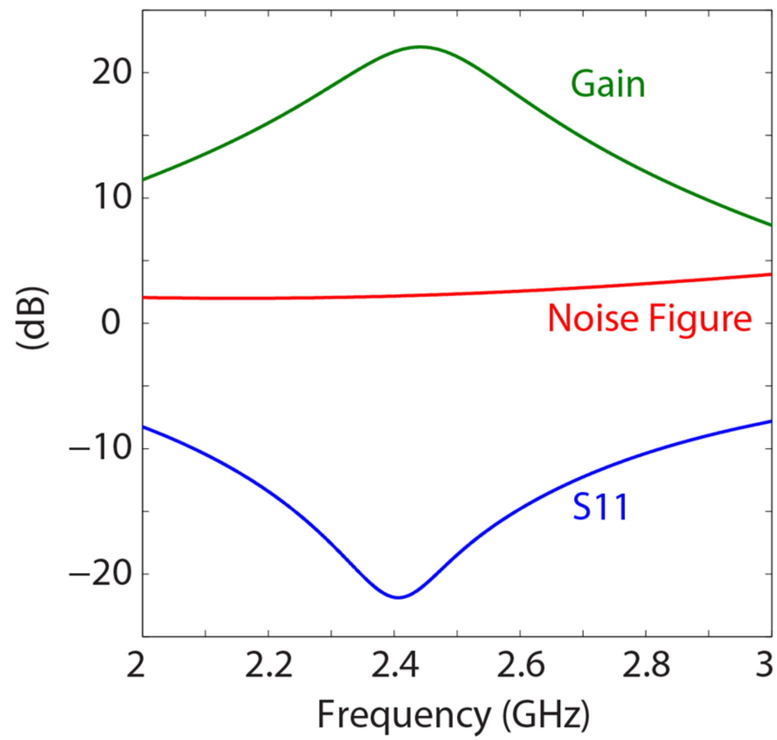
LNA

- Single-ended cascode topology
- Same design methodology as CAD 2
- Simulated with bond wire inductors
- Input matched to 50 ohms
- Output loaded by RC-CR Filter



Performance Summary

Gain	22 dB
S(1,1)	-20 dB
Noise Figure	2.25 dB
1 dB Compression	-10.5 dBm
Power	1.4 mW

