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# Quadrature GPS Receiver Front-End in $0.13\mu\text{m}$ CMOS: The QLMV cell



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# Global Positioning System

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- A global navigation satellite system maintained by US government
  - Other systems: GLONASS (Russia), COMPASS (China), Galileo (EU)

- 30 NAVSTAR satellites in orbit
  - First satellite launched in 1978

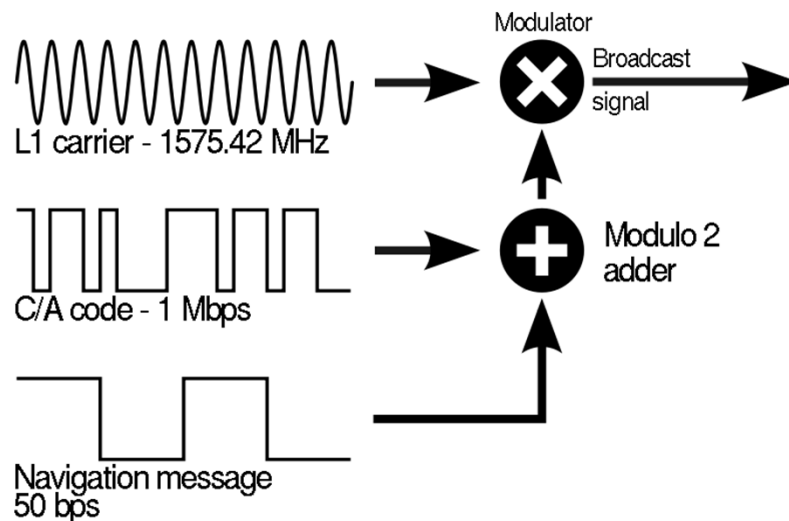


[www.blaugh.com]

- Approved for civilian use in 1983

# Global Positioning System

- Requires line of sight to four or more GPS satellites (latitude, longitude and altitude)
- 50W transmitter power

