Design of a RF Transmitter for RFID Tags in a New Technology with Ultra Thin Silicon Substrates

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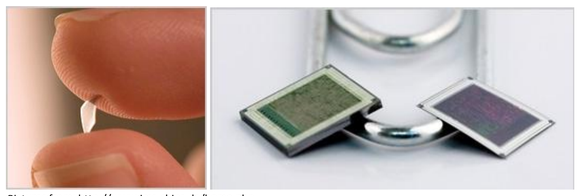
Introduction

Technology

- Flexible 20-µm substrates.
- 0.5-µm sea-of-gates structure.
- Approx. dimensions 3.2mm x 2.7mm.

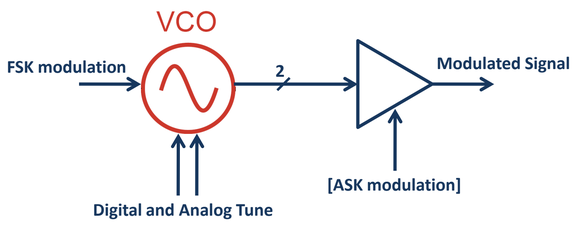


Pictures from: http://www.ims-chips.de/home.php

Motivation

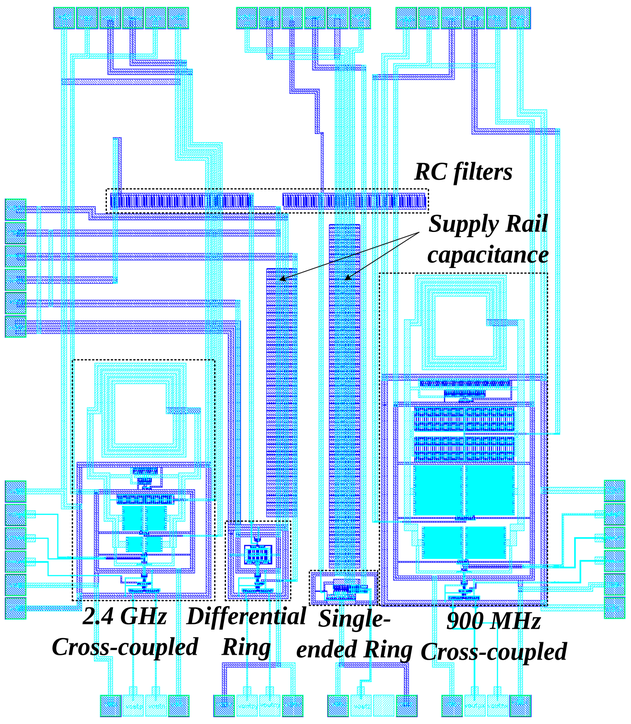
- RFID increasing in popularity and applications, it is therefore required to be inexpensive and easily embedded (thin, small and flexible).
- Aim: to implement RFID on the new technology.
- First step: modeling of passive and active components.
- Low inductor Q presents design bottleneck.

Design Approach



- Simple design for first prototype.
- Direct baseband modulation.
- Optional ASK modulation.
- Design for ISM band (433 MHz and 2.45 GHz) and SRD band (869 MHz).
- 4 transmitter circuits designed:
  1. 2.45 GHz cross-coupled VCO.
  2. 869 MHz cross-coupled VCO.
  3. Differential ring VCO.
  4. Single-ended ring VCO.

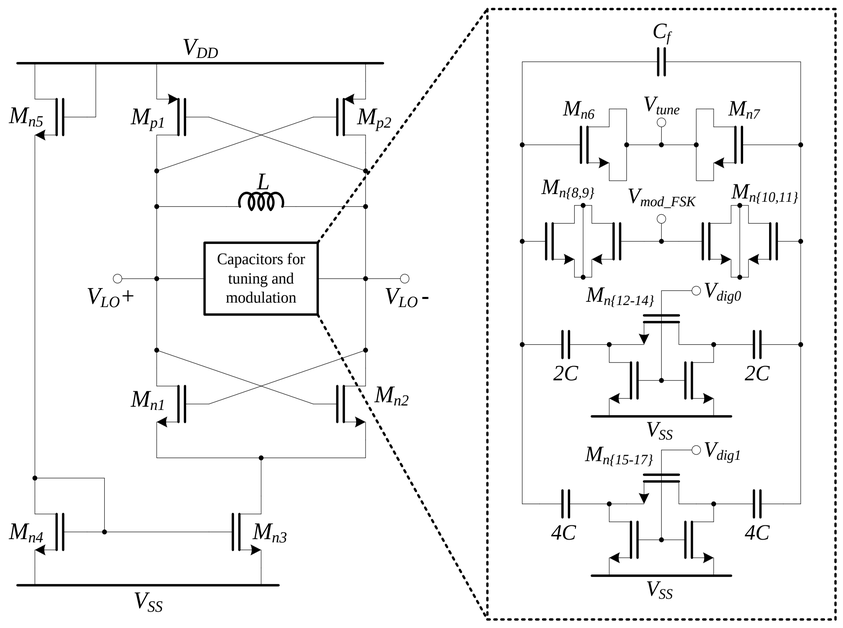
Layout



- Layout is optimized for testing.
- 2 metal layers (shown).
- Total chip area: 9.28 mm^2.

