A 65nm CMOS 282µW 915MHz Direct Conversion Receiver Front-end

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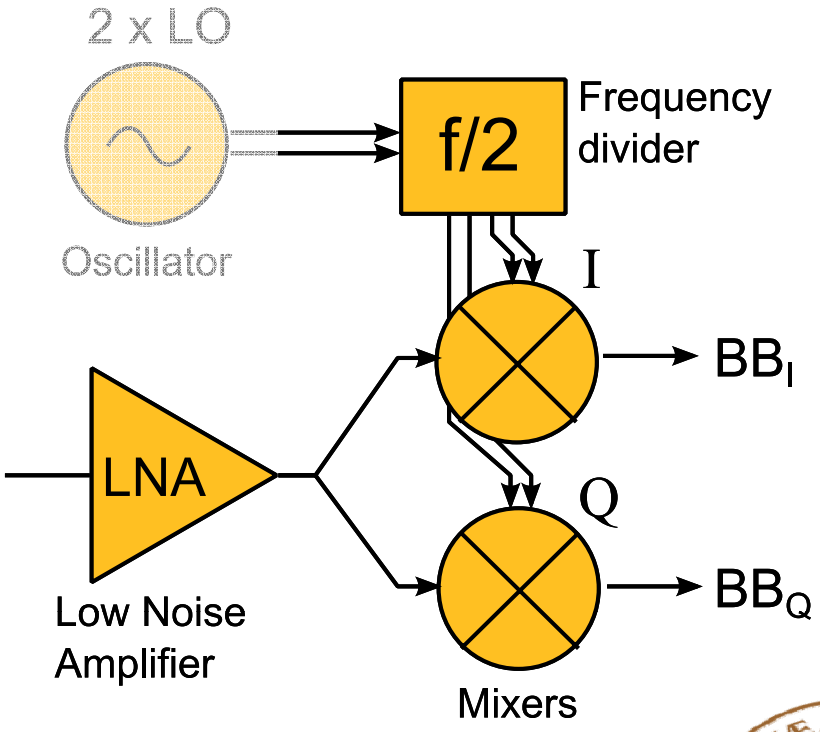
Introduction

- Receiver for ultra low power applications
  - Implants, sensor networks etc.
  - Compact (small battery)
  - Very long battery time (years)

- Goals
  - <<1mW (active)
  - <<1mm^2 (inductorless)

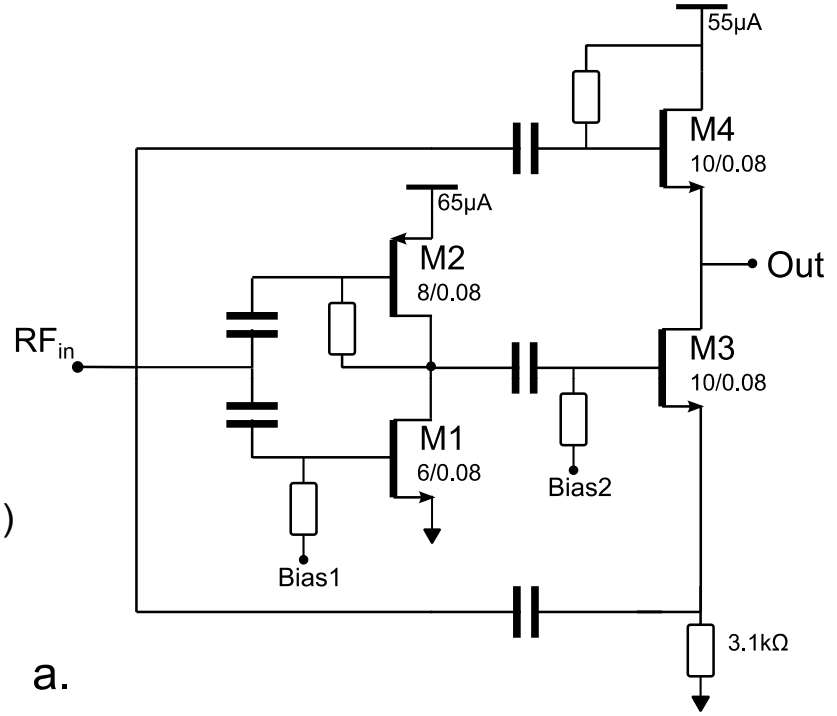
Receiver Overview

- Direct conversion
  - BFSK
- Frequency divider provides quadrature reference
- Single oscillator minimizes area
  - More power, but OK