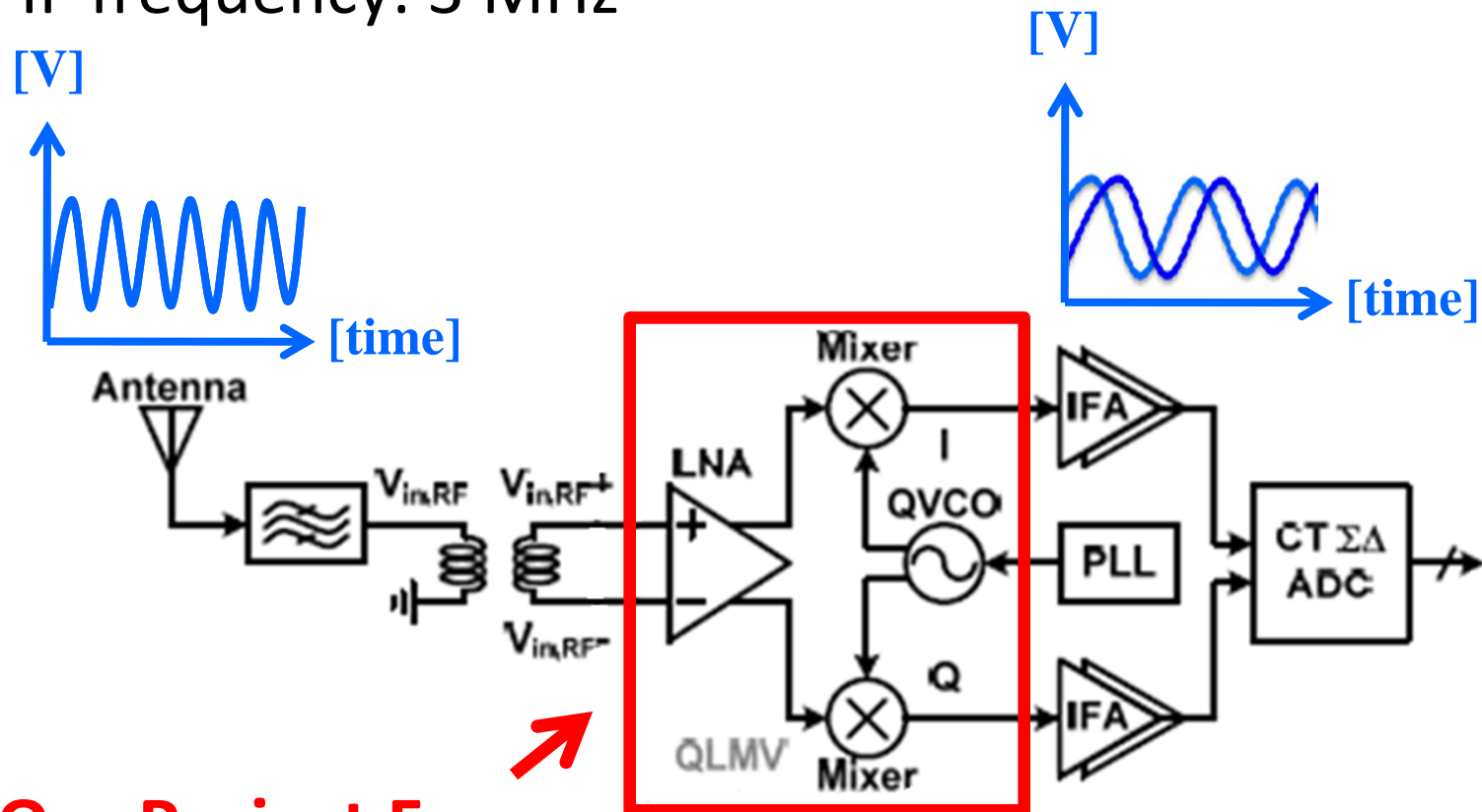


[[www.sparkfun.com](http://www.sparkfun.com)]

- L1 signal - 1.57542 GHz (Civilian)  
