A Current Re-use Quadrature Front-End Receiver for ISM Band

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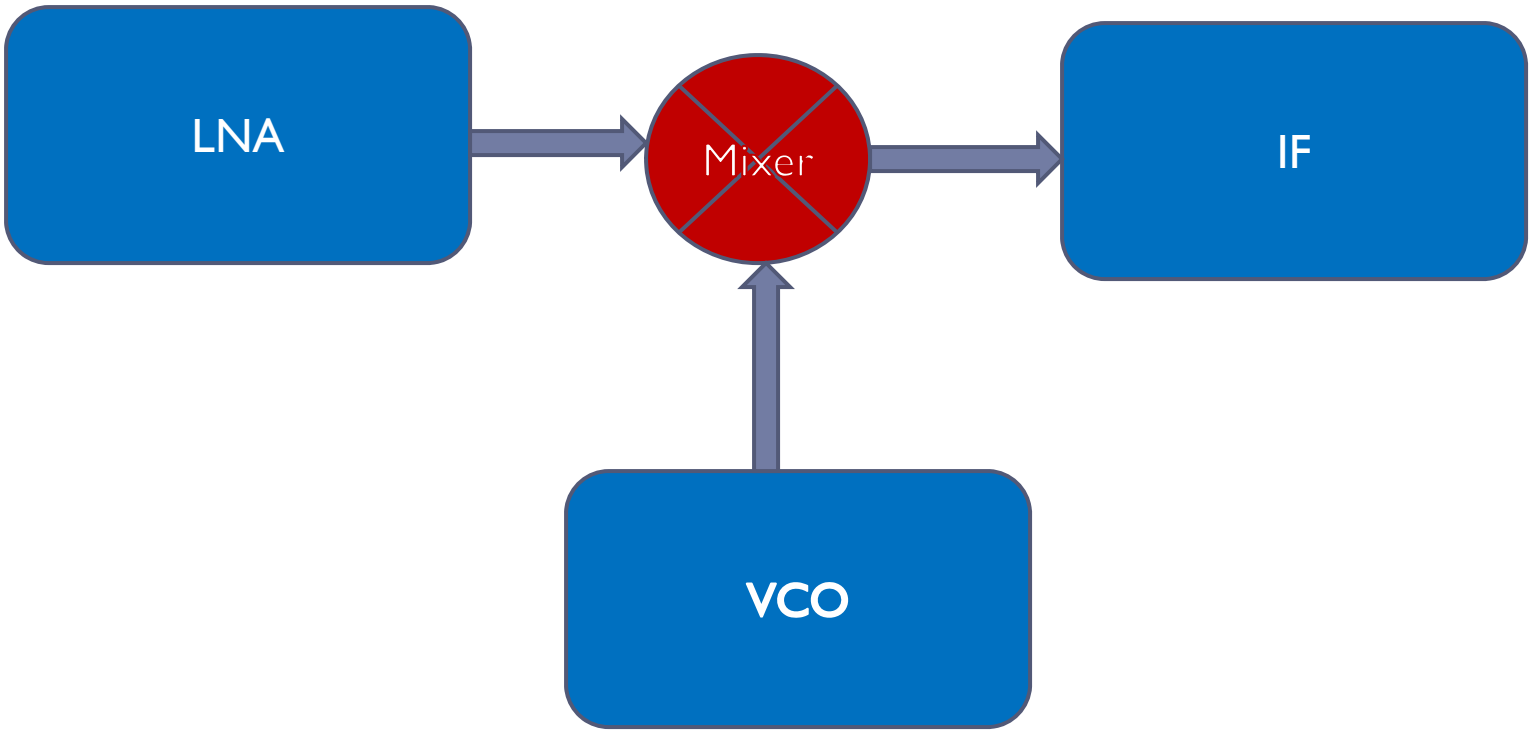
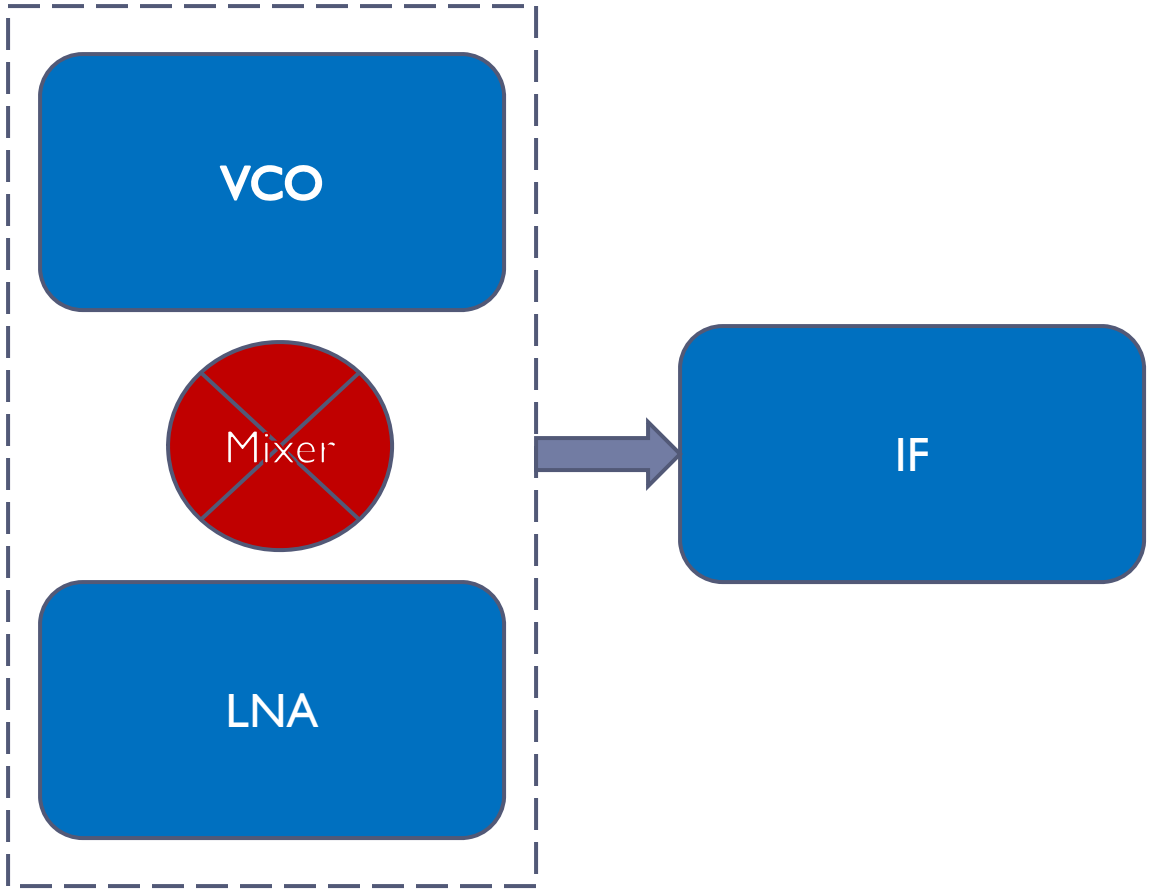
Introduction

- Stacked current reuse architecture for front-end
  - Low power, bias current re-use
  - No coupling required from stage to stage
- I and Q demodulation
  - Image rejection
- ISM Band 915 MHz
  - Intermediate frequency is 10 MHz
  - IF amplifier with LO leakage reduction
  - BPSK coding
- Applications:
  - Cordless phone
  - WSN nodes
  - ZigBee devices

