BLUETOOTH RECEIVER

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EECS 522 Group Project

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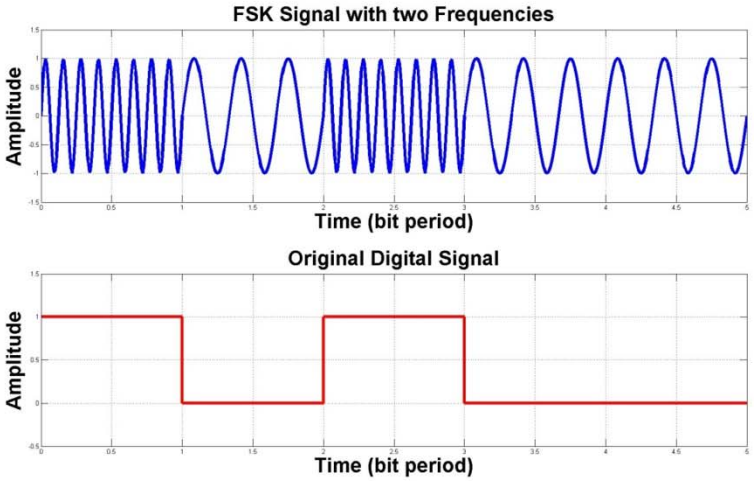
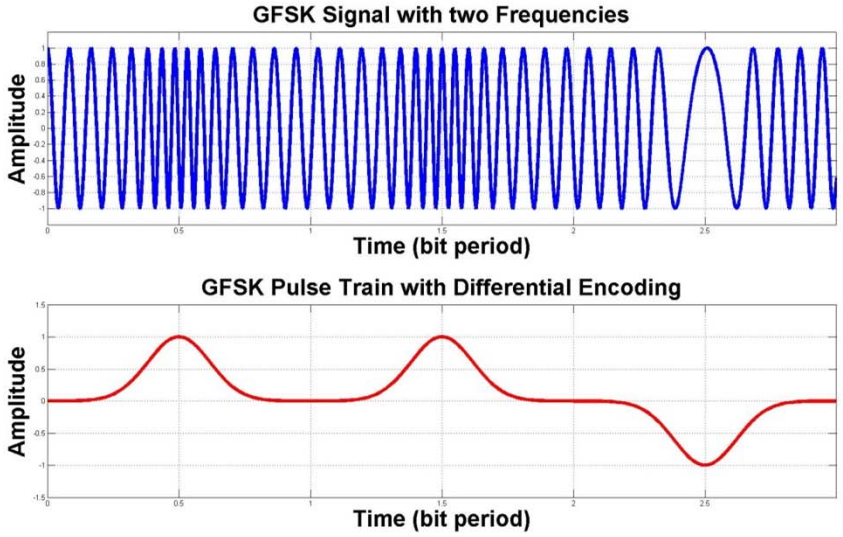
Bluetooth

- Started in 1994 by Ericsson, used for low-data rate streaming
- First generation was 1Mb/s
- Uses Gaussian Frequency Shift Keying (GFSK)
- Enhanced Data Rate (EDR) uses π/4- and 8-DPSK to achieve 3 &4 Mb/s, respectively
- 80 channels: 2.420GHz + k*1MHz (kX0…79)

GFSK

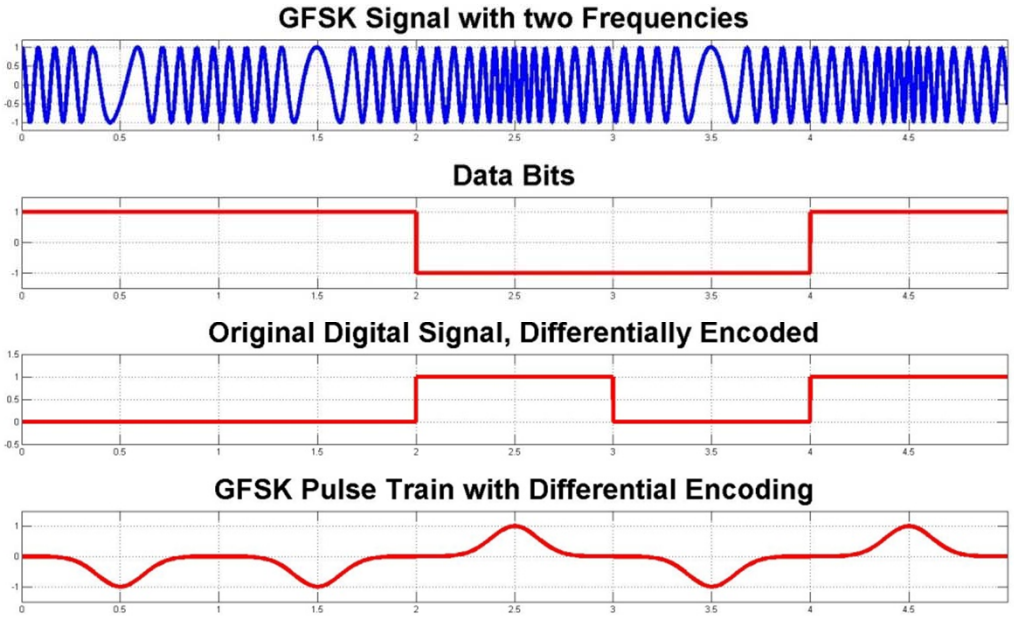
- Each bit is passed through a Gaussian filter before frequency encoding