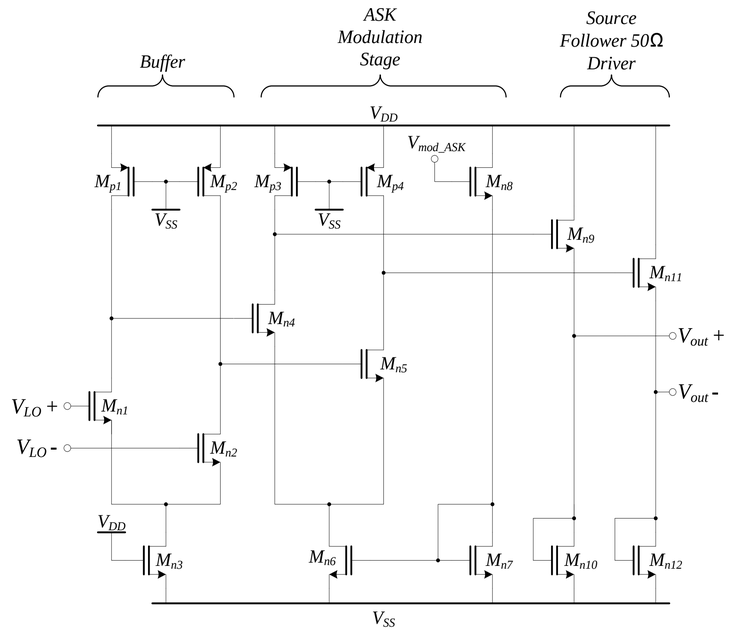
Cross-Coupled VCOs

Capacitor Bank For Tuning and Modulation



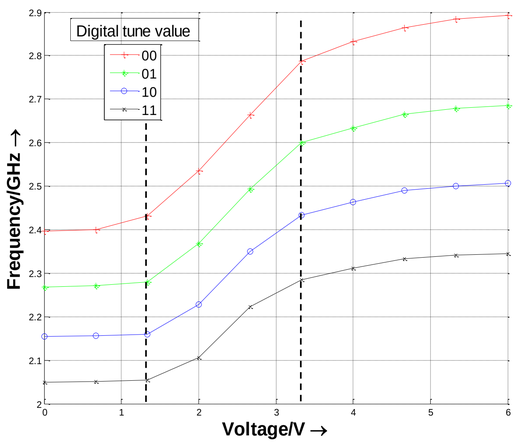
- Both NMOS and PMOS negative transconductance components.
- Large varactor for analog frequency tune.
- Small series varactor for direct FM/FSK modulation.
- 2-bit digital tune binary-weighted switched capacitor array.

Differential CML Output Stage



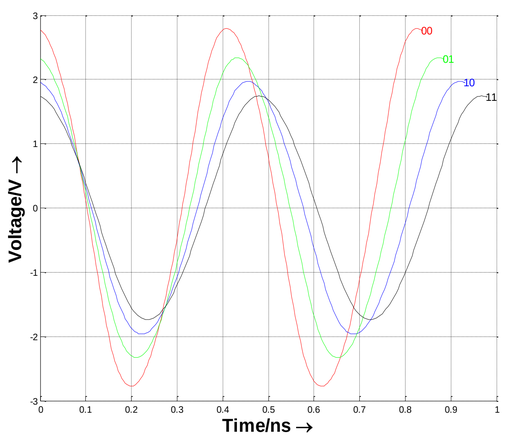
- CML buffer isolates LO signal and reduces frequency pulling.
- ASK modulation through current steering in a CML amplifier.
- Source follower driver for 50 Ω load (Measurement equipment termination).