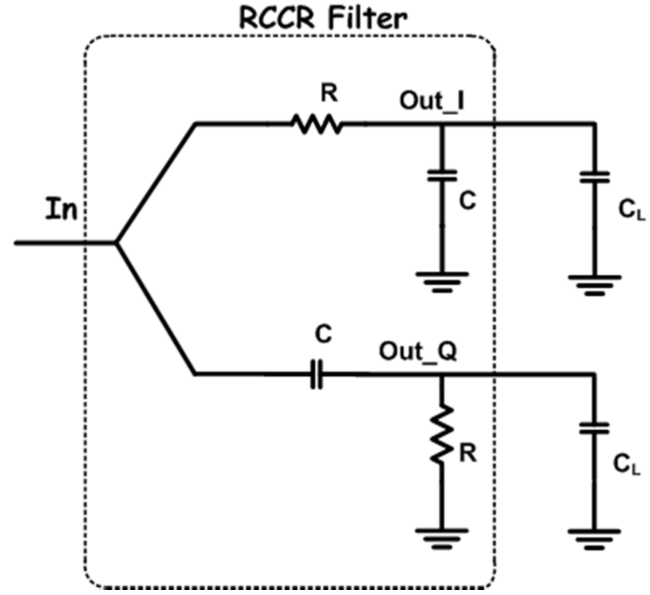


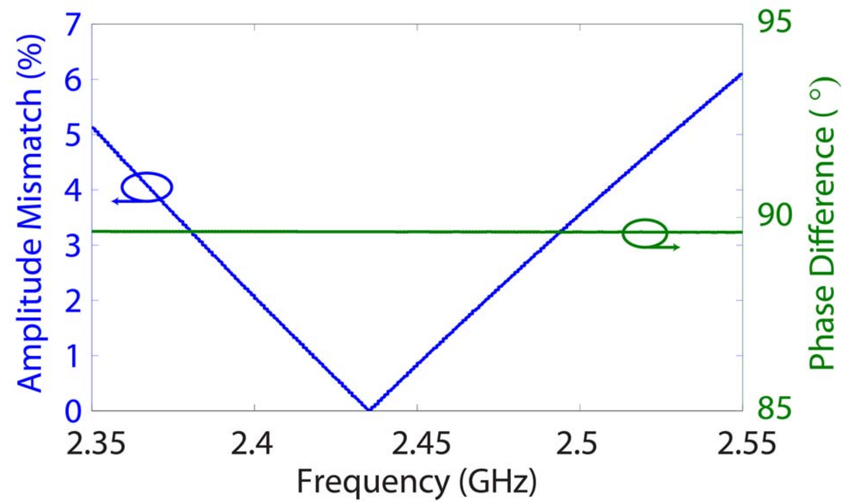
RC-CR Filter

- Output signals are phase shifted by 90°
- Transfer function with load cap:

$$A_{VI} = \frac{1}{1 + sR(C + C_L)} \qquad A_{VQ} = \frac{sRC}{1 + sR(C + C_L)}$$

- Set $w_o = \frac{1}{RC}$
- Acceptable amplitude mismatch
- Design considerations:
  - C >> C_L to reduce attenuation
  - Input impedance $\sim \frac{1}{sC}$
  - Added L to resonate C_{gs} of SOM input
  - Attenuation = 6dB , NF = 6 dB

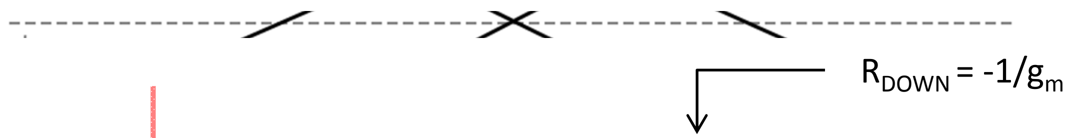




Self-Oscillating Mixer (SOM)

Mixers

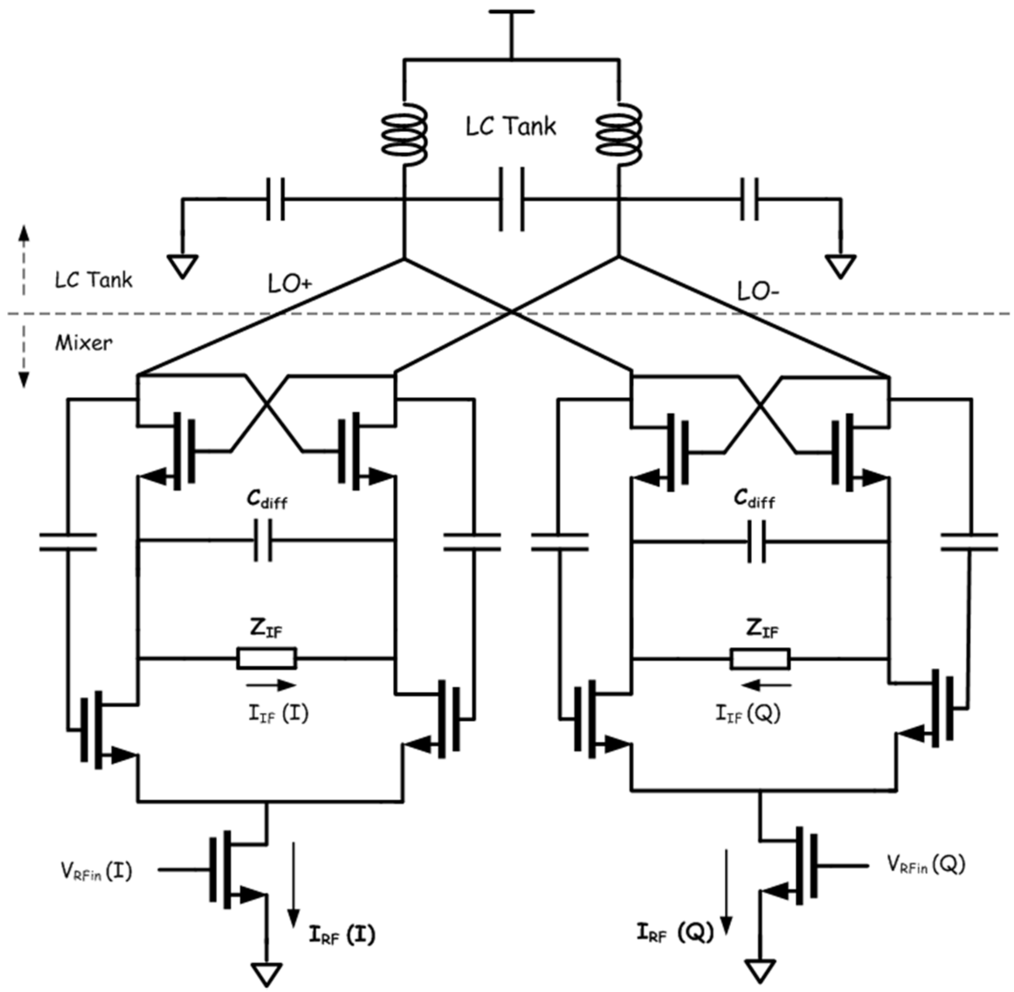
- Four switches steer current through IF load
- LO current shorted through C_{diff}
- Finite output impedance limits output voltage ($R_{OUT} = 4\omega_{LO}L_T Q_{TANK}$)