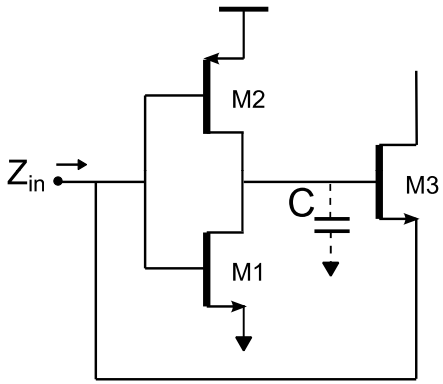


Low Noise Amplifier

- Resistive input through feedback
  - Lower noise than passive match
  - Low gain -> high impedance
  - Sensitive to capacitance (PAD+ESD)
- Active inductor
- 200Ω



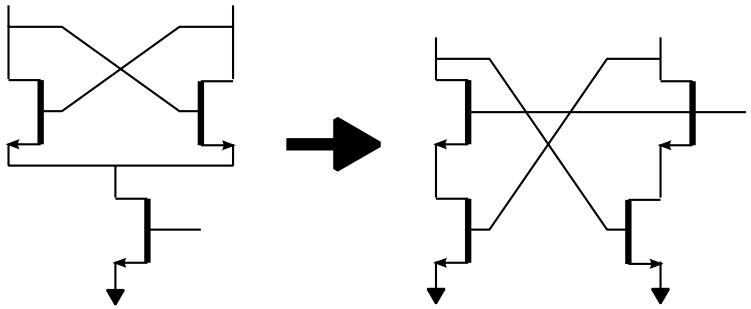
a.