2.45 GHz Frequency Tune



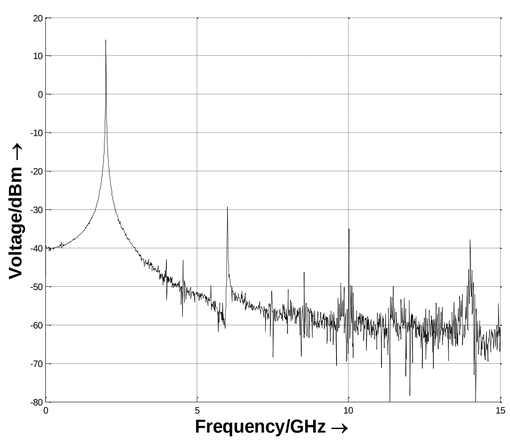
- 2-bit digital tune spans 2^2=4 tune bands.
- Analog tune within bands using varactor.
- Better linearity for a smaller voltage range.

2.45 GHz LO Waveform



- Amplitude decreases when more (lossy) switches are operating.
- Peak-to-peak voltage ≈ 5 V.

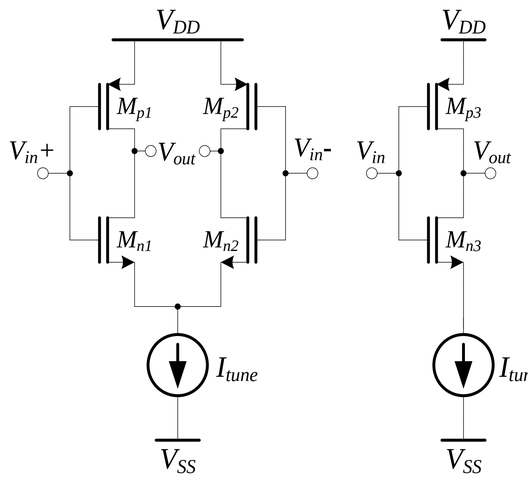
2.45 GHz LO Spectrum



- Nearest harmonic component is -35 dBm.
- Simulated phase noise: -65 dBc/Hz at 100 kHz offset frequency.

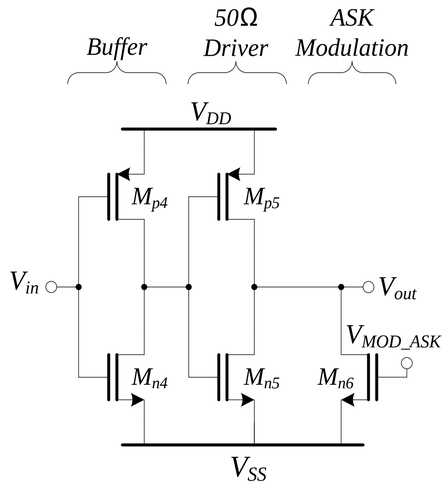
Ring VCOs

CMOS Inverters



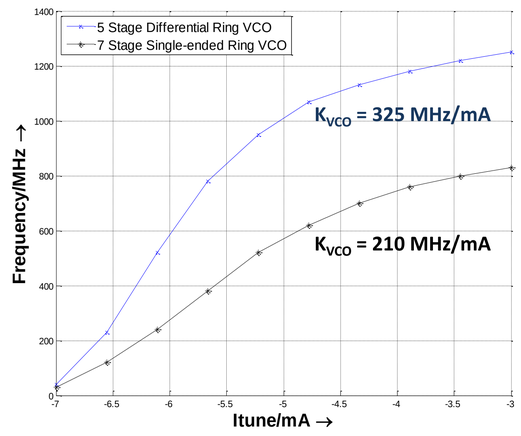
- CMOS topology maintains amplitude well for a wide current tuning range.
- 5-stage differential ring oscillator.
- 7-stage single-ended ring oscillator.
- Frequency tune by current steering.

CMOS Output Stage



- CMOS inverter with small transistors to buffer oscillator.
- CMOS inverter with large transistor to provide enough current for 50 Ω load.
- Amplitude control using an appropriately sized pull-to-ground transistor for ASK ratio 3:1.

Tuning Characteristics



- Single-ended ring max. freq.: 840 MHz.
- Differential ring max. freq.: 1.25 GHz.
- Better tuning linearity for a smaller voltage range.
- K_{VCO} decreases as frequency increases.

Conclusion

- From simulation: both cross-coupled and ring oscillators can be implemented using the new technology.
- Ring oscillators were superior in power consumption, tuning range and area.
- Cross-coupled oscillators operated at higher frequencies and had better spectral purity and lower phase noise.
- Measurements will be conducted pending fabrication.

	Cross-coupled		Ring	
Features	2.45 GHz	869 MHz	Diff.	Single
Area/mm^2	0.57	0.89	0.07	0.04
VCO Power/mW	23	60	17	7
Tuning range/GHz	2.0 - 2.95	0.73 – 1.1	<1.2	<0.9
Spectral purity	Good		Bad	

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