Conventional Receiver Architecture

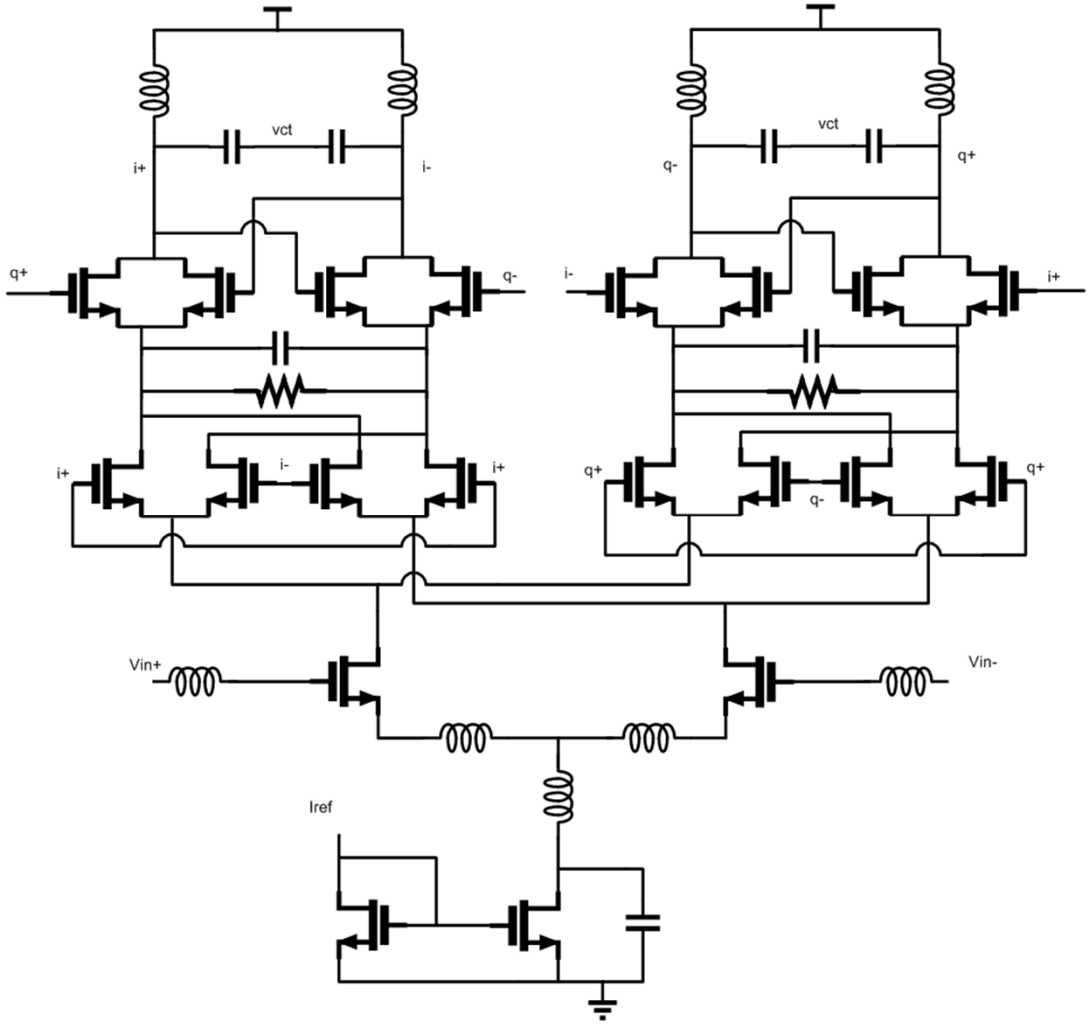


QLMV – Block level



QLMV Cell Stack

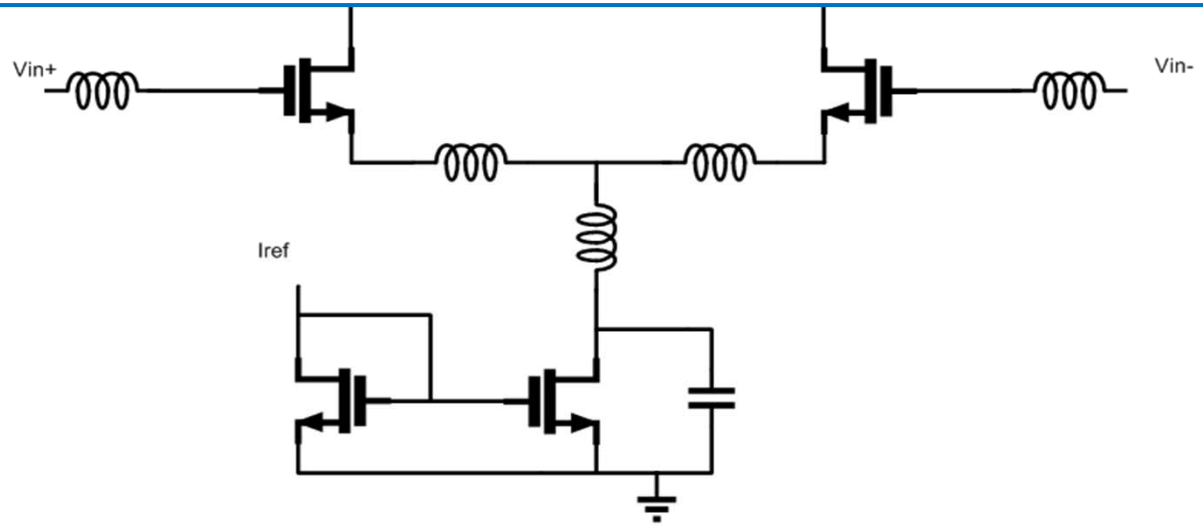
QLMV Cell (Top-Level)

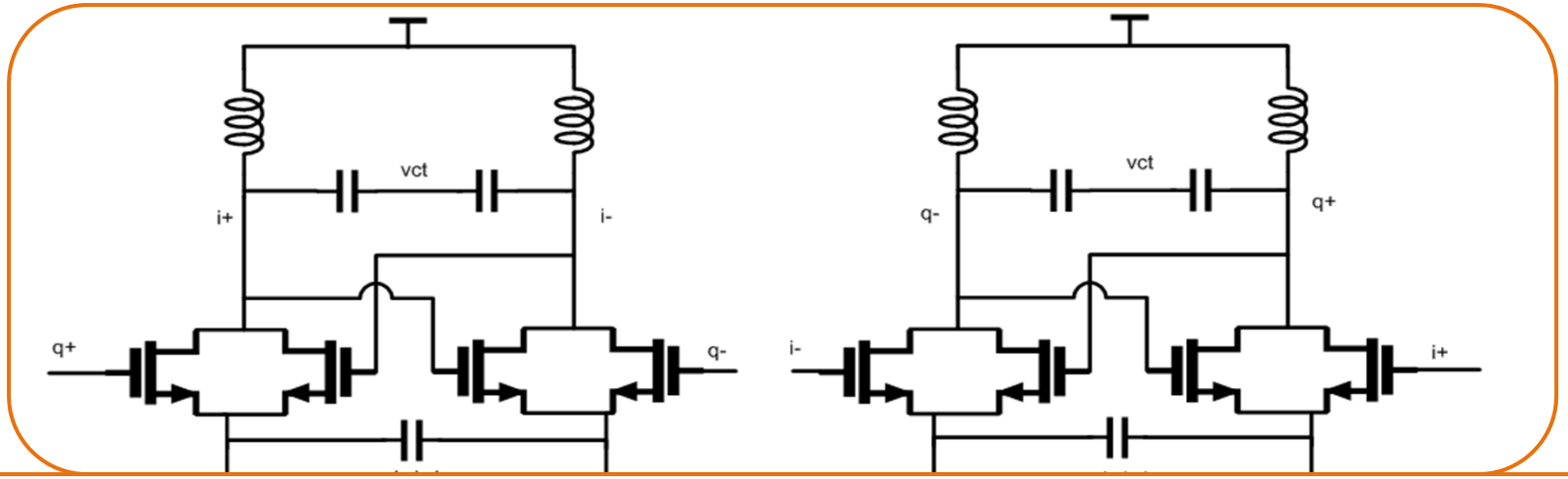


[1], [3]

LNA:

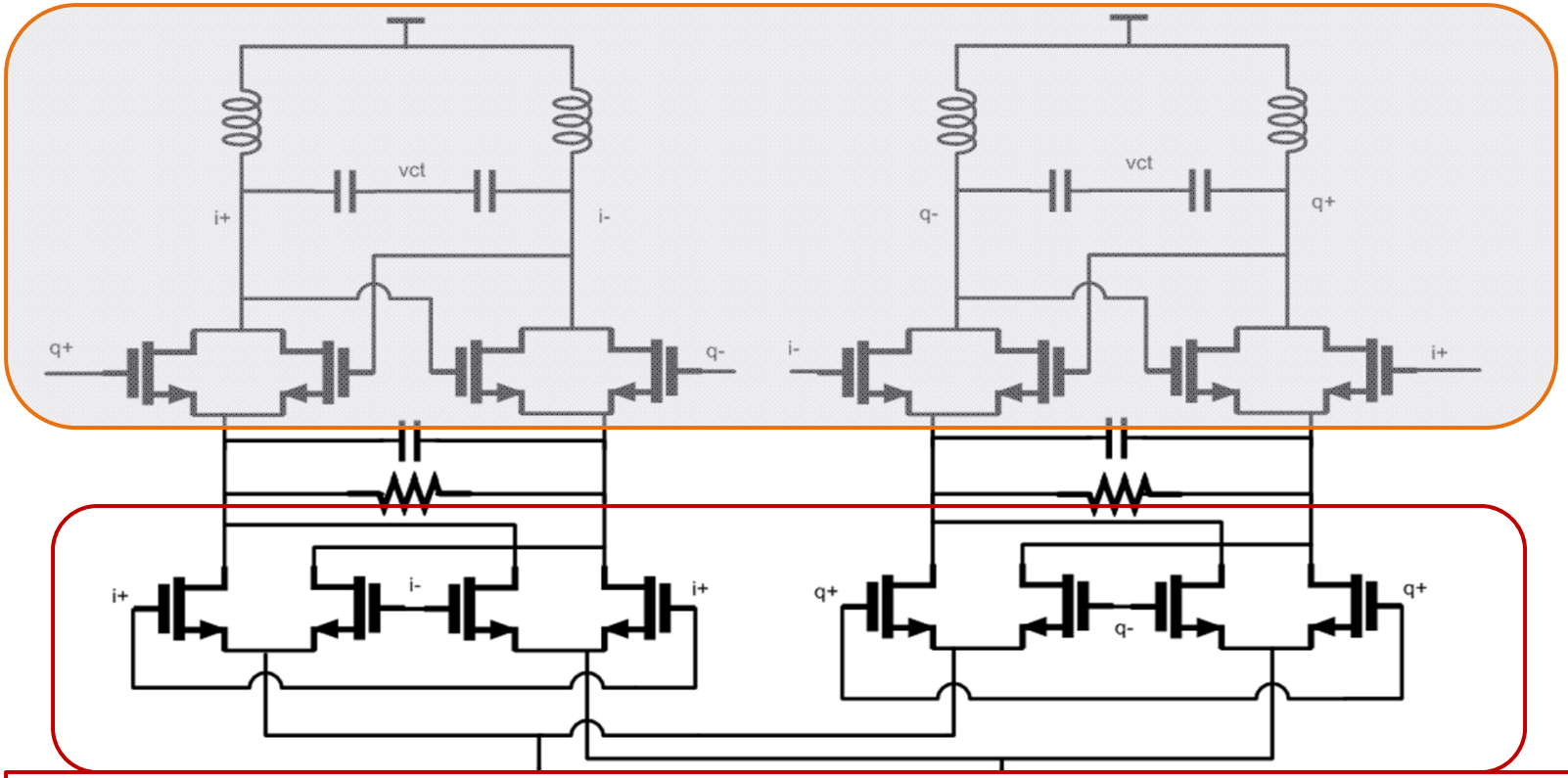
- Degenerated Common Source Amplifier
- Tested with balun as well as a direct input port
- S_{11} : -18dB @ 900MHz
- Inductor to decouple
  - Open circuit at high frequencies
- Tail current of 1.8mA.
- LNA NF (individual characterization) : 2.1 dB





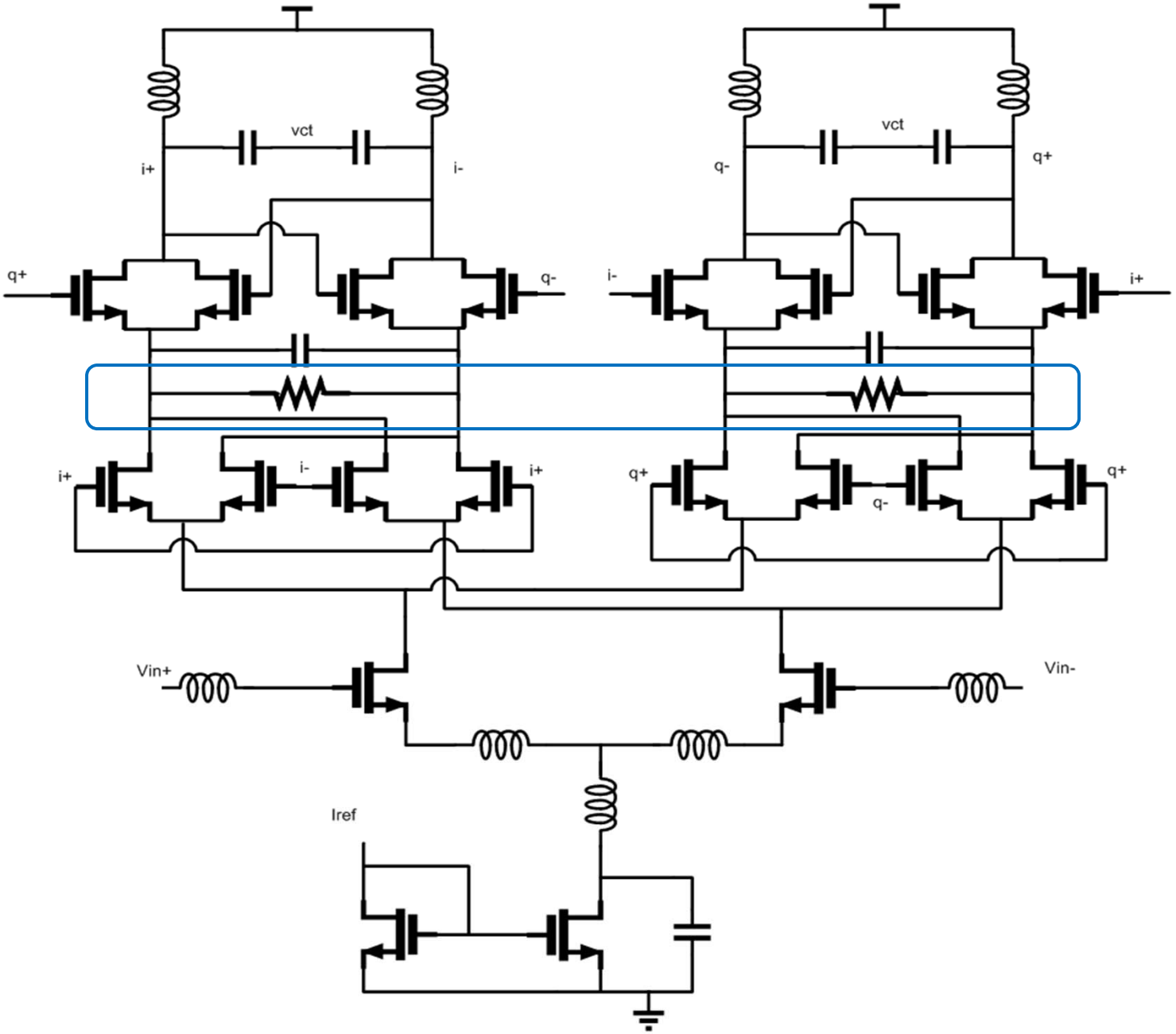
QVCO:

- Gate-modulated architecture proposed by the paper
  - Less frequency pulling and increased phase noise
- Chose to implement a PVCO
- Phase Noise. - 115dBc (900Mhz – 940Mhz)
- Tunability: Vct - 500mV – 700mV. (for PLL or outside tuning)
- Bottom cap for increasing Q-factor and reducing feedthrough of LO
- Transistors sized up to reduce flicker noise