L2 signal - 1.2276 GHz (Military)

# GPS Receiver Architecture

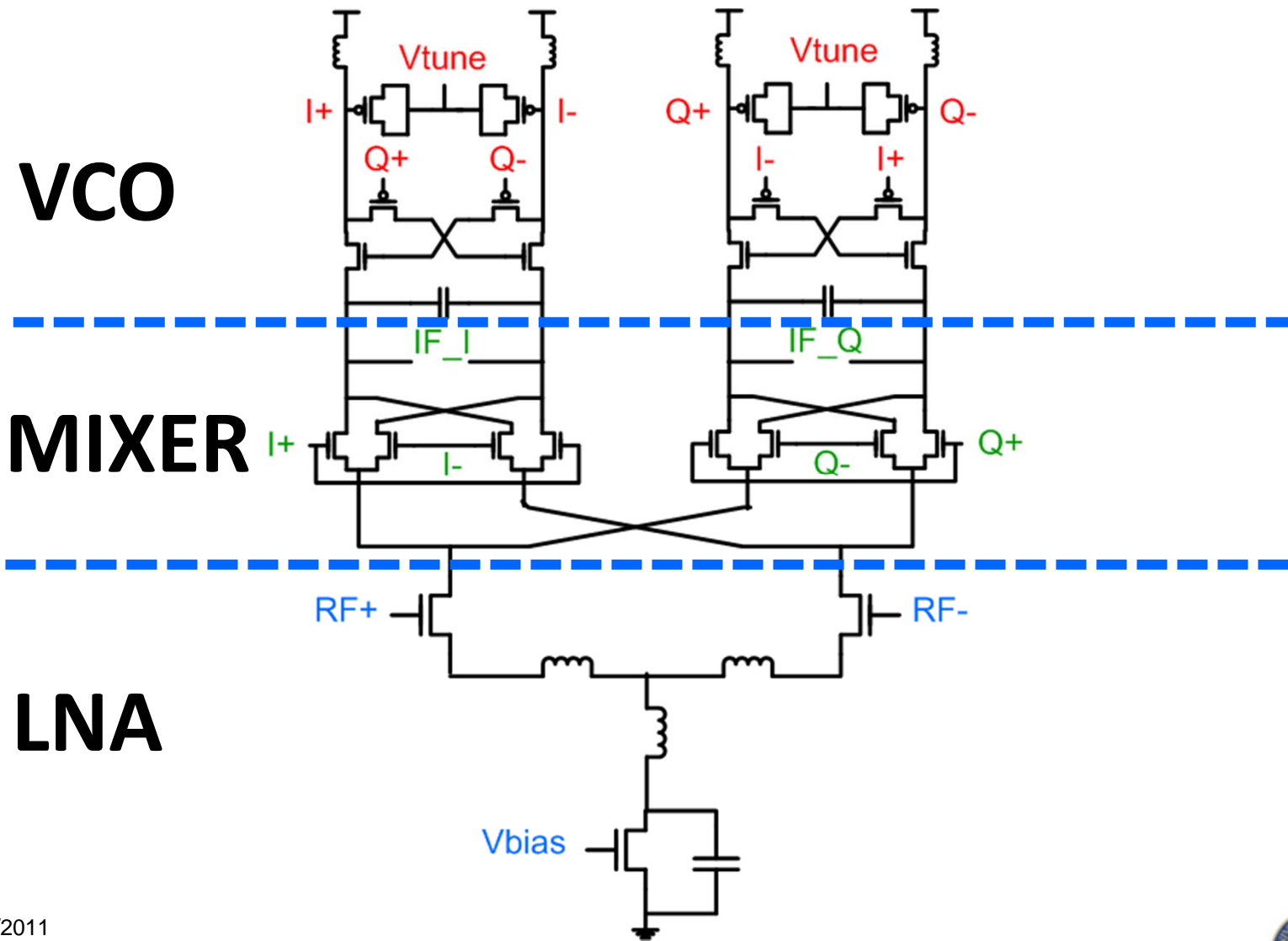
- Emphasizes on low-power design
- IF frequency: 3 MHz