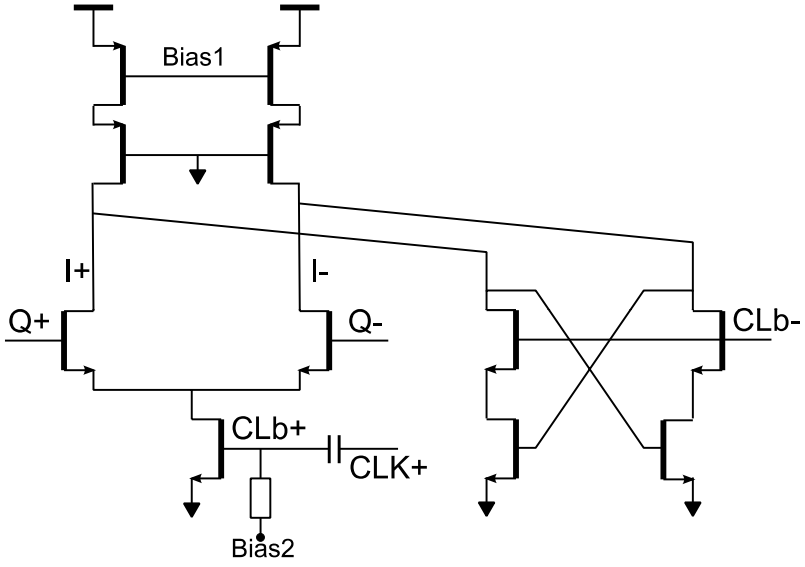


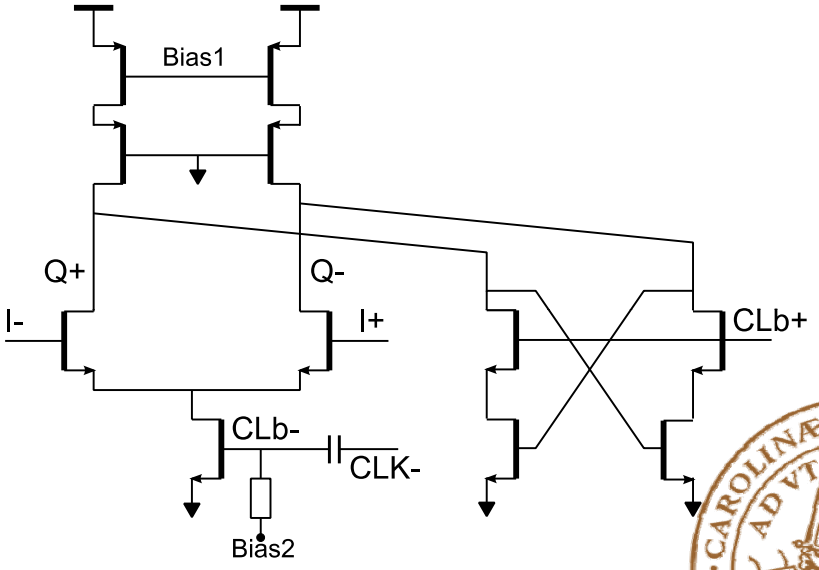
b.

Frequency Divider

- Based on standard CML solution
- High impedance current sources
- Improved output voltage headroom