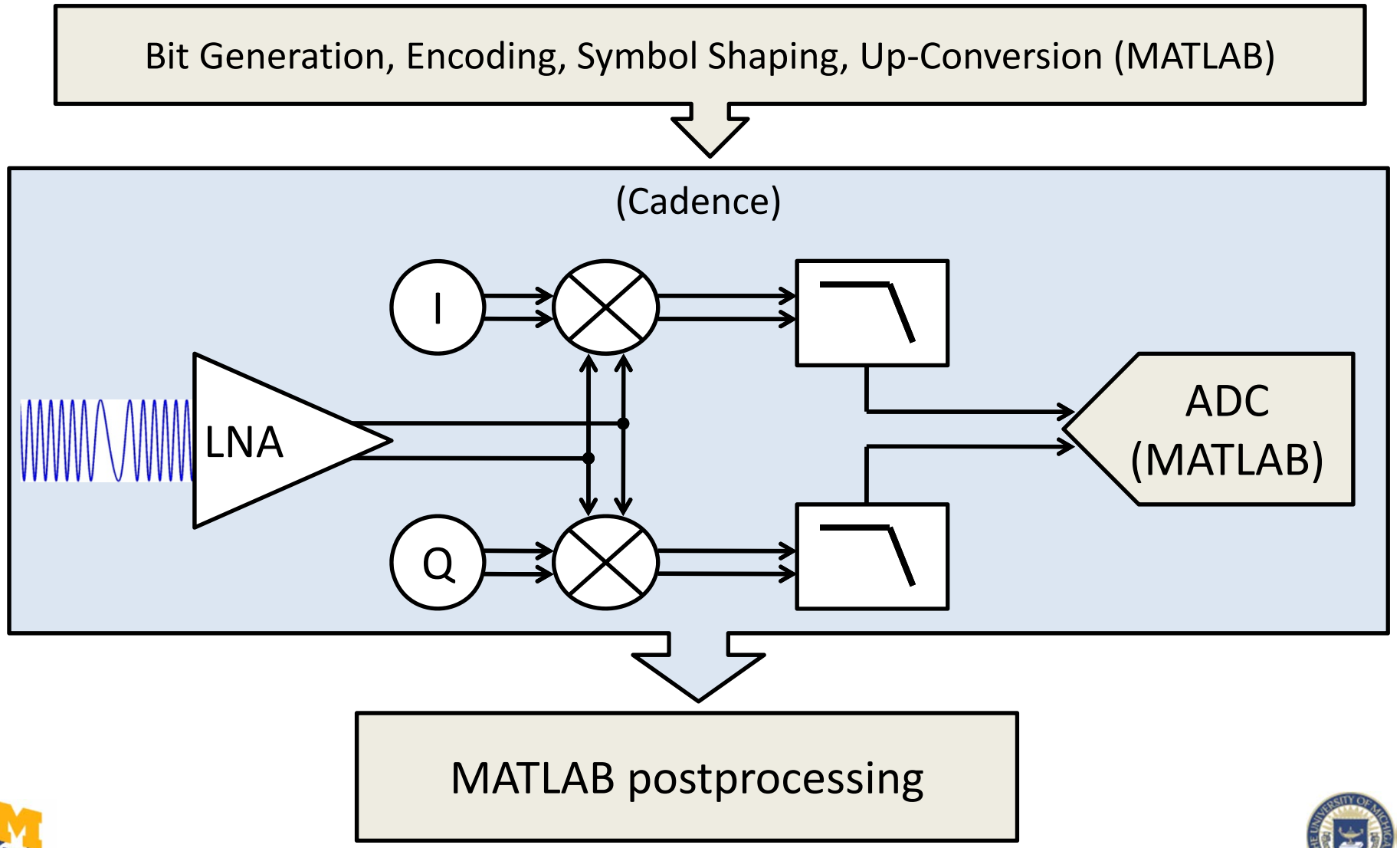


Our Signal

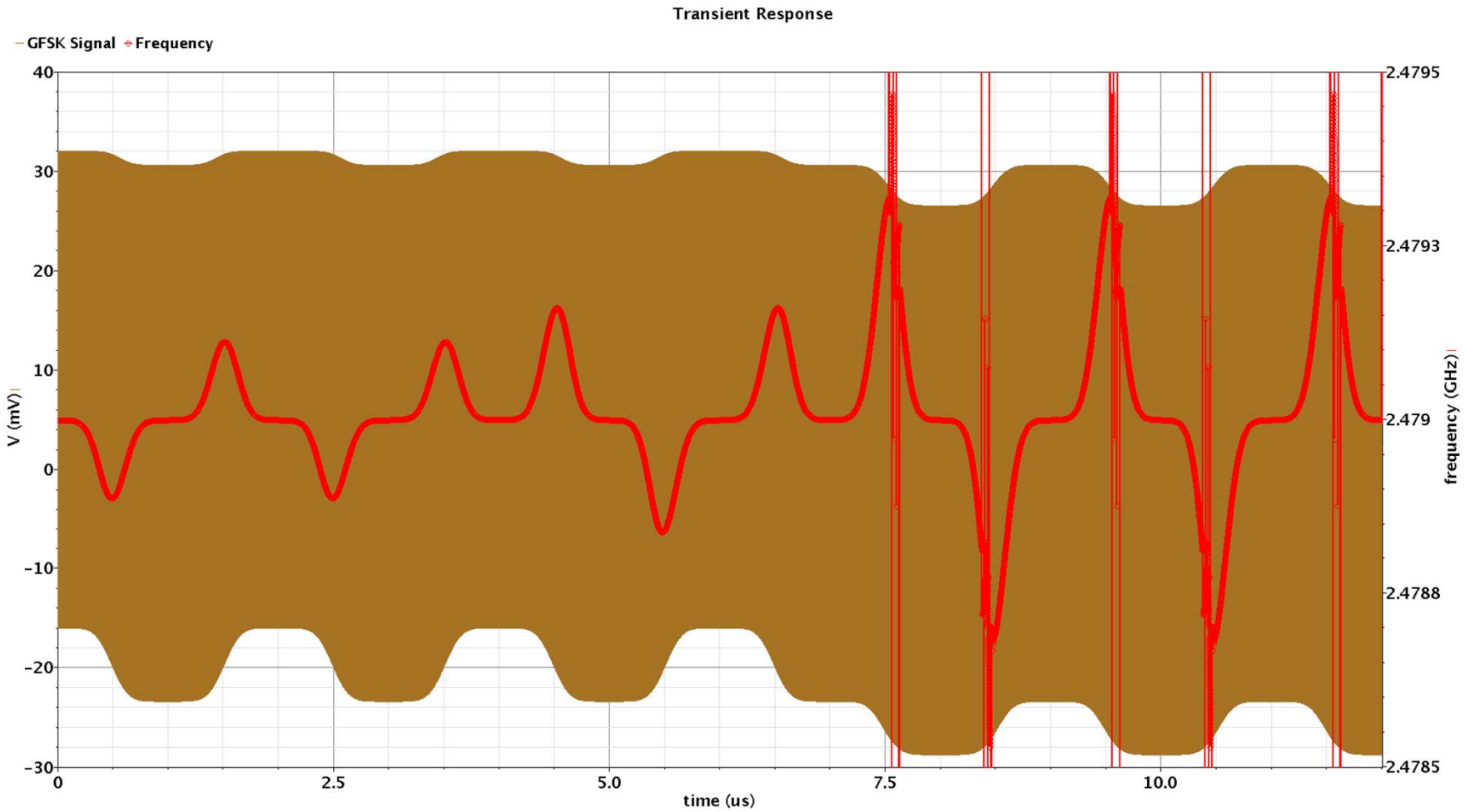
- Precursor + Start Sequence + Data
  - 0101010101010…1001…[data]
- Data is differentially encoded