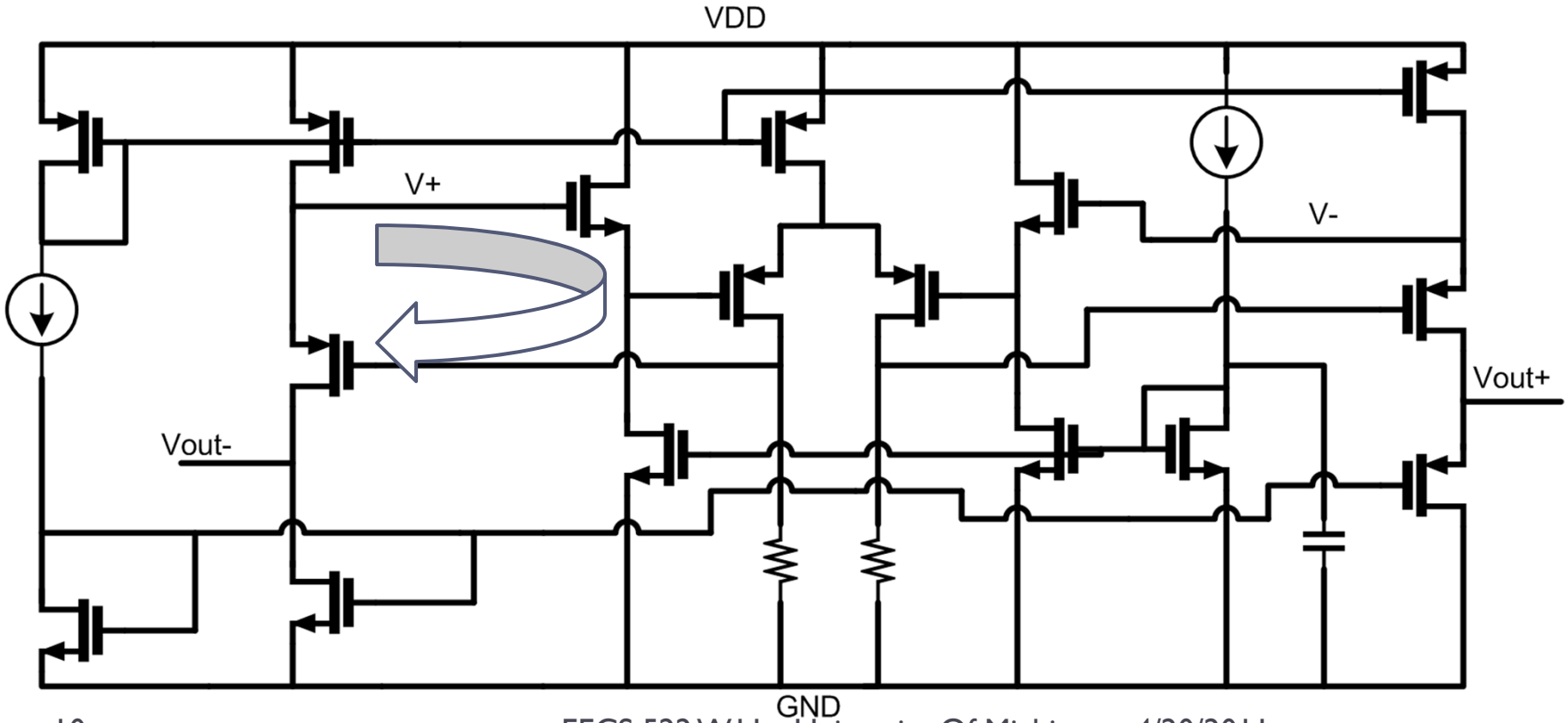
Mixer:

- Doubly balanced Gilbert mixer
- Mixer works in triode
  - Running in saturation needs external circuitry (adds noise)


vct
i+
i-
q+
q-
vct
q-
q+
i-
i+
i+
i-
i+
q+
q-
q+
Vin+
Vin-
Iref

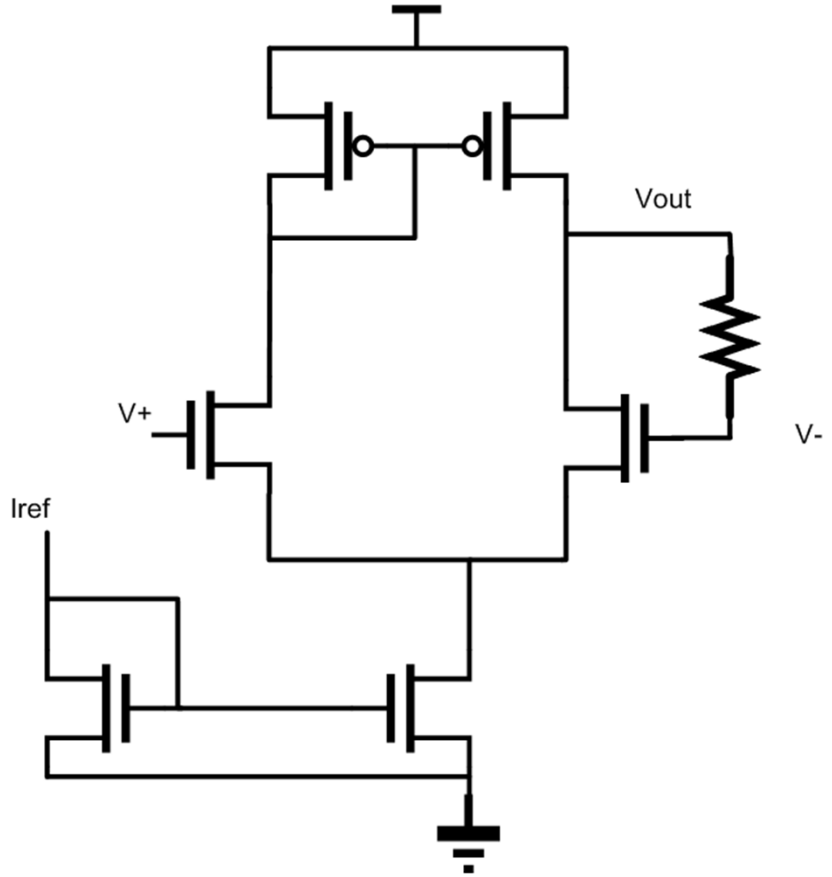
IF Amplifier 2 (IF_2)

- New architecture – trans-impedance amplifier
- 40dB/dec roll off
- Power consumption: 1mW



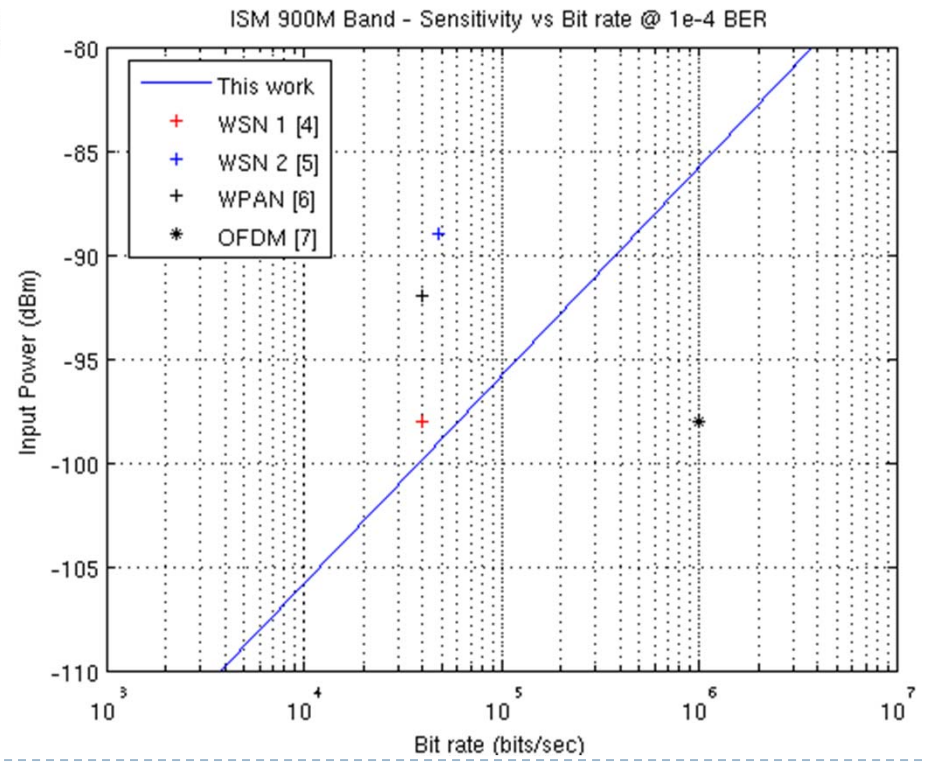
IF Amplifier 1 (IF_1)

- Single pole trans-impedance amplifier
- Bandwidth – 15 MHz
- 20dB/dec roll-off
- Power: 300 µW



