Basic Concepts in Oscillator Design

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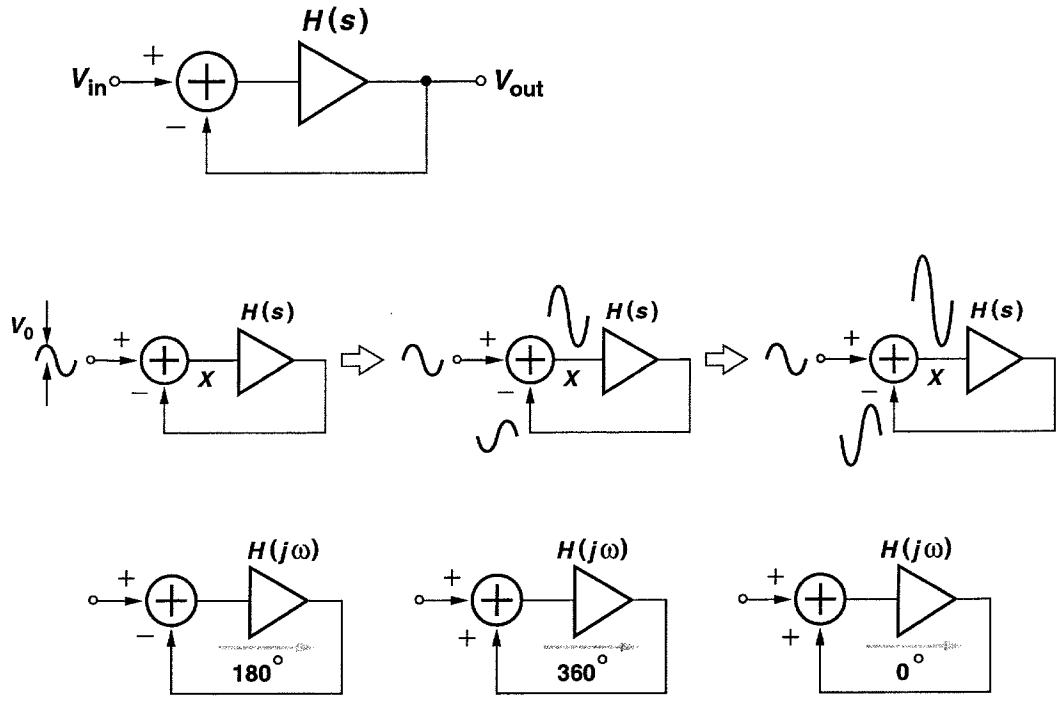
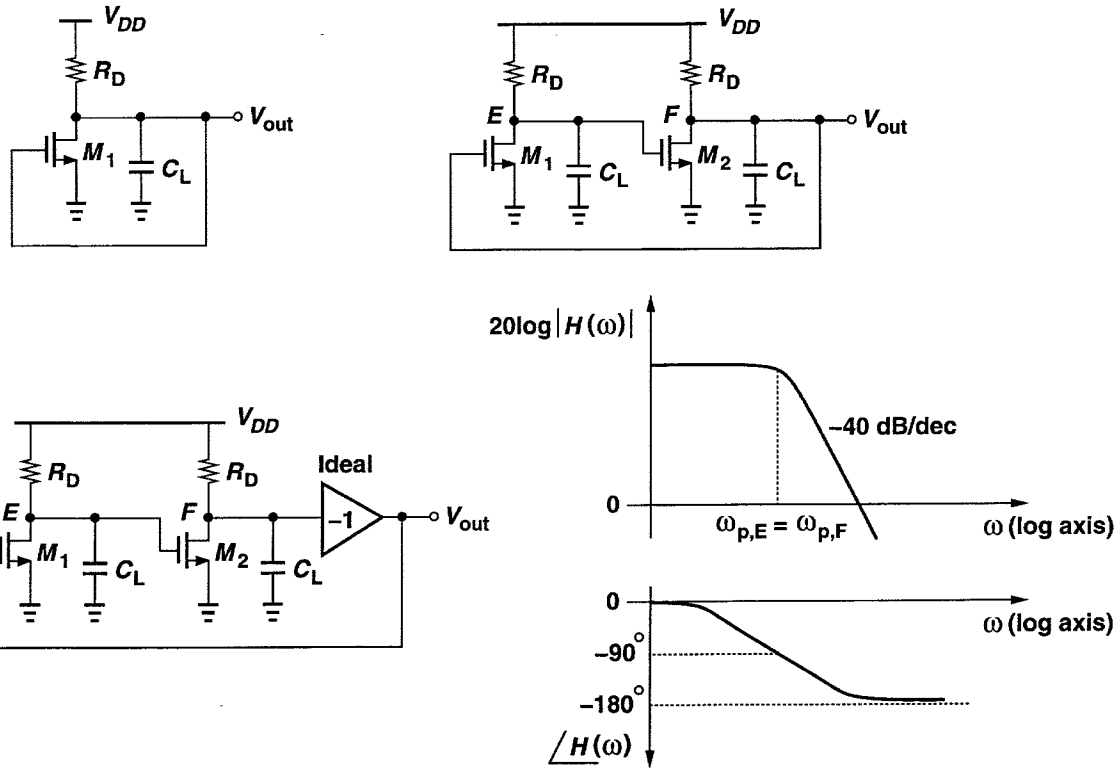
Outline