System Flow Chart

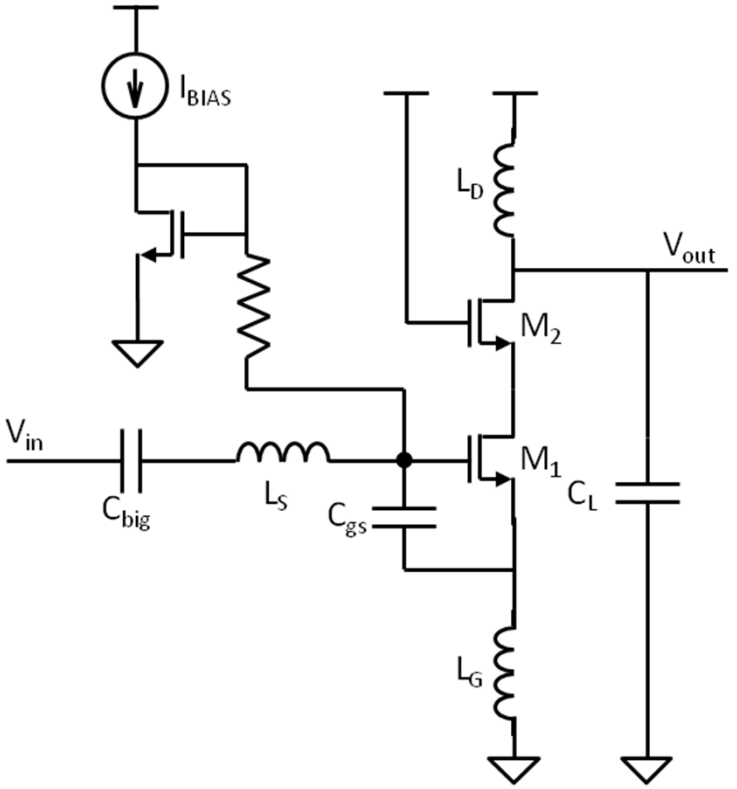


Quantization Noise



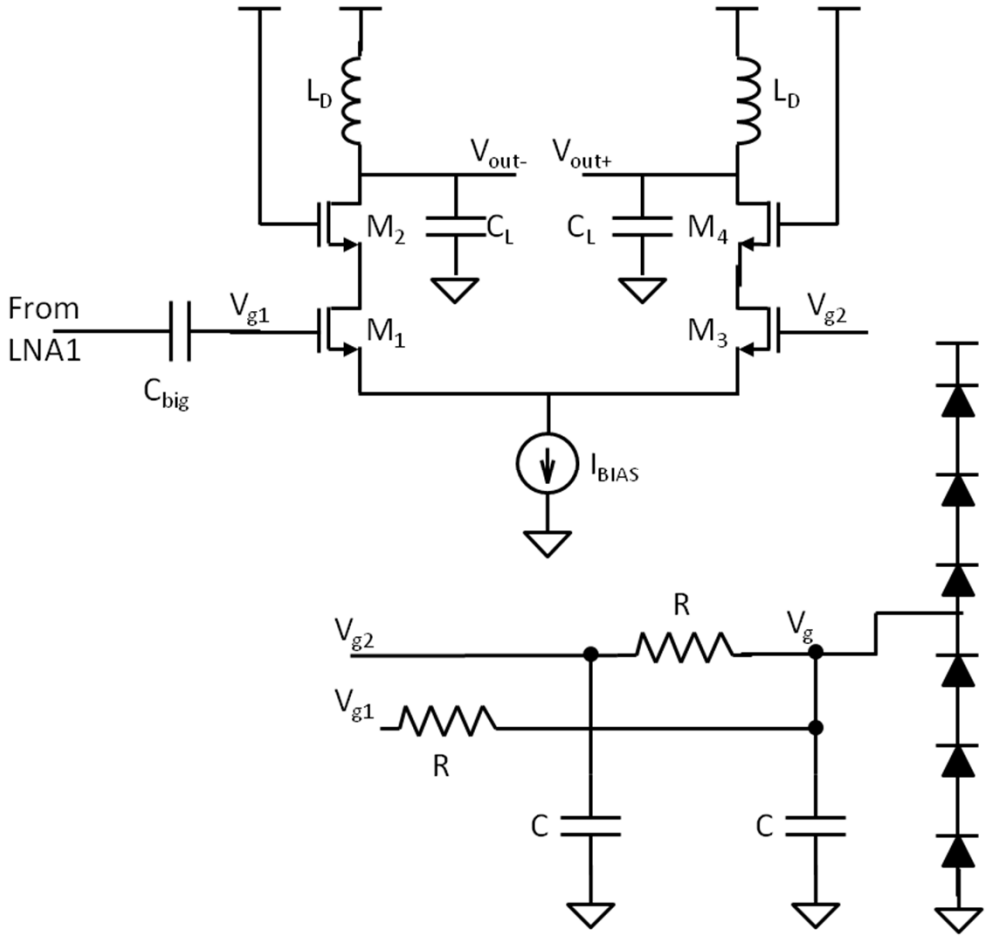
LNA1

- Performance
  - S11 < -13.5dB
  - S21 > 15dB
  - NF < 2dB
  - 13.9dB Voltage Gain
  - -30dB at 2nd harmonic
  - P1dB = -21dBm
  - 876uW @ 1.2Vdd



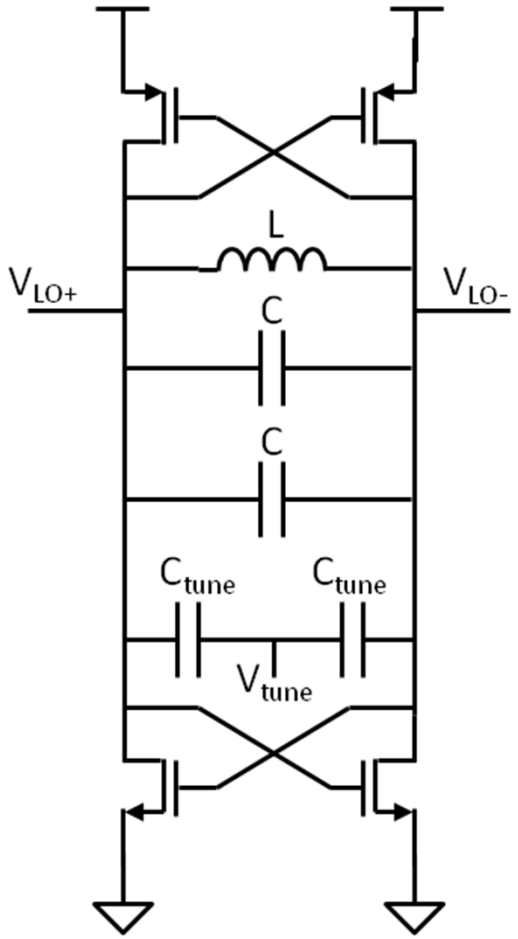
LNA2