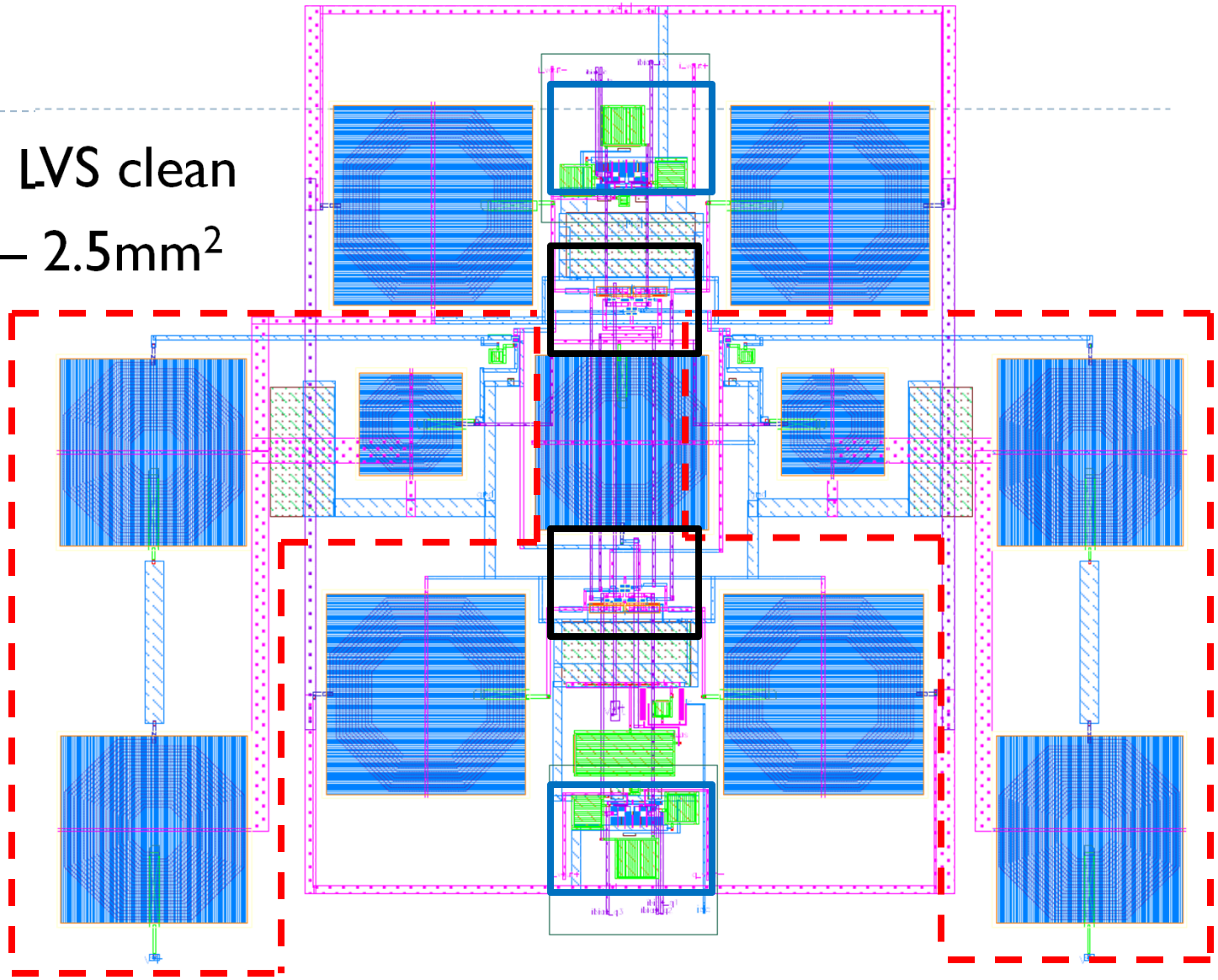
System Integration and Comparison

- RC polyphase filters for image rejection
  - Generates bandpass filter
- PLL for frequency control
- Baseband DSP processing
- Typical BER - 10^{-4}
- Link Budget Analysis
  - 900MHz Protocols



Layout

- DRC and LVS clean
- Die area – 2.5mm^2



LNA
VCO + mixer
IF Amplifier

Summary Chart

	QLMV (IF_1)	QLMV (IF_2)	[1] GPS Rx
S_{11} (dB)	< -10	< -10	< -10
IIP3 (dBm)	21.5	- 55	- 30
P_{-1}dB (dBm)	- 41.5	- 65	- 40
Conversion gain (dB)	46	42	42.5
Noise Figure (dB)	9.8	12	6.5
VCO Phase Noise (dBc/Hz) @1 Mhz	-116	-116	-110
VDD (V)	1.2	1.2	1
Current QLMV (mA)	1.8	1.8	1
Current IF Amp (mA)	1	1.8	1

References

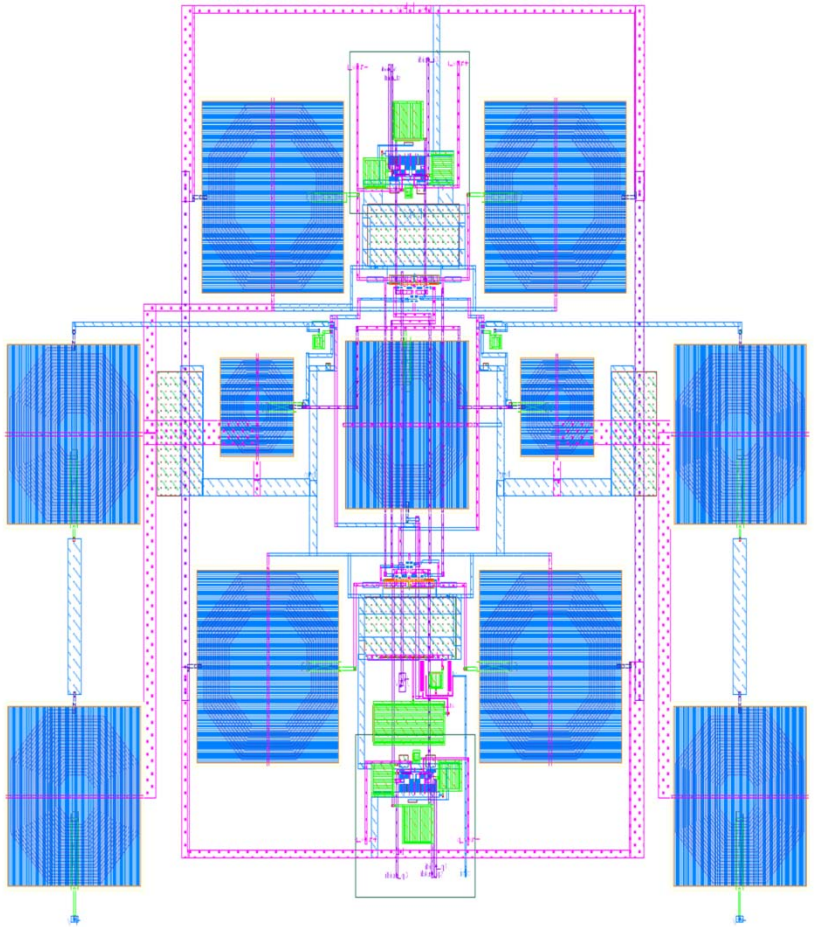
- [1] Kuang-Wei Cheng; Natarajan, K.; Allstot, D.J.; , "A Current Reuse Quadrature GPS Receiver in 0.13 m CMOS," *Solid-State Circuits, IEEE Journal of* , vol.45, no.3, pp.510-523, March 2010
- [2] A. Liscidini, A. Mazzanti, R. Tonietto, L. Vandi, P. Andreani, and R. Castello, "Single-stage low-power quadrature RF receiver front-end: The LMV cell," IEEE J. Solid-State Circuits, vol. 41, pp. 2832–2841, Dec. 2006.
- [3] K.-W. Cheng and D. J. Allstot, "A gate-modulated CMOS LC quadrature VCO," in *IEEE Radio Freq. Integrated Circuits Symp. Dig., 2009,* pp. 267–270.
- [4] RF Link Budget Analysis at 915 MHz band for Wireless Sensor Networks

  Abdellah Chehri, Member, IEEE, Hussein Mouftah, Fellow, IEEE, Paul Fortier, Senior, IEEE, and Hasnaa,