- Small–Signal View
- Ring and LC Oscillators
- One–Port View
- Quadrature Oscillators
- Frequency Tuning

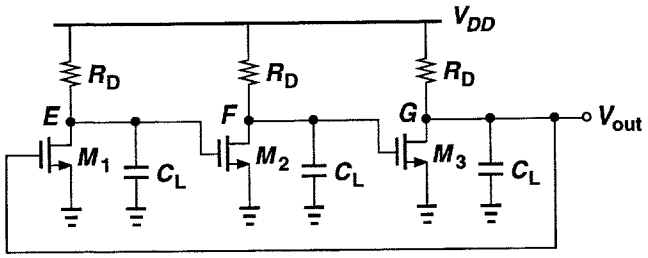
Small–Signal View

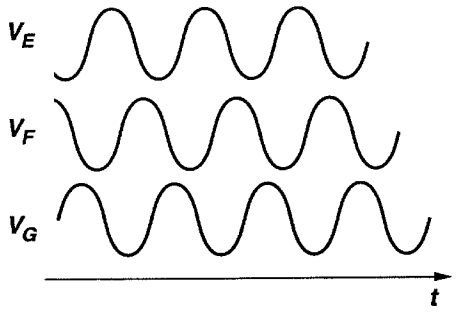


Ring Oscillators (I)



Ring Oscillators (II)