Differential LC Tank

- Oscillation Criteria: $R_p > 1/g_m$
- Bond wire inductors implemented to achieve high Q

Self-Oscillating Mixer (SOM)



Oscillation Frequency:	2.4 GHz
Phase Noise (@ 3.5 MHz):	-138 dBc/Hz

Conversion Gain*:	0.62
Power:	2.2 mW
LO Leakage**:	-101 dB
Noise Figure:	21 dB
IIP3:	-8.6 dBm
1 dB Compression:	-15 dBm

* Conversion Gain = I_{IF} / I_{RF}
** LO Leakage = $I_{OUT}(\omega_{LO})$ / V_{LO}

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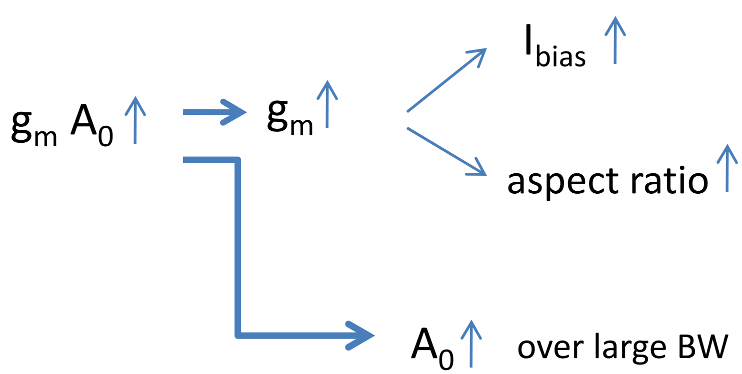
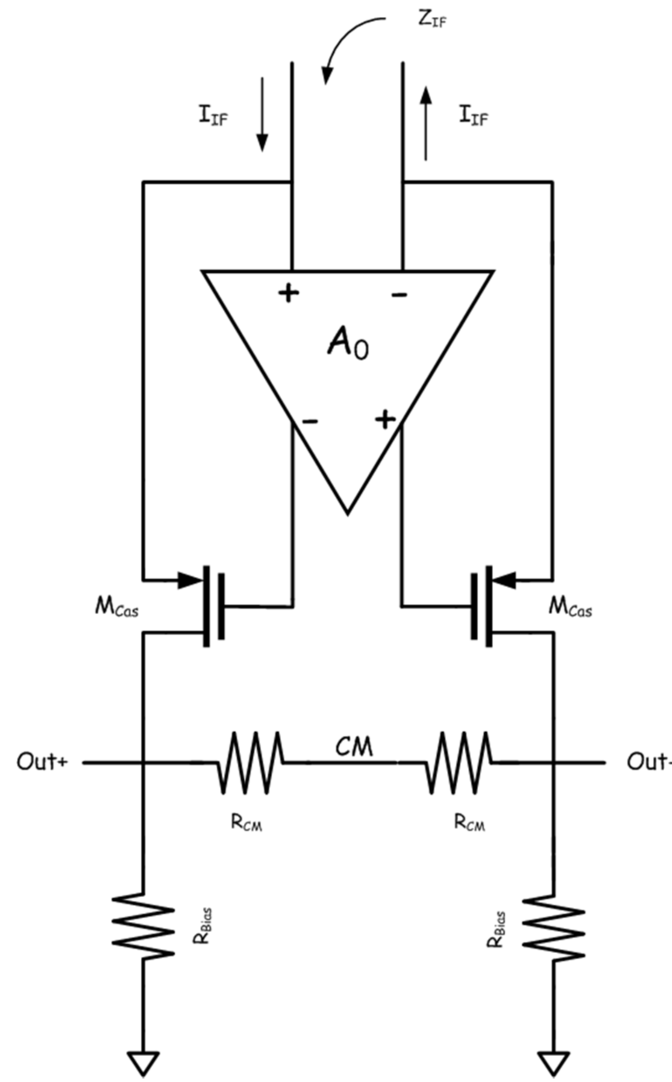
Transimpedance Amplifier (TIA)