- Performance
  - S21 > 15dB
  - NF < 6dB
  - P1dB = -8dBm
  - 990uW @ 1.2Vdd



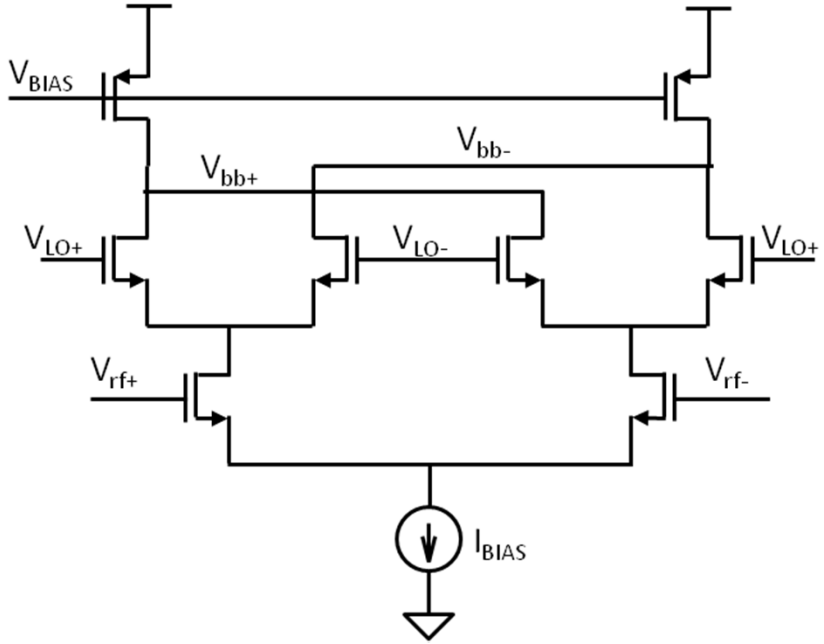
VCO

- Tuning Range
  - 2.41GHz ~2.49GHz
- Vtune Range
  - 400mV ~ 600mV
  - 2.5mV steps
  - Nonlinear steps
- 350mV swing at 750mV
- 562uW @1.2 Vdd (each)
- Coupling through subc
  - Use PMOS C_{tune} for isolation