**Our Project Focus**

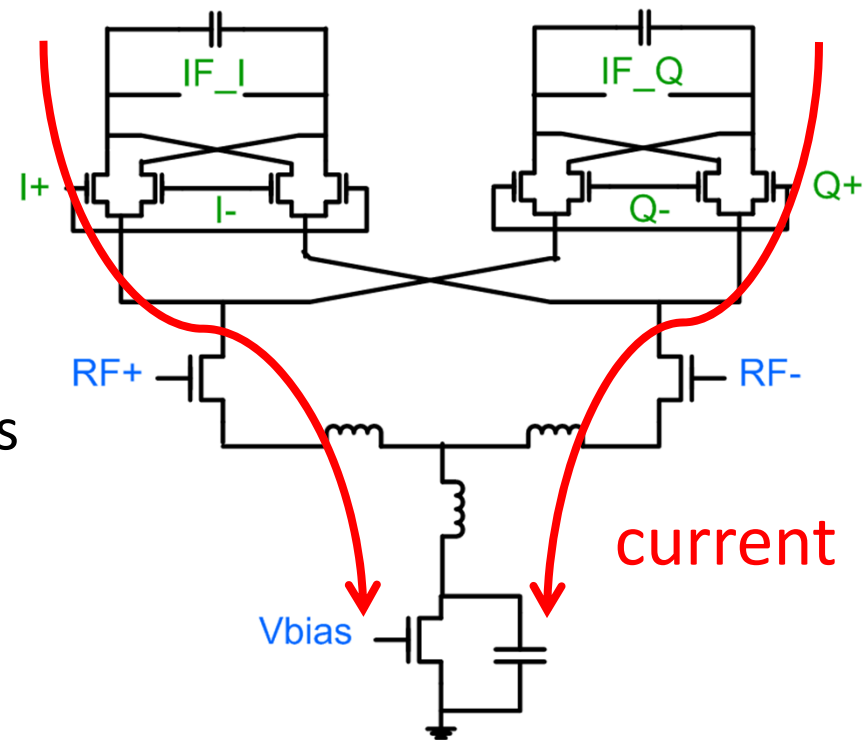
[Cheng et al. ISSCC'09]