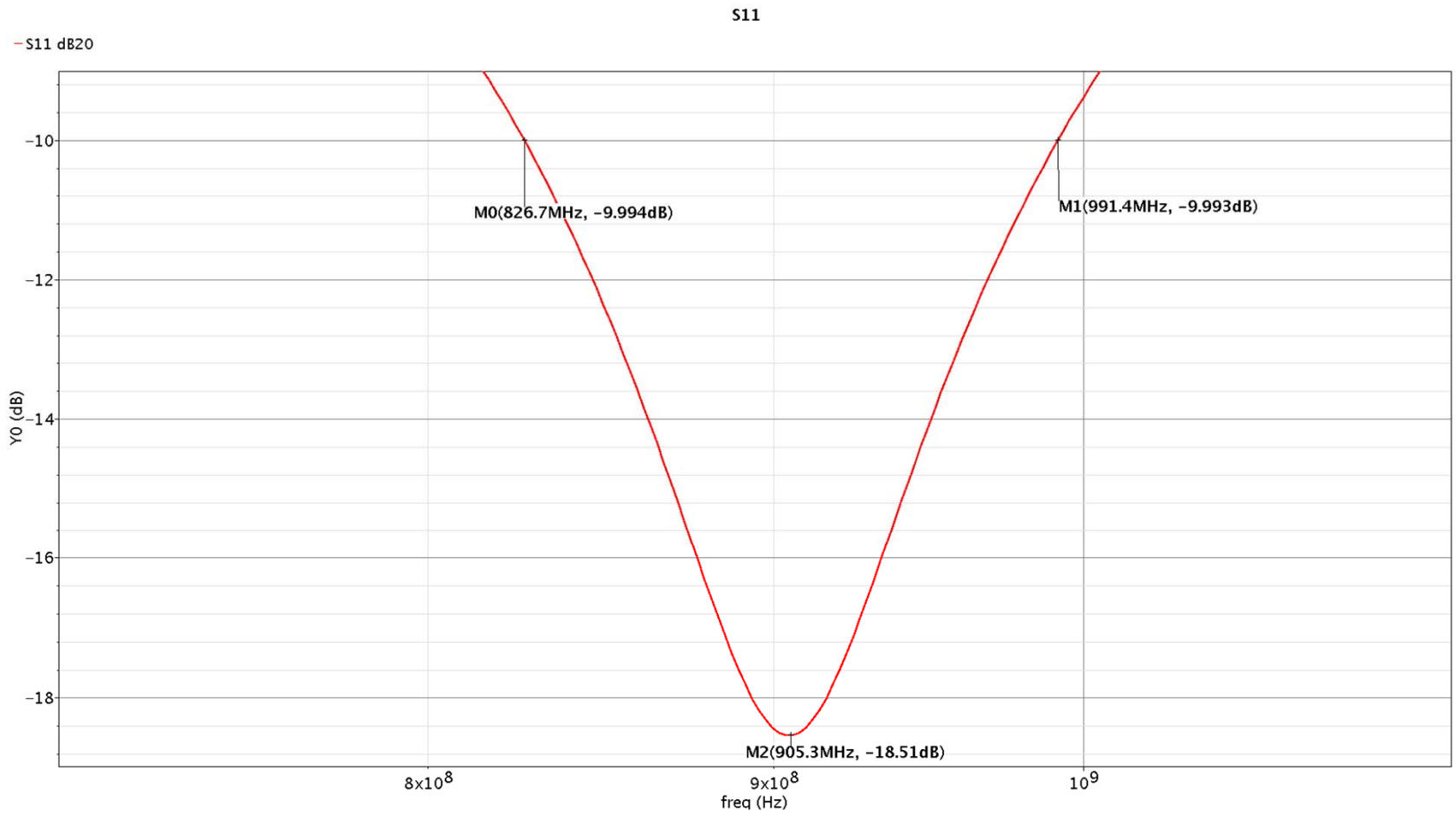
  Aniss, Member, IEEE
- [5] An Ultra-Low-Power 868/915 MHz RF Transceiver for Wireless Sensor Network Applications

  R. van Langevelde1, M. van Elzakker1, D. van Goor, H. Termeer, J. Moss and A.J. Davie
- [6] IEEE 802.15.4-2006 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group.
- [7] http://doodlelabs.com/products-and-services/ofdm-radio-modules/900-mhz-ism-band-dlm108.html

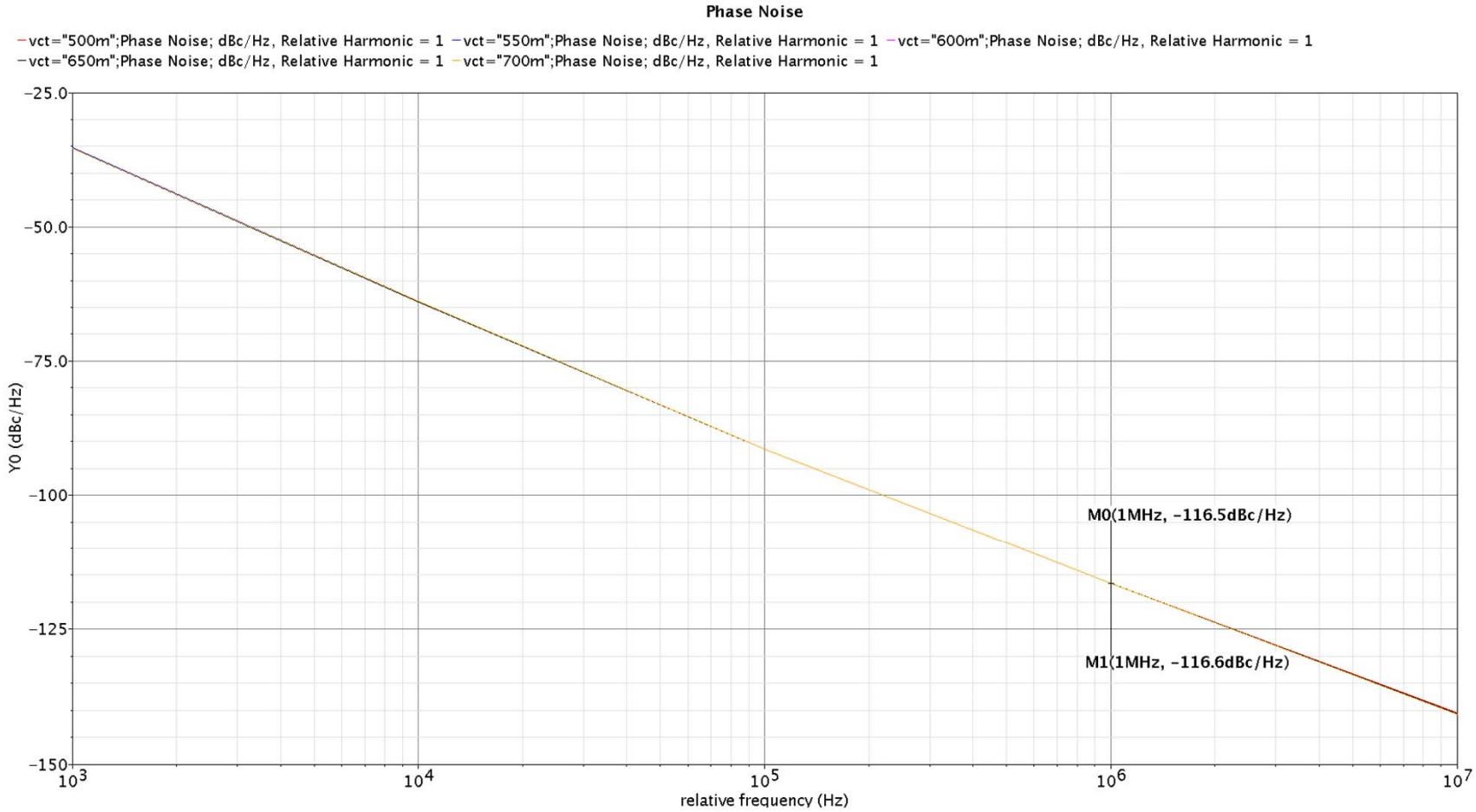
Thank You !!!