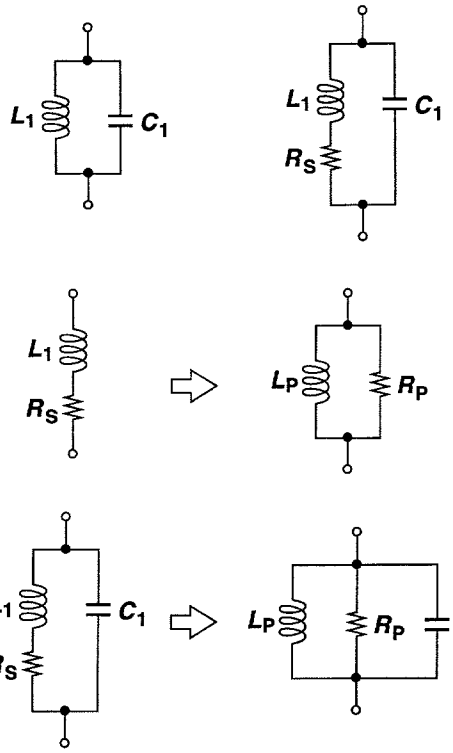




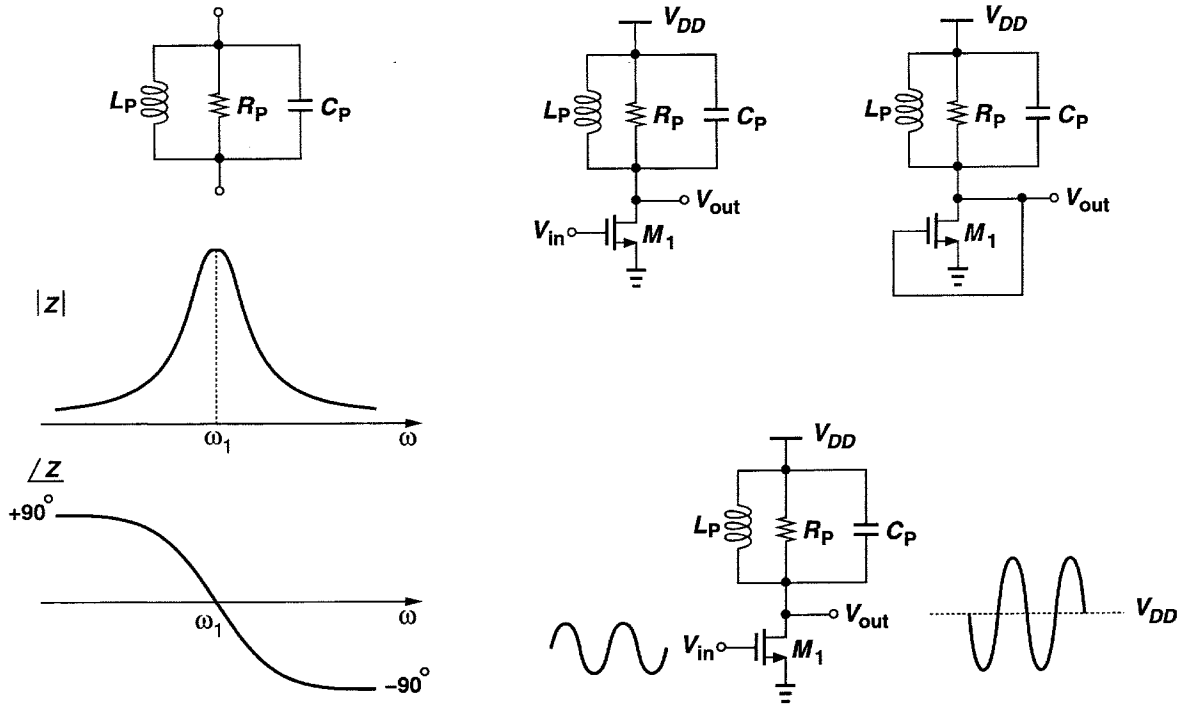
LC Oscillators

- Much lower phase noise than ring and relaxation oscillators (for given power and frequency)
- Much narrower tuning range
- Need high–Q inductors and varactors.
- Control input is usually single–ended.
- Voltage swings may exceed the supply voltage; good because relative phase noise decreases, bad because device reliability suffers.