# Stacked Quadrature LNA-Mixer-VCO



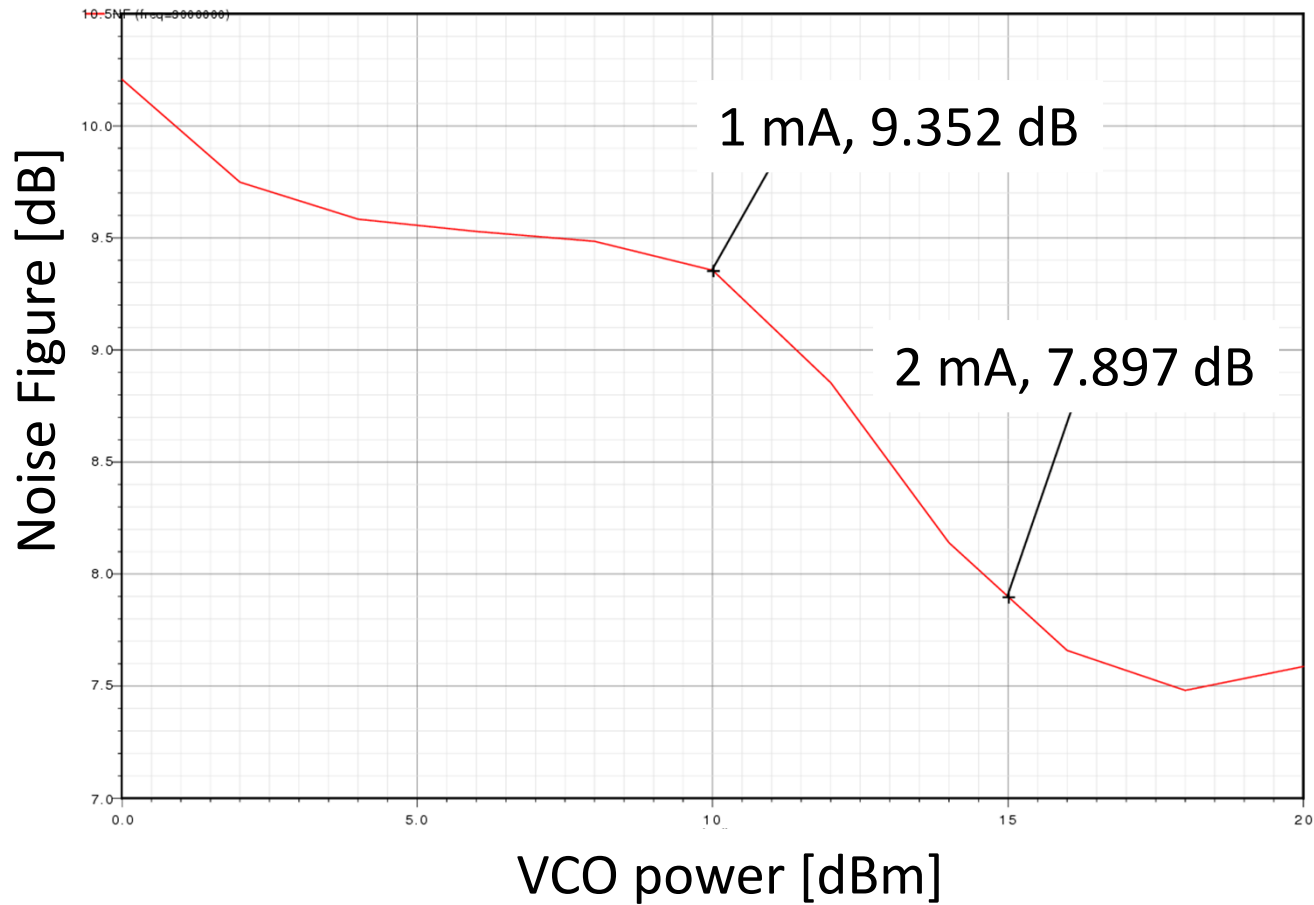
# Mixer-LNA

- Advantages
  - Current reuse
  - $1/f$  noise is minimized
  - 2X conversion gain comparing the single-balanced mixer
  - Number of transistors is reduced to optimize LNA NF and RF loss