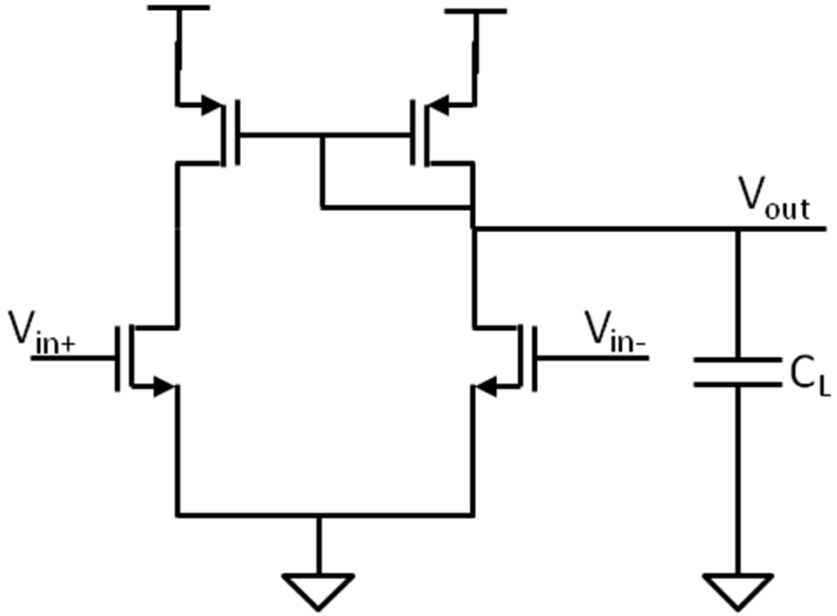
Mixer

- Direct Downconversion
  - No IF or image reject
  - DC output of mixer must be matched to next stage
- Performance
  - 1.98mW @ 1.2Vdd (each)
  - 200kHz f_{corner}
  - 9.5dB thermal noise
  - 11dB noise at f_c-f_{mod}
  - 18.5dB Conversion Gain
  - -4dBm P1dB