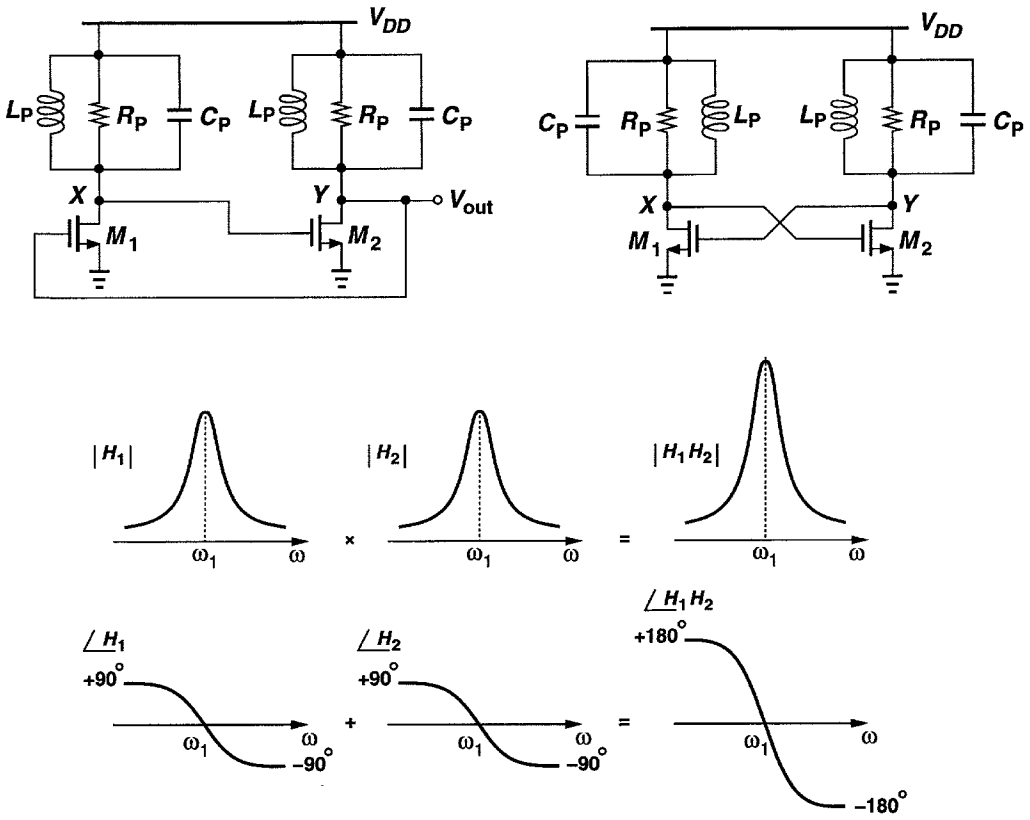
Basic LC Concepts



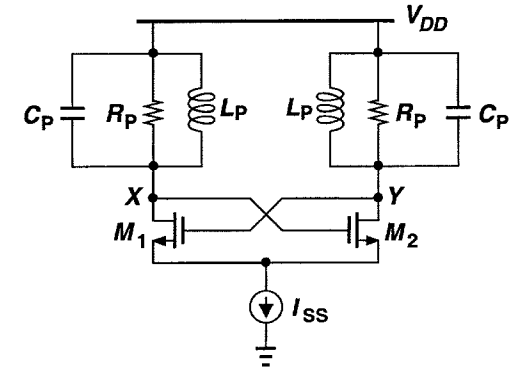
Basic Tuned Stage

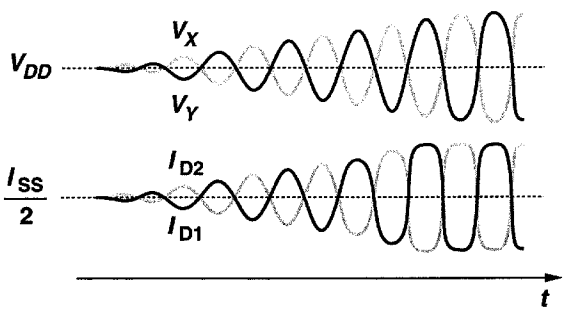


Cross–Coupled LC Oscillator

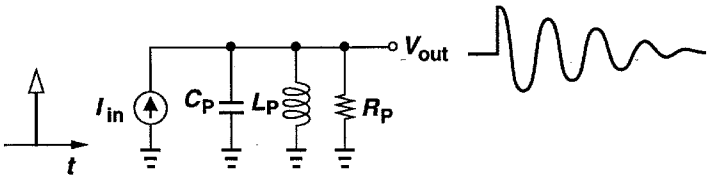


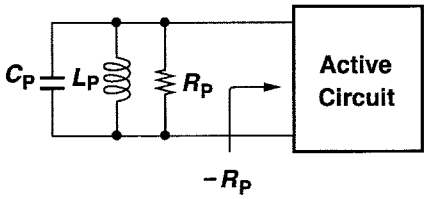
Cross–Coupled LC Oscillator

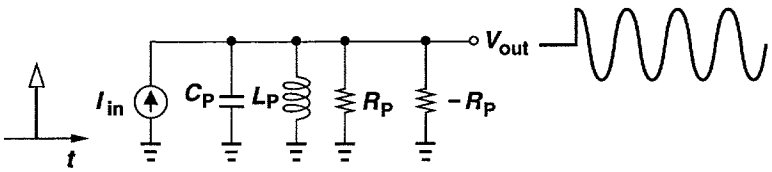


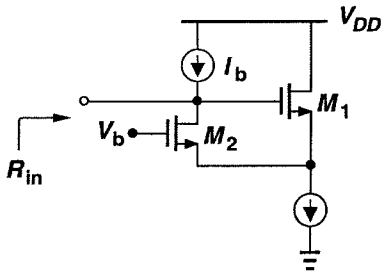


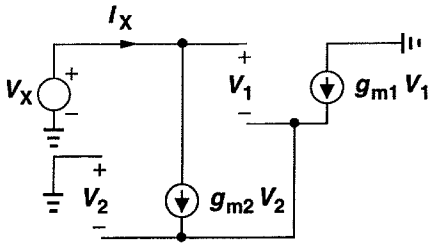