# Mixer-LNA

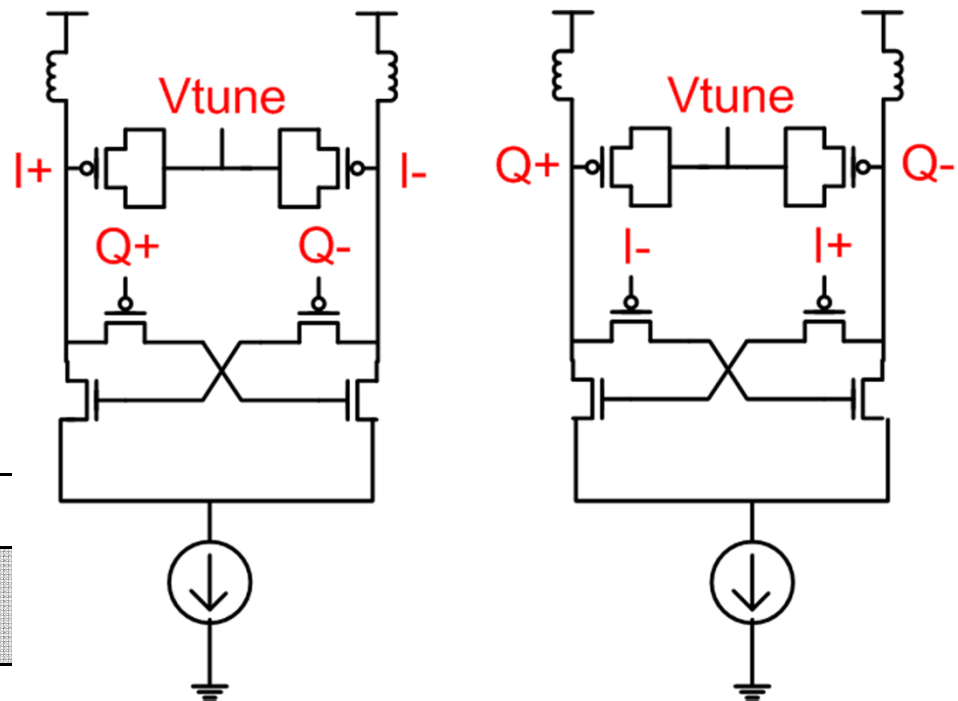
- Noise Figure



# Gate Modulated CMOS QVCO

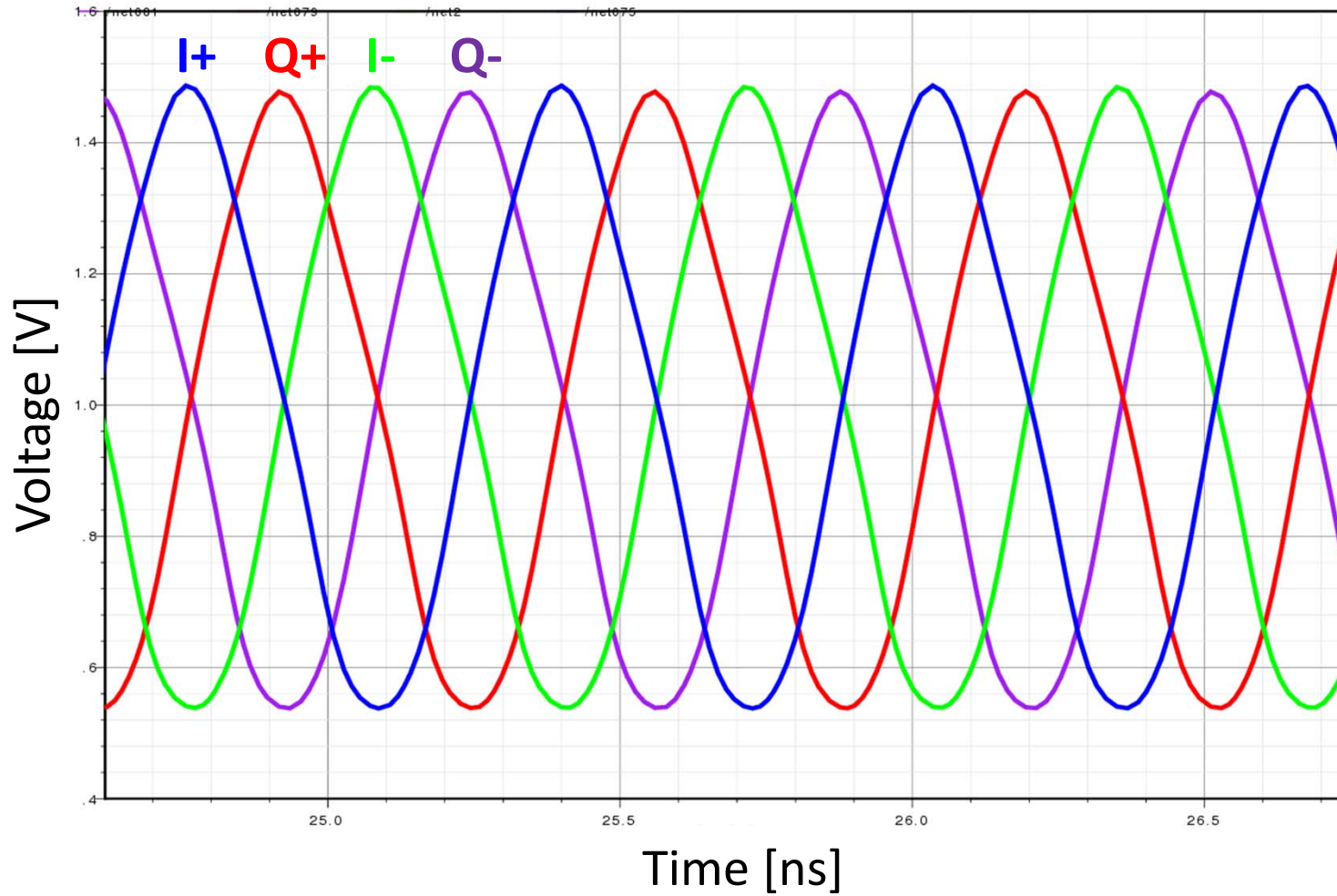
- Low power supply voltage operation
- Low phase noise
- Added parasitic capacitance