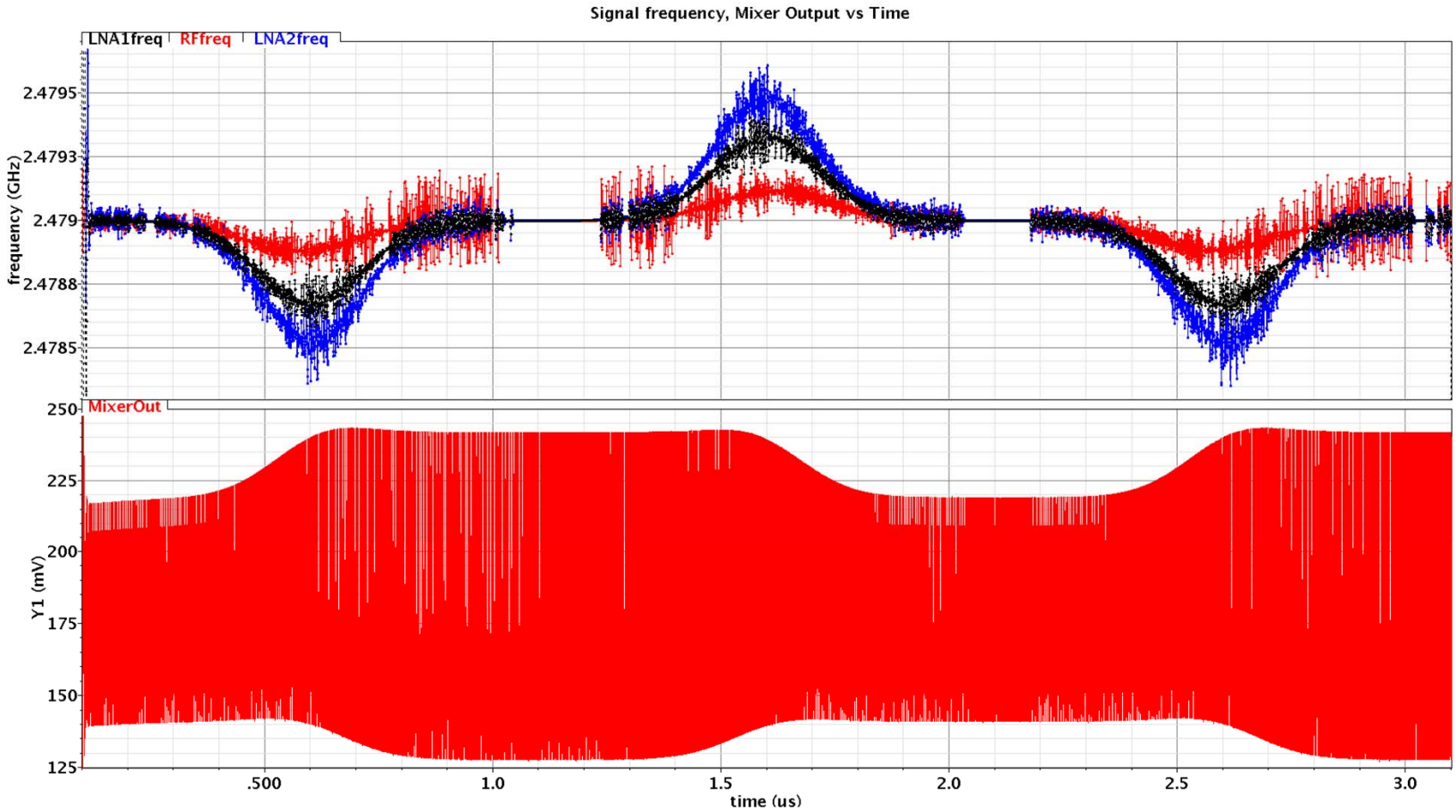


Active Low Pass Filter

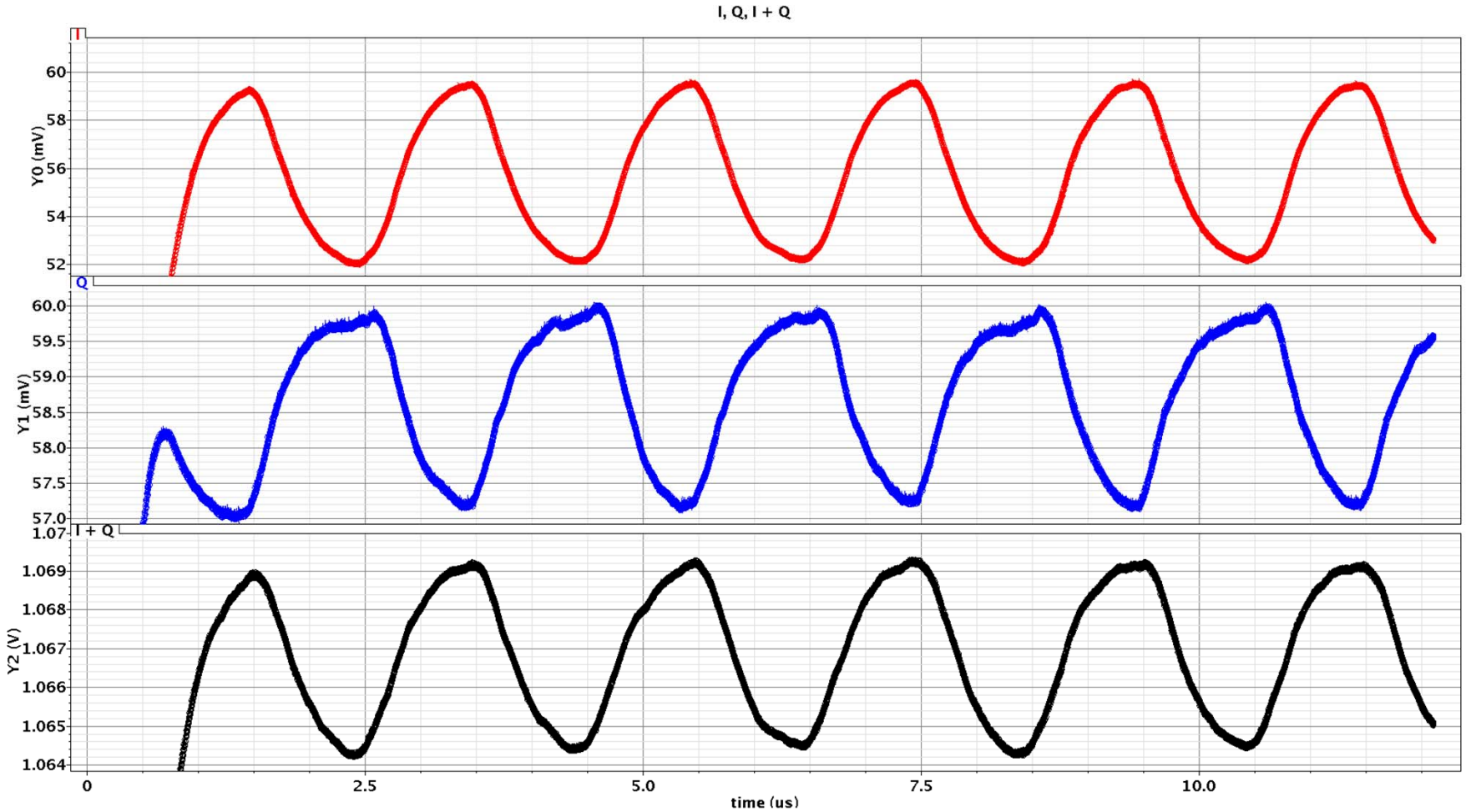
- Envelope Detector
- Active Balun
  - Tail source could provide variable gain
- Performance
  - 136uW @ 1.2Vdd (each)
  - Gain = 19.2dB
  - P1dB = -2.1dBm
  - BW(7pF) = 750kHz