One–Port Oscillators



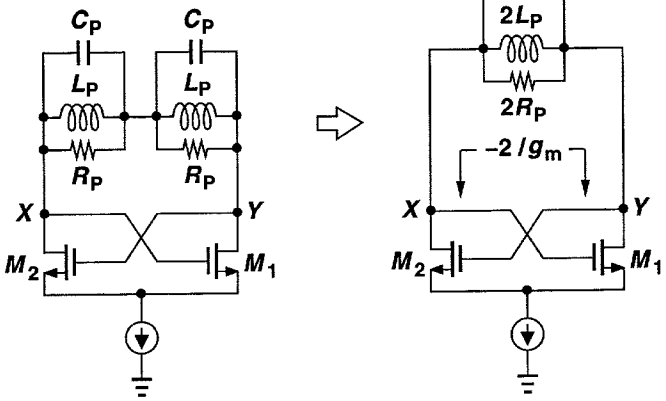




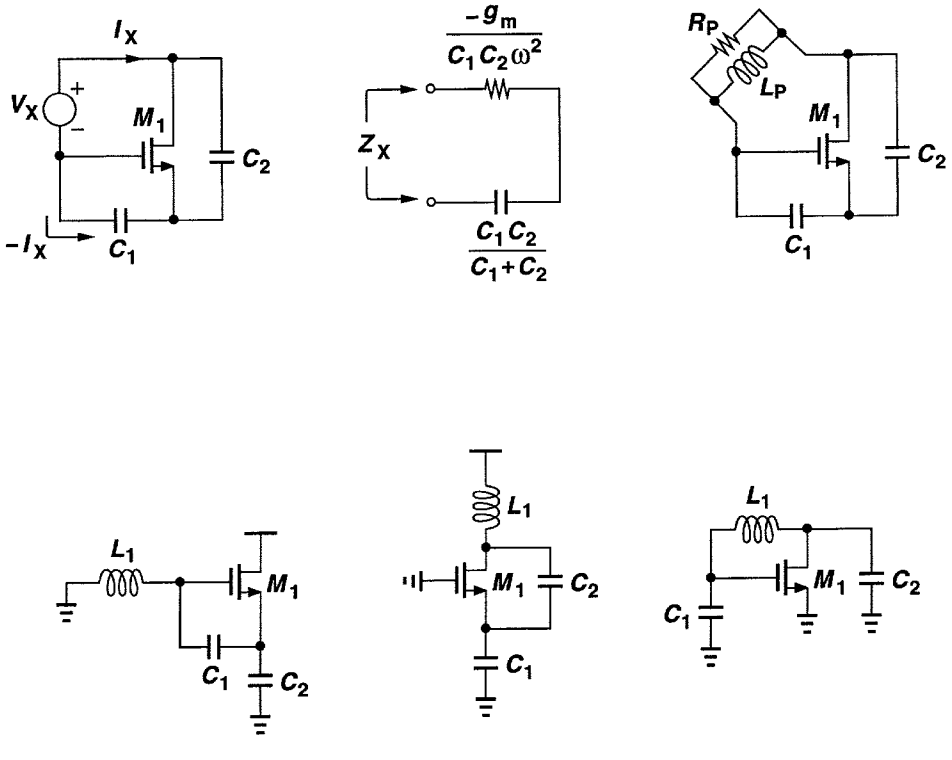




Negtive–Gm Oscillator



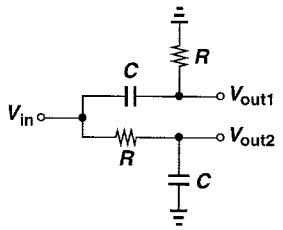
"Three–Point" Oscillator



Quadrature Signal Generation

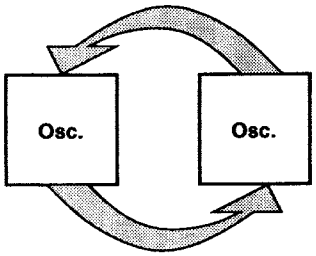
- RC–CR Network
- Polyphase Network
- Divide–by–Two Circuit
- LO with Quadrature Outputs

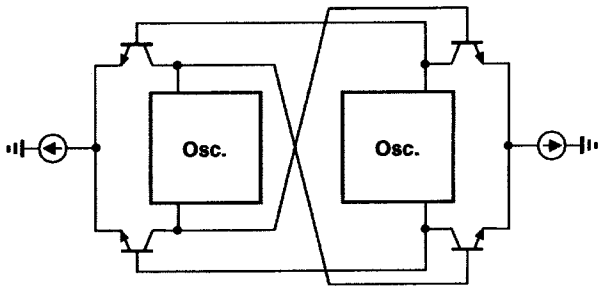
RC–CR Network



- Absolute tolerance causes gain mismatch.