- Sense IF current through virtual ground
- Virtual ground → Transimpedance Amplifier (TIA)
- TIA : gain-boosted cascode topology
- Low impedance at IF output nodes

$$R_{IF} = \frac{2}{g_{m\,Cas} A_0}$$





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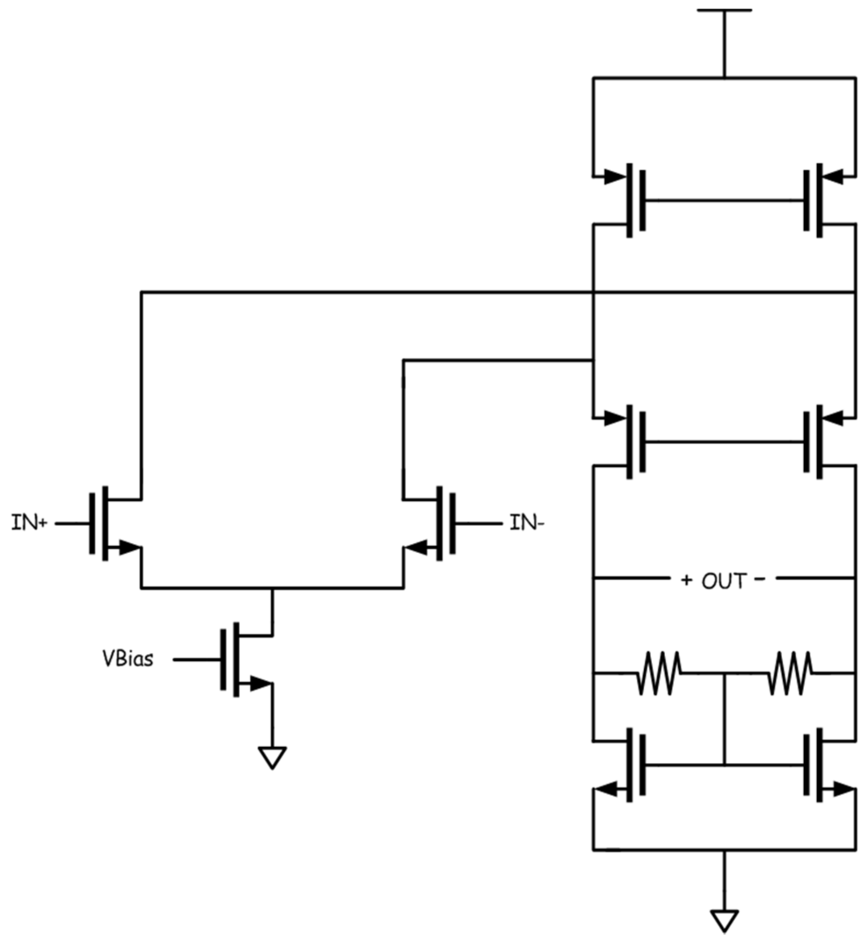
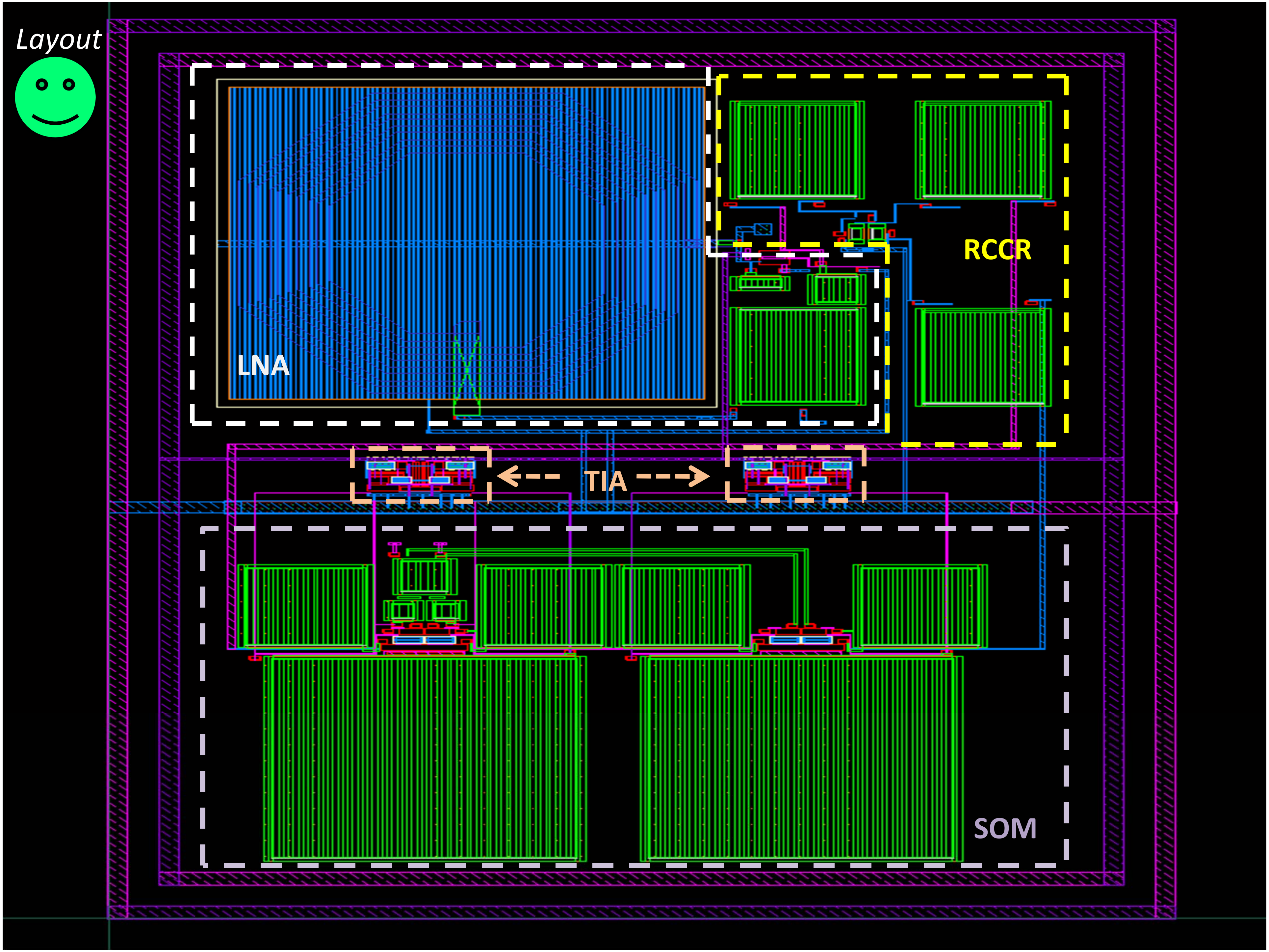
Core Amplifier

- Increase core amplifier gain over frequency
  - Folded cascode core amplifier
    - High gain
    - High stability
    - Improved bandwidth
- Input stage transistors critical in terms of noise
  - Large channel → less noise
  - Small size → less capacitance load



Our TIA Design :

Core Amplifier Gain	32 dB
Bandwidth	8 MHz
Bias Current	68 µA
Z_{IF}	12 Ω
Overall TIA Gain	65 dB



Layout
LNA
RCCR
TIA
SOM

Comparison

	[5]	[3]	[1]	This work *
Gain [dB]	33	75	76	**36**
NF [dB]	7.5	12	10	**12**
IIP3 [dBm]	-10	-12.5	-13	**-21**
IF Frequency [MHz]	-	2	3	**5**
PN @ 3.5MHz [dBc/Hz]	-	-107	-124	**-138**
Power diss [mW]	5.4	3.6	3.6	**3.72**
Integrated inductors	2	1	0	**1**
Area [mm^2]	0.23	0.35	0.23	**0.34**
Vdd [V]	1.35	-	1.2	**1.2**
Technology[µm]	0.09	0.09	0.09	**0.13**

* Does not include IF Filter

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