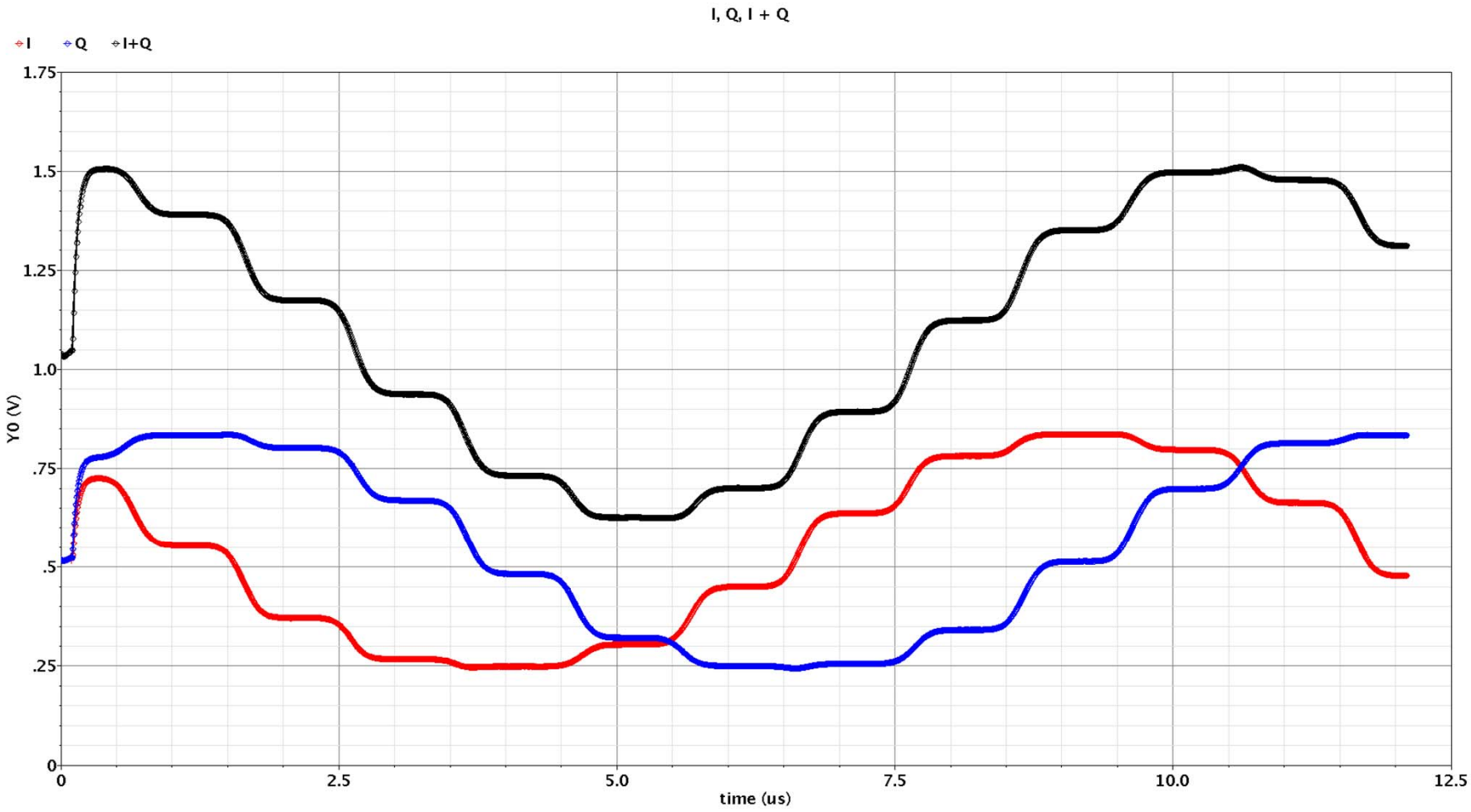
Input Freq vs Mixer Output



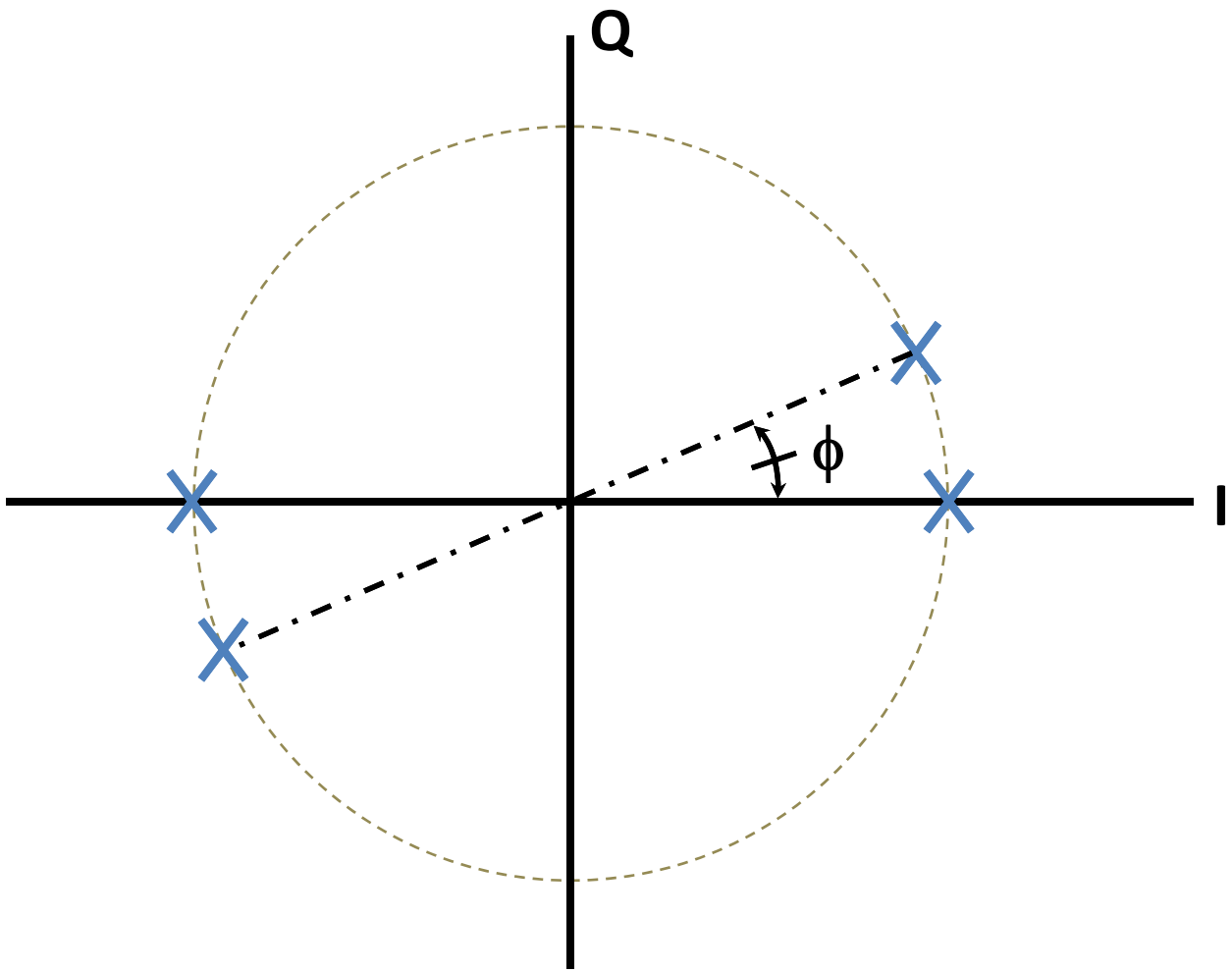
010101010101 at -80dBm



111111111111 at -50dBm

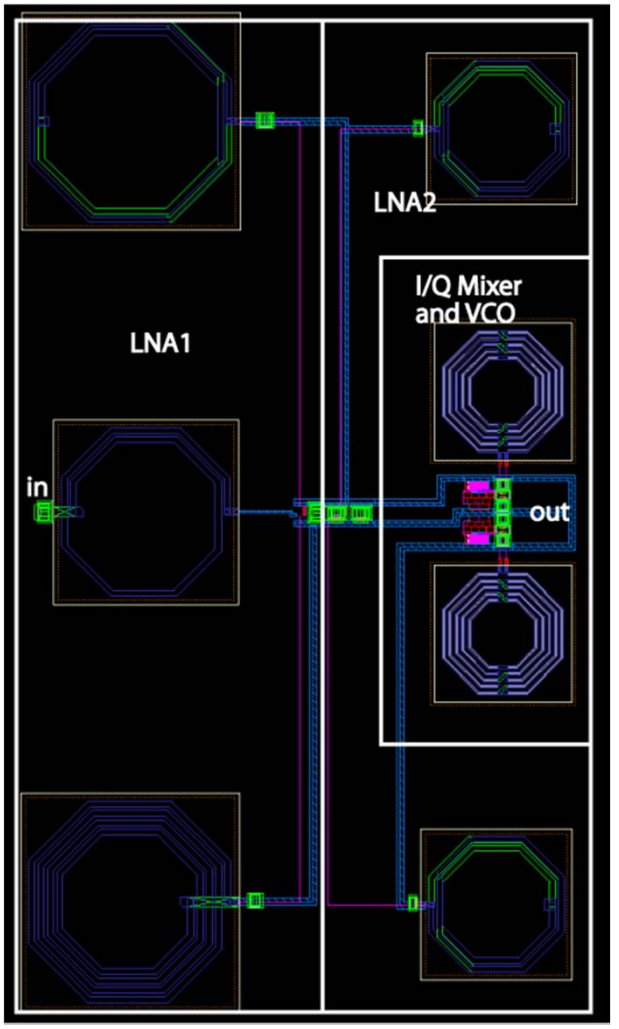


Binary GFSK Constellation



Layout

- 1.5 x 0.8 mm^2
- Separated Mixer and VCO from LNA to decrease subc coupling
- Symmetric Inductors for VCO
- Symmetric Layout



Comparison

	2004 [2]	2008 [3]	Our Design
NF	-	13.11	~16.5
Sensitivity [dBm]	-87	-	-
Gain [dB]	70	~90	67
IIP3 [dBm]	-21	-20.8	-21.9
VDD [V]	2.7	1.2	1.2
P_{VDD} [mW]	135	15.42	7.86
Technology (CMOS)	0.25um	0.13um	0.13um

Future Work

- Noise Analysis
- Demodulation of Cadence Data
- More complex encoding schemes for higher data rates

References

[1] Cheung, V.S.L.; Luong, H.C.; , "A 1V 10-mW monolithic Bluetooth receiver in a 0.35µm CMOS process," *Solid-State Circuits Conference, 2003. ESSCIRC '03. Proceedings of the 29th European* , vol., no., pp. 687- 690, 16-18 Sept. 2003.

[2] Yeon-Jae Jung et al, "A 2.4-GHz 0.25-um CMOS Dual-Mode Direct Conversion Transceiver for Bluetooth and 802.I1b", IEEE J.Solid State Circuits, Volume: 39 Issue: 7, JULY 2004.

[3] Aboueldahab, W.F.; Sharaf, K.M.; , "A 1.2V low power CMOS receiver for Bluetooth," *Solid-State and Integrated-Circuit Technology, 2008. ICSICT 2008. 9th International Conference on* , vol., no., pp.1577-1580, 20-23 Oct. 2008.

[4] *Bluetooth Enhanced Data Rate (EDR): The Wireless Evolution*. Tech. Agilent Technologies. Print. Application Note.

[5] *Specification of the Bluetooth System Version 4.0*. 30 June 2010. Master Table of Contents & Compliance Requirements.