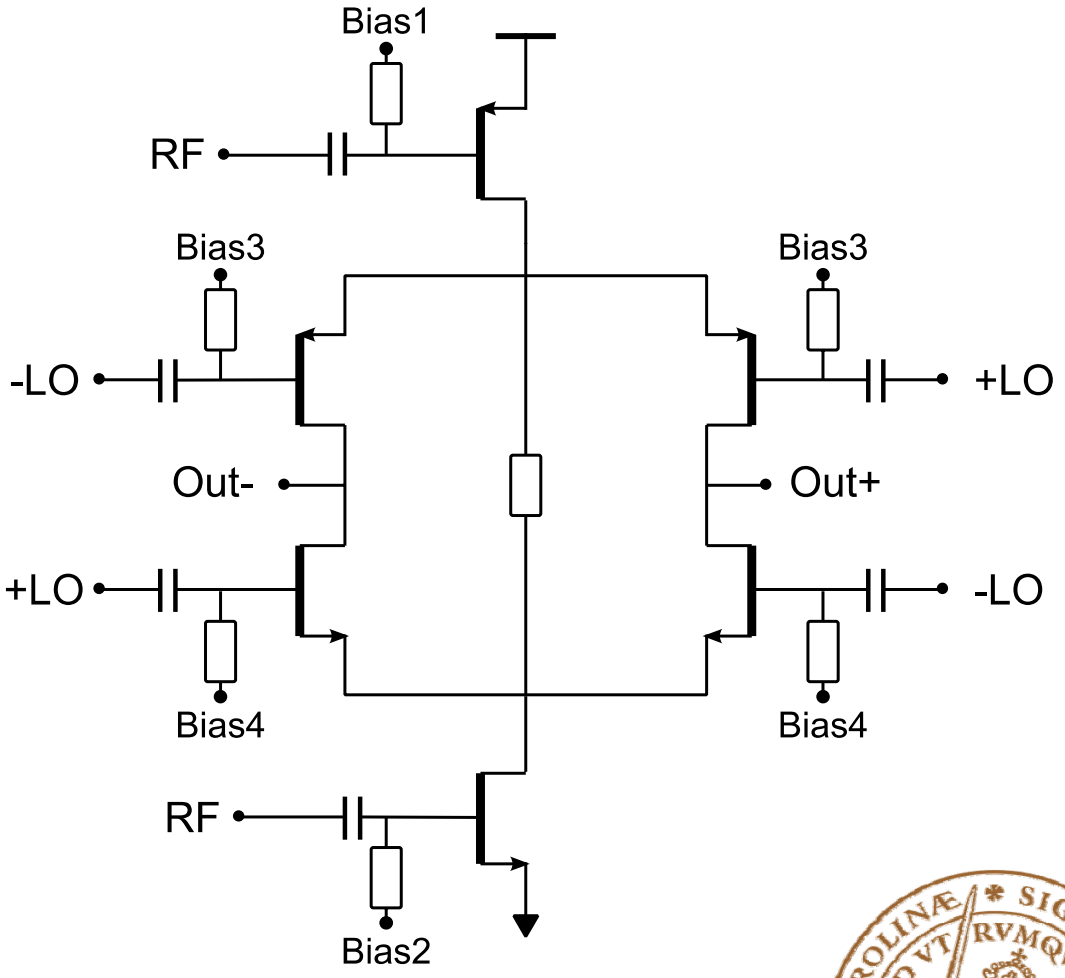






Mixers

- Complementary design
- Pseudo balanced
  - Low LO feedthrough
- High output impedance
  - High gain
- IM2 cancellation
- Current bleeding
  - Improves 1/f noise



Results

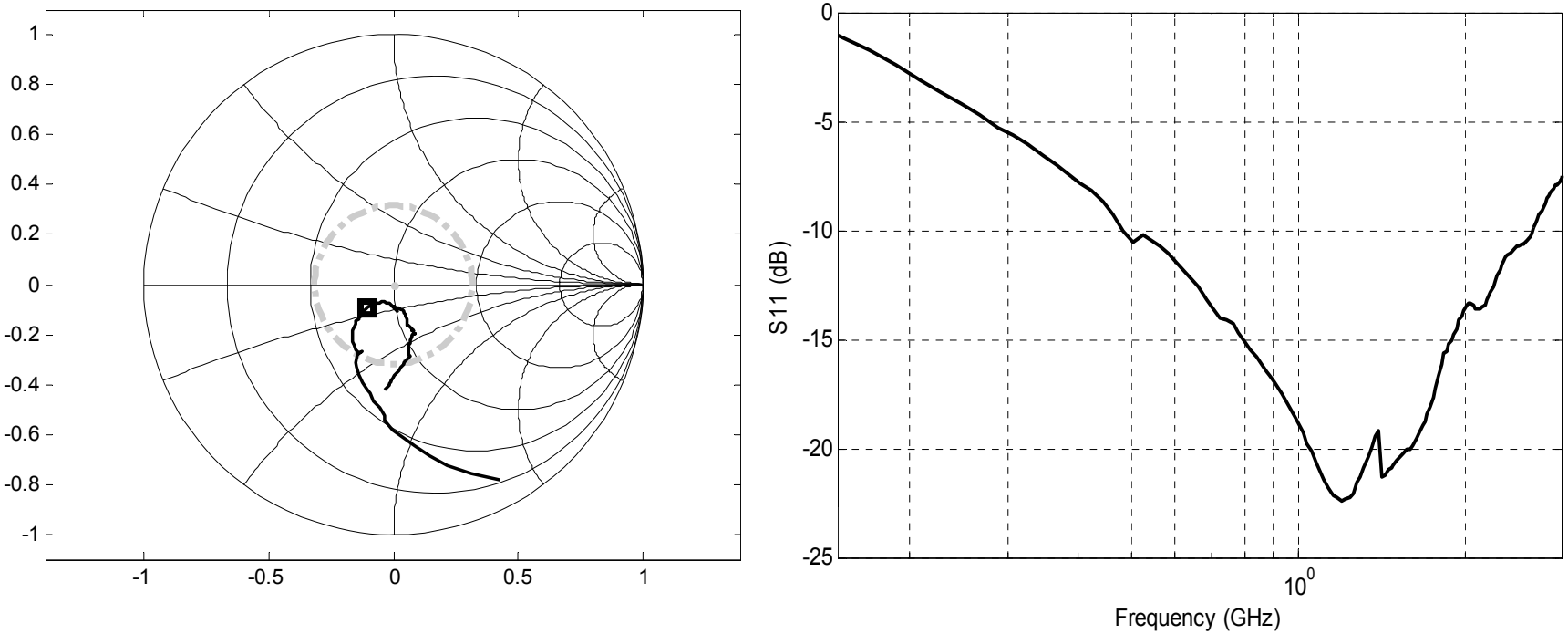
LNA	109µW
Divider	100µW
Mixers (I & Q)	73µW
Total	**282µW**