- Device mismatch causes phase imbalance.
- Requires sinusoidal input.
- Sensitive to load capacitance

Quadrature Oscillators

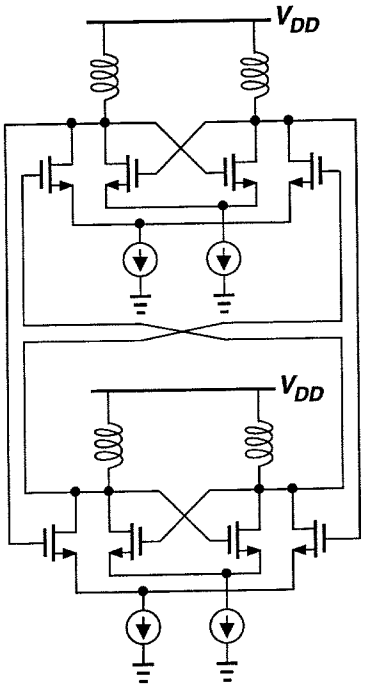




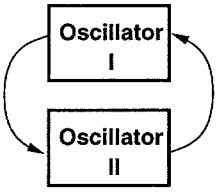
(Verhoeven, JSSC, July'92)
(Rofougaran et al, ISSCC'96)

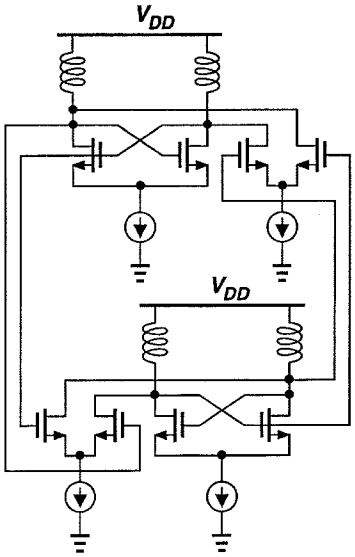
- Inherently quadrature outputs
- Somewhat higher power dissipation
- Q's add but more devices contribute noise.