S11

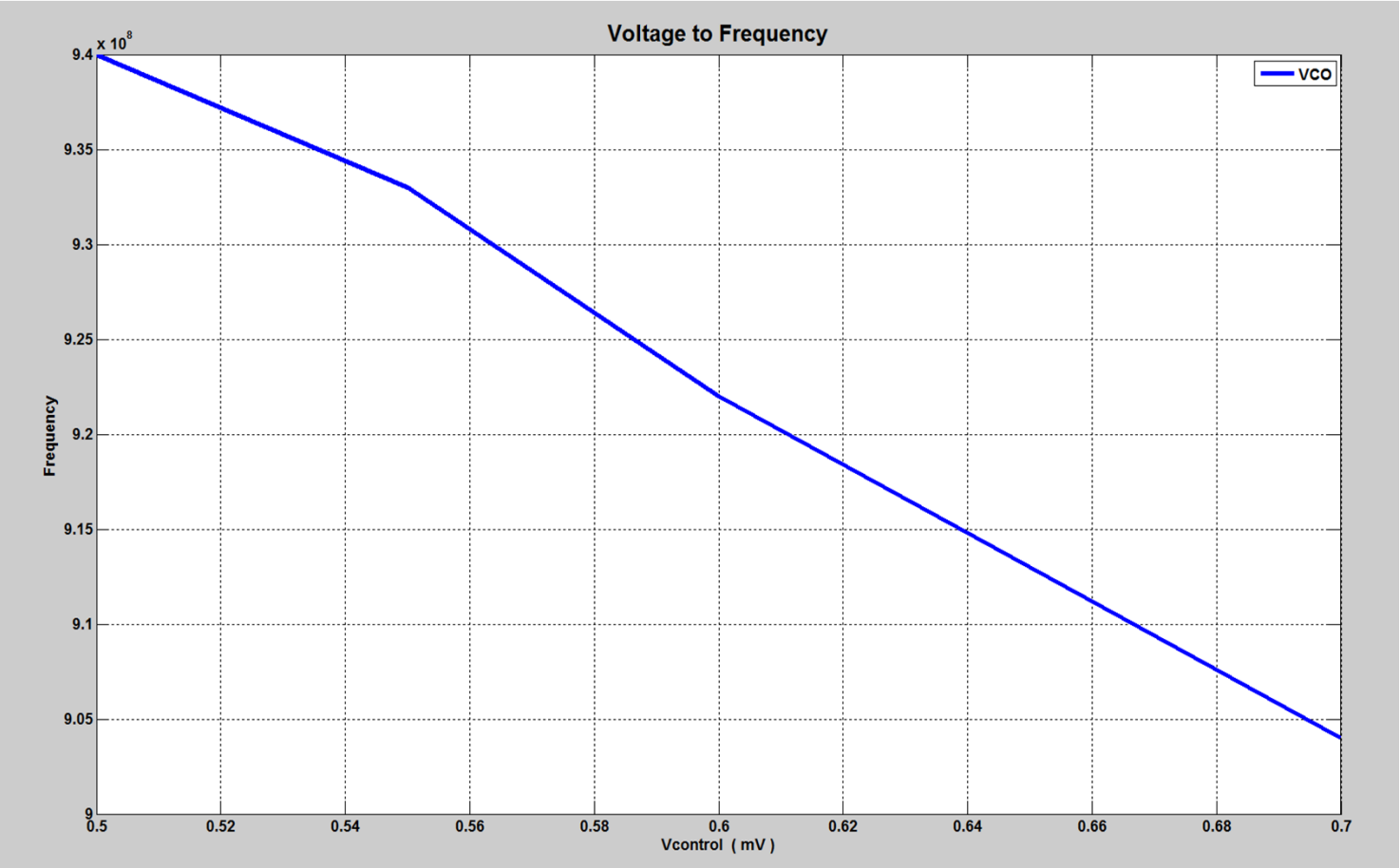

S11
S11 dB20
-10
-12
-14
-16
-18
Y0 (dB)
M0(826.7MHz, -9.994dB)
M1(991.4MHz, -9.993dB)
M2(905.3MHz, -18.51dB)
8x10^8
9x10^8
10^9
freq (Hz)

Phase Noise

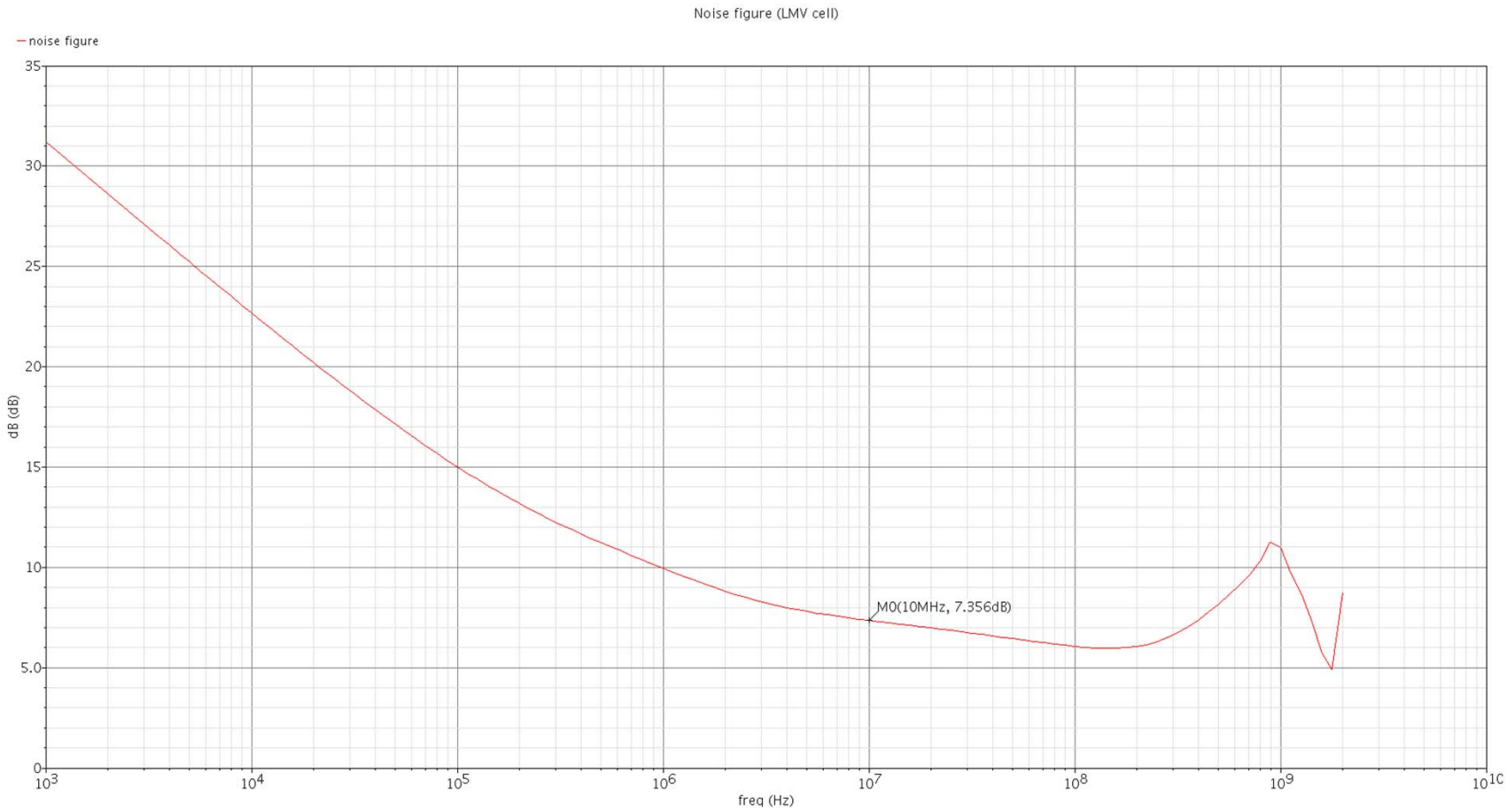

Phase Noise
vct="500m";Phase Noise; dBc/Hz, Relative Harmonic = 1
vct="550m";Phase Noise; dBc/Hz, Relative Harmonic = 1
vct="600m";Phase Noise; dBc/Hz, Relative Harmonic = 1
vct="650m";Phase Noise; dBc/Hz, Relative Harmonic = 1
vct="700m";Phase Noise; dBc/Hz, Relative Harmonic = 1
-25.0
-50.0
-75.0
-100
-125
-150
Y0 (dBc/Hz)
M0(1MHz, -116.5dBc/Hz)
M1(1MHz, -116.6dBc/Hz)
10^3
10^4
10^5
10^6
10^7
relative frequency (Hz)