VCO Frequency	1.57 GHz
Phase Noise @ 1MHz	- 114 dBc/Hz

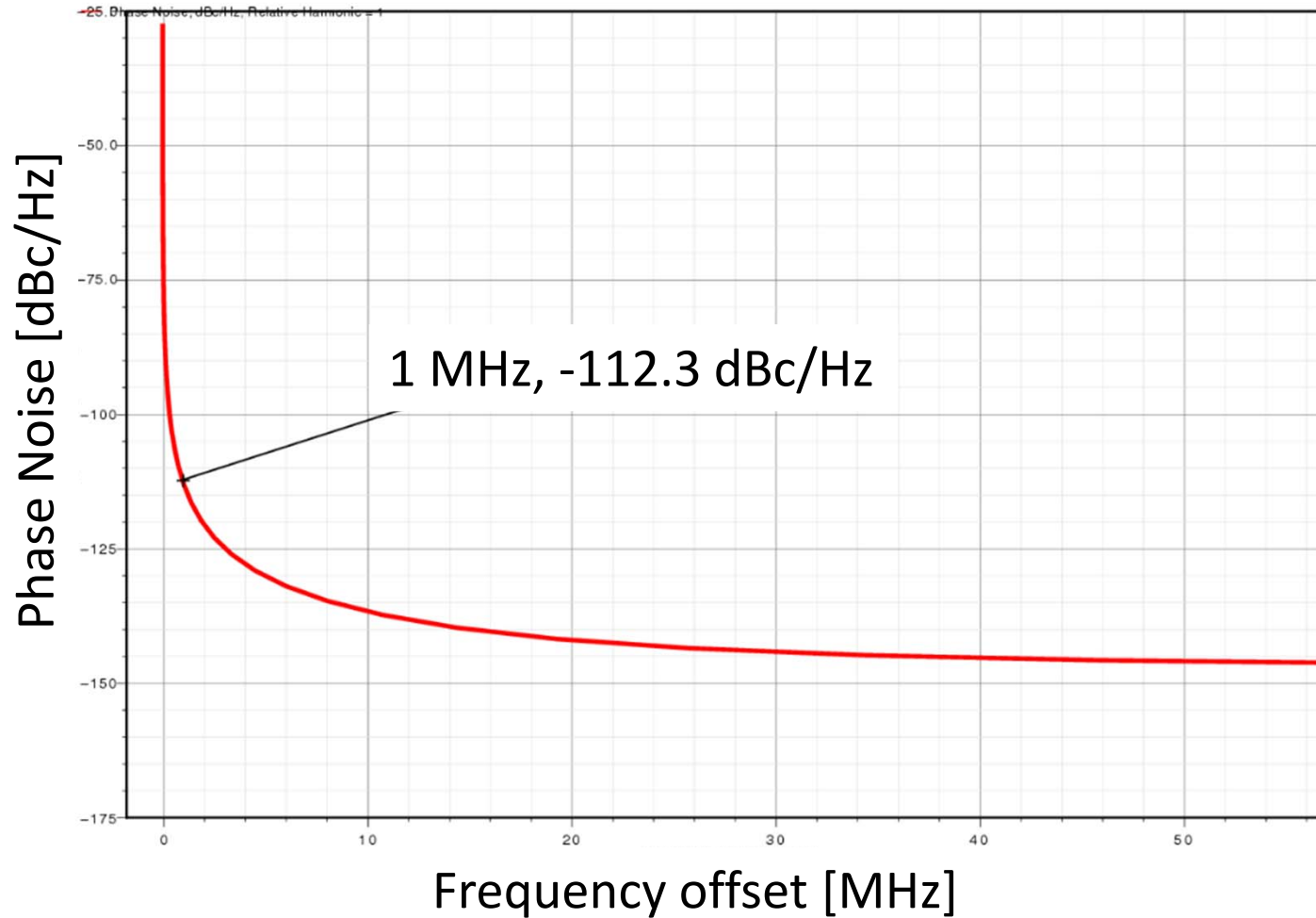




# QVCO Output

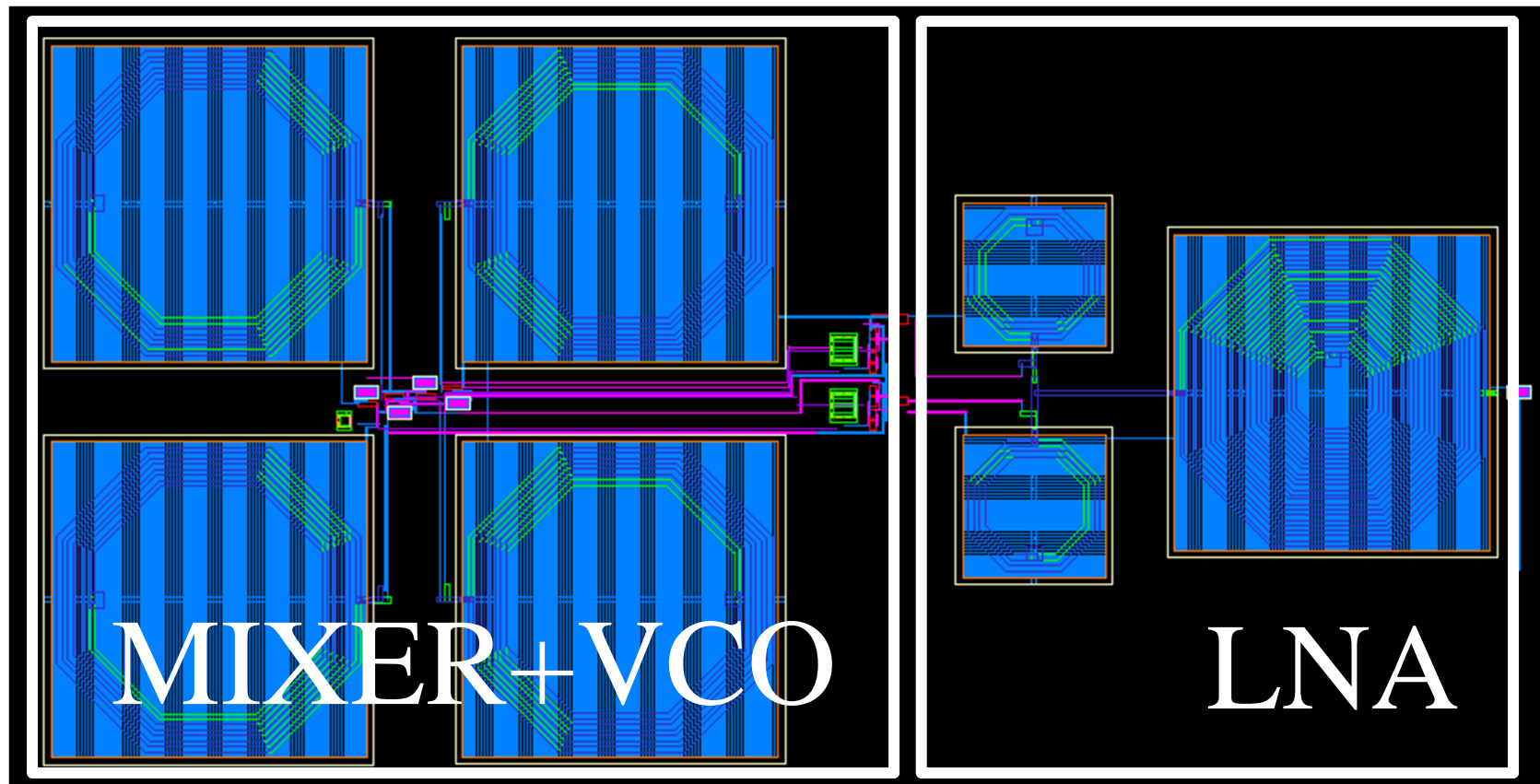


# QVCO Phase Noise



# QLMV Cell Layout

- Area:  $\sim 1\text{mm}^2$



4/20/2011



# Data Comparison

	<u>This Work</u>	[1]	[4]
<b>Technology</b>	0.13 $\mu$ m CMOS	0.13 $\mu$ m CMOS	0.13 $\mu$ m CMOS
<b>RF frequency</b>	1.57542GHz		
<b>Power (mW)</b>	2.14	1	5.4
<b>Conversion Gain (dB)</b>	27.7	42.5	36
<b>Phase Noise @ 1MHz (dBc/Hz)</b>	-112.3	-110	-104
<b>NF (dB)</b>	48	6.5	4.8
<b>P1dB (dBm)</b>	-68	-40	-31
<b>IIP3 (dBm)</b>	-57	-30	-19
<b>S11 (dB)</b>	< -30	< -10	< -10
<b>Current (mA)</b>	2.14	1	4.5
<b>Supply Voltage (V)</b>	1	1	1.2
<b>Area (mm<sup>2</sup>)</b>	1.05	-	1.5



# Questions?

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4/20/2011



# References

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- [2] Kuang-Wei Cheng, et al., "A 7.2mW Quadrature GPS Receiver in 0.13  $\mu\text{m}$  CMOS" *IEEE Int. Solid-State Circuits Conf. (ISSCC) Dig. Tech. Papers*, Feb. 2009.
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- [5] Kuang-Wei Cheng, et al., "A Gate-Modulated CMOS LC Quadrature VCO", *IEEE Radio Frequency Integrated Circuits Symposium*, 2009
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