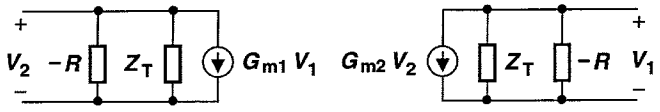
Quadrature Oscillators



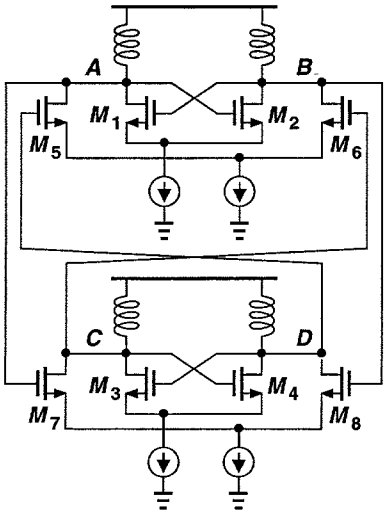
Quadrature Oscillator

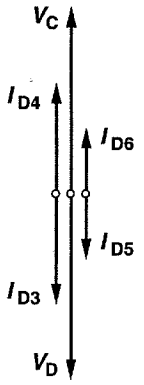


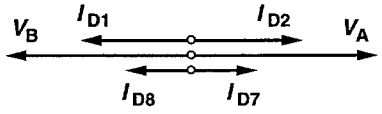


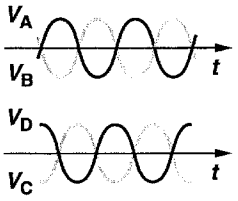


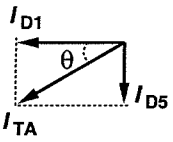
Quadrature Oscillator

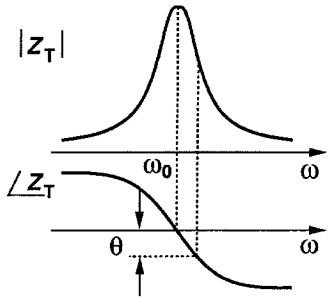








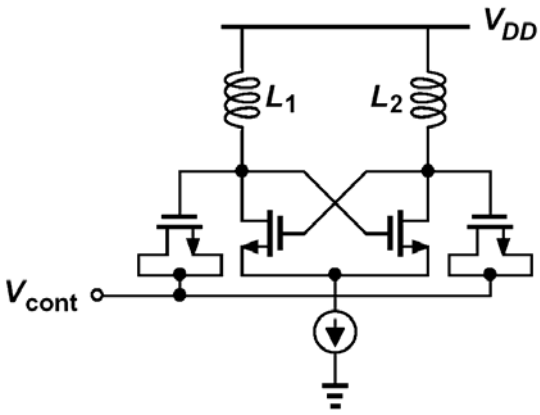




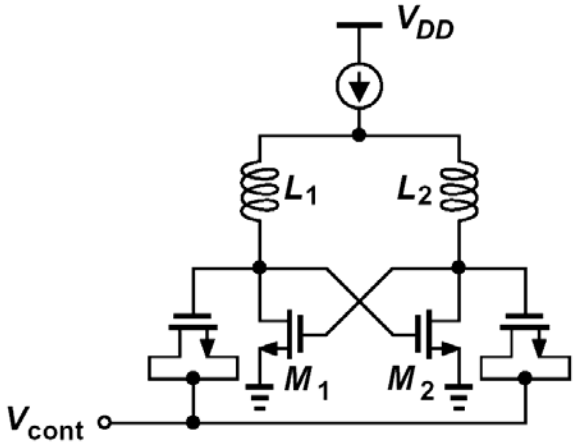
VCO Design Issues

- Center Frequency
- Tuning Range
- Phase Noise
- Tuning Linearity
- Output Amplitude
- Power Dissipation
- Supply and CM Rejection