VCO frequency control

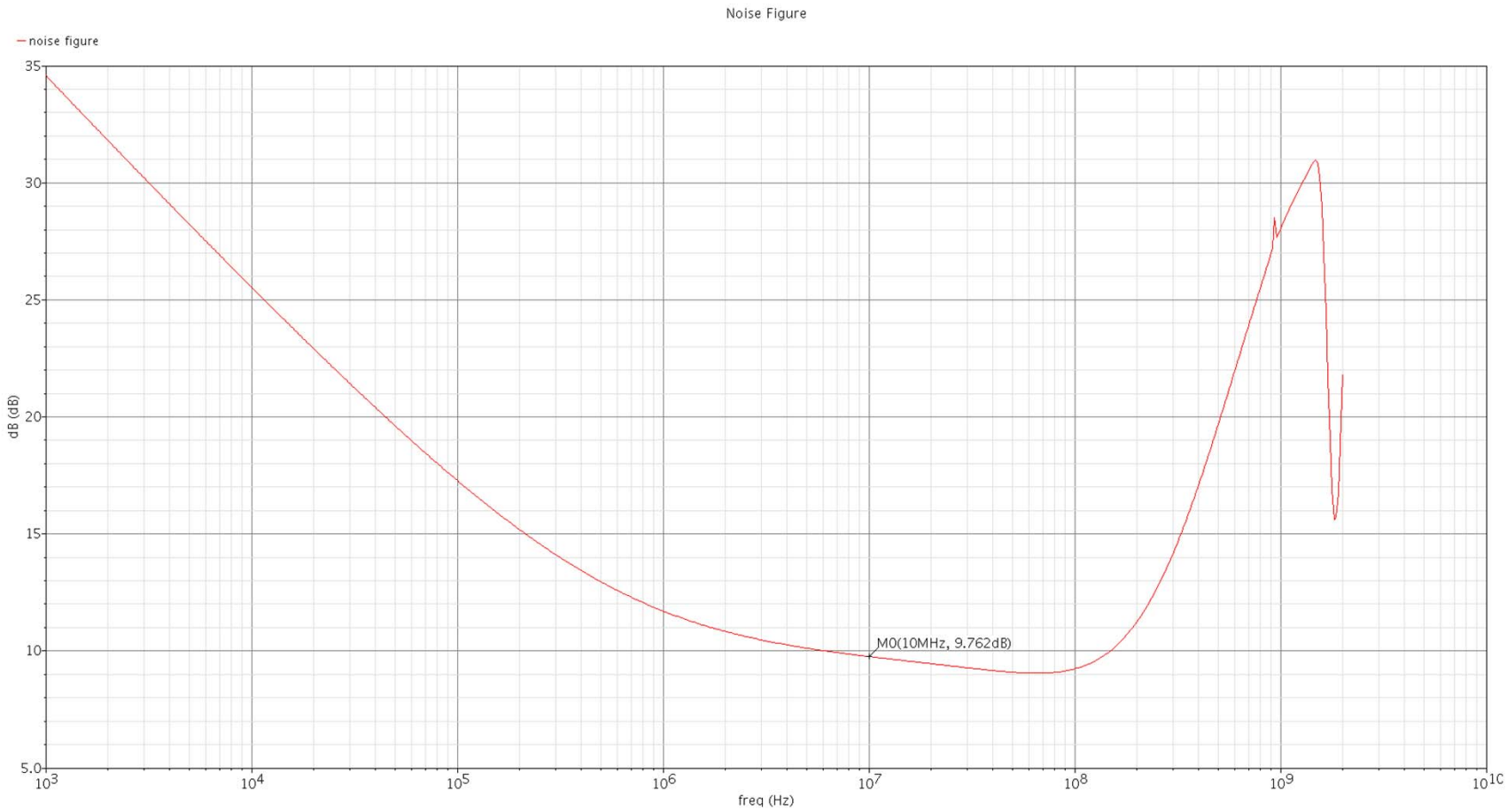
- $V_{control}$ vs VCO frequency plot:



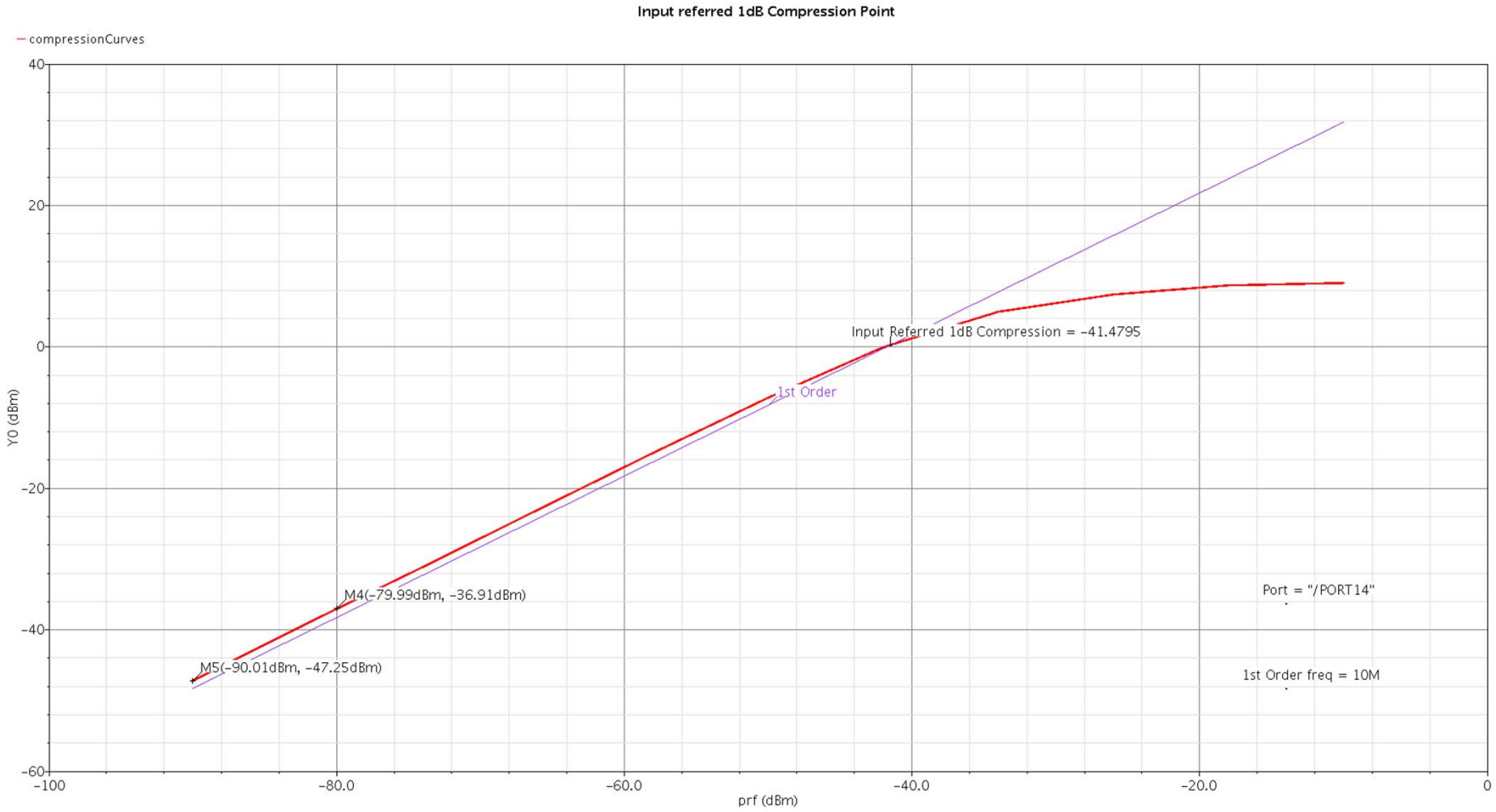
Noise figure for LMV cell



Noise figure



P1dB (-41 dB)


Input referred 1dB Compression Point
compressionCurves
40
20
0
-20
-40
-60
Y0 (dBm)
-100
-80.0
-60.0
-40.0
-20.0
0
prf (dBm)
Input Referred 1dB Compression = -41.4795
1st Order
M4(-79.99dBm, -36.91dBm)
M5(-90.01dBm, -47.25dBm)
Port = "/PORT14"
1st Order freq = 10M

IIP3 = -21.493dB