- 0.9V Supply
- 65nm CMOS

- Custom TRL kit to measure impedance
- LC match for noise & linearity measurements
- External opamp buffers to drive equipment

Results

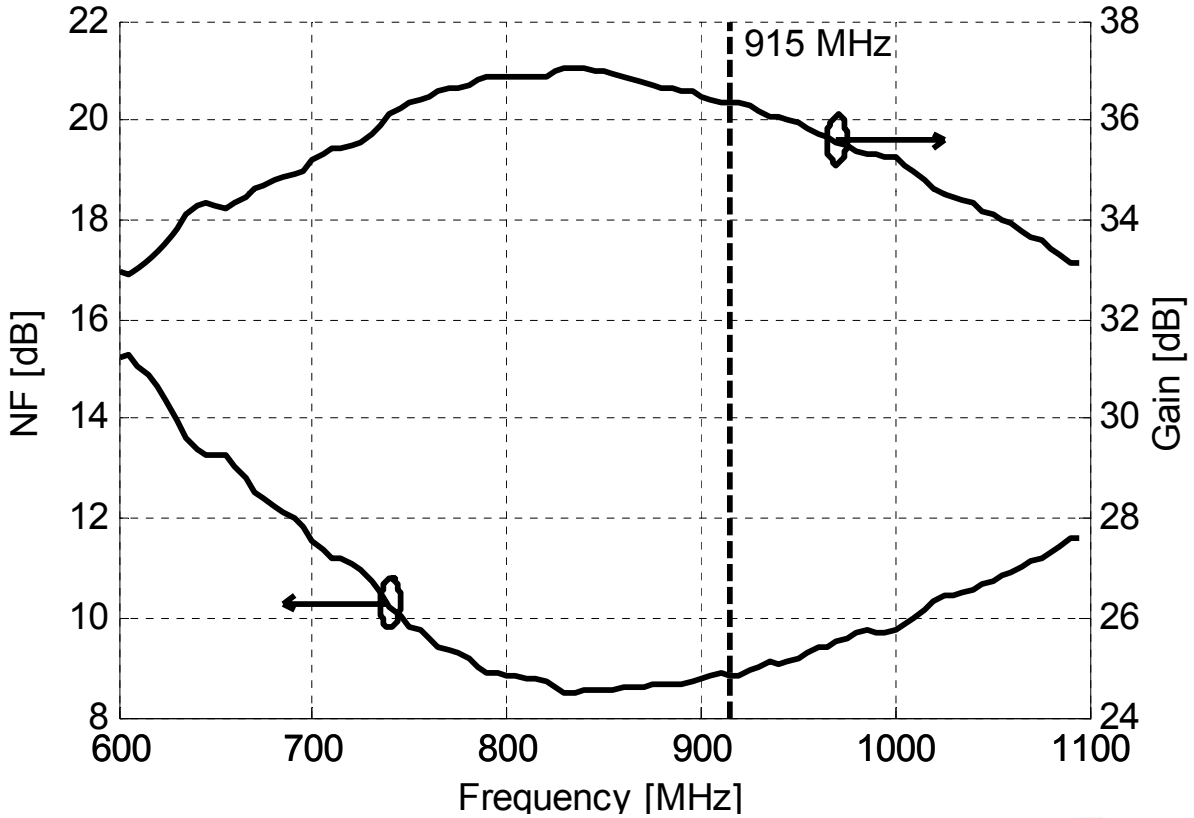
Z_0=200Ω



- S_{11} < -17dB @ 200Ω

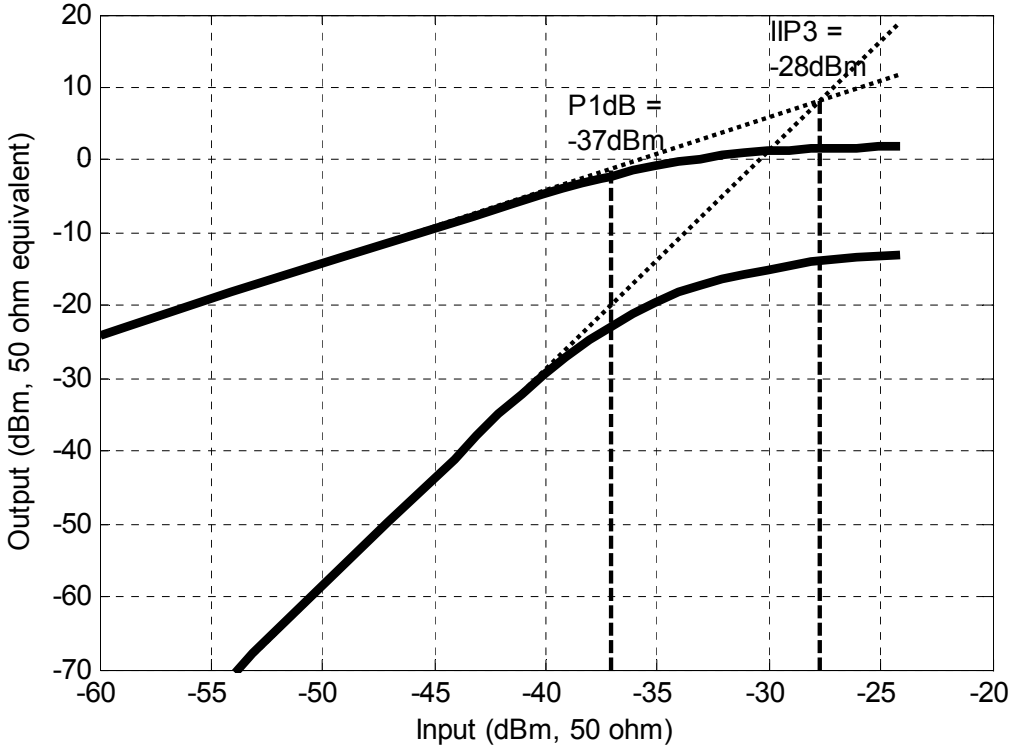
Results

- <9dB NF
- 30dB gain (from 200Ω)
  - LNA: 12dB
  - Mixer: 18dB



Results

- CP_{1dB} = **-37dBm**
- IIP_3 = **-28dBm**
- IIP_2 > **-5dBm**
  - Compare to 802.15.4 : >10dBm with 10dB margin



Summary

	This work	JSSC 11	ISSCC 10	JSSC 08	ISCAS 08
Technology (CMOS)	65nm	130nm	130nm	180nm	180nm
Frequency [MHz]	915	1575	1575	2500	2500
Power [µW]	**182 (282[1])**	200	1000	1400	1060
NF [dB]	< 9	7.2	6.5	5	8.4
Gain [dB]	30 (36[2])	41.8	42.5	43	24
IIP_3 [dBm]	-28	-35.8	-30	-37	-21
IIP_2 [dBm]	> -5				-5
Area [mm^2]	0.016	0.9	0.5	0.8	0.85

[1] with divider **[2] with added 50Ω match**

- Similar performance/power
- Notably smaller (inductorless)
  - Even if 50Ω LC match included

Conclusions

- Direct conversion receiver constructed
- Ultra-low power consumption
- Inductorless
- Matching through current feedback

- Similar performance to state of the art
  - but much smaller

Die Photo