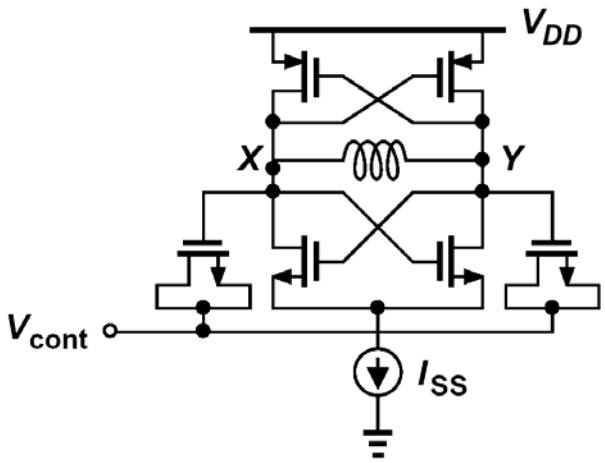
Oscillator Type I



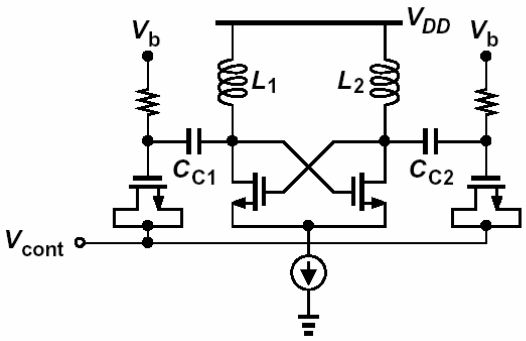
Oscillator Type II

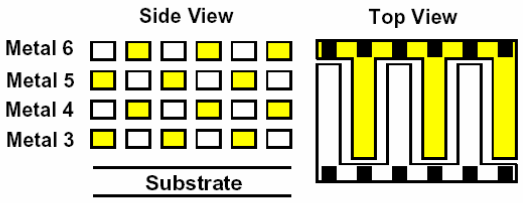


Oscillator Type III

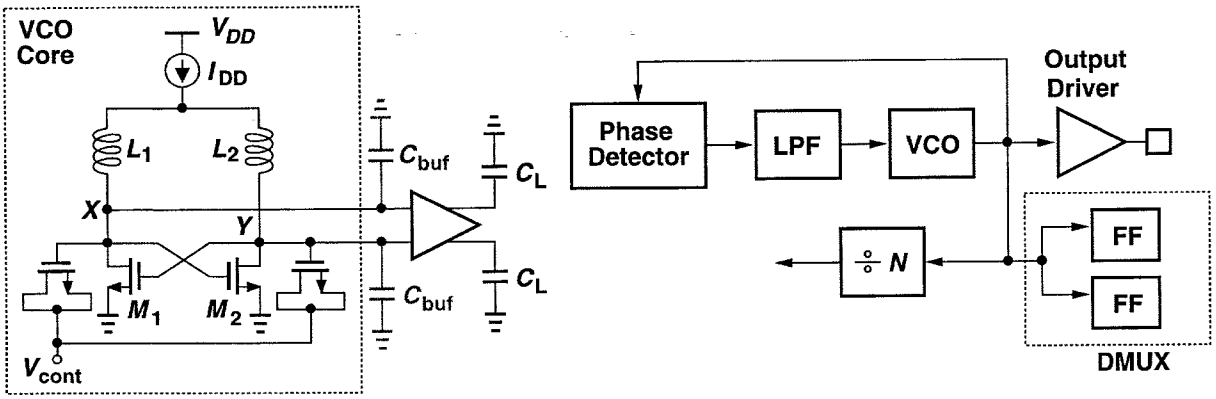


Oscillator Type IV



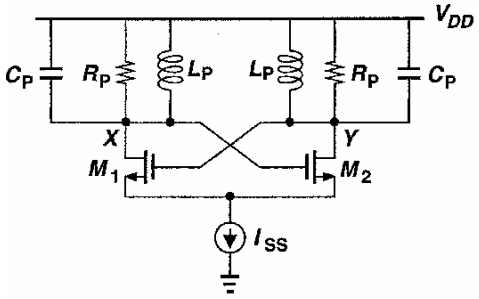


Tuning Range Limitations



- Charge pump output voltage range
- Capacitance of cross–coupled pair
- Capacitance of inductors
- Constant component of varactors
- Buffer input capacitance

VCO Design Procedure



- Begin with (1) power budget, (2) output swing, (3) load capacitance.
  → Required tail current and R_p known.
- Find the smallest inductance that provides R_p.
- Determine transistor width for nearly complete switching with given swing.
- Determine varactor capacitance.
- Check resulting tuning range. → Iterate.