1S-19

# A Tail-Current Modulated VCO with Adaptive-Bias Scheme

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## 1. Research Background

### Effects of Phase Noise


### Transceiver Power Budget

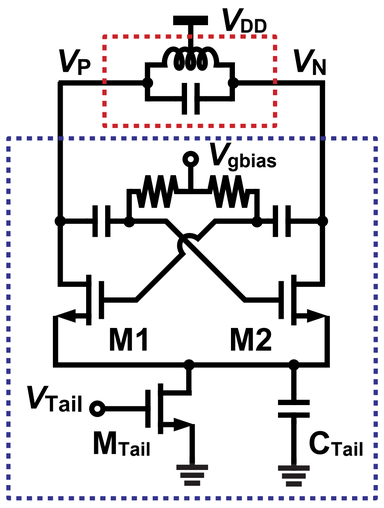

**Voltage Controlled Oscillator (VCO)**

- Significantly affects TRx noise performance.
- One of the most power hungry TRX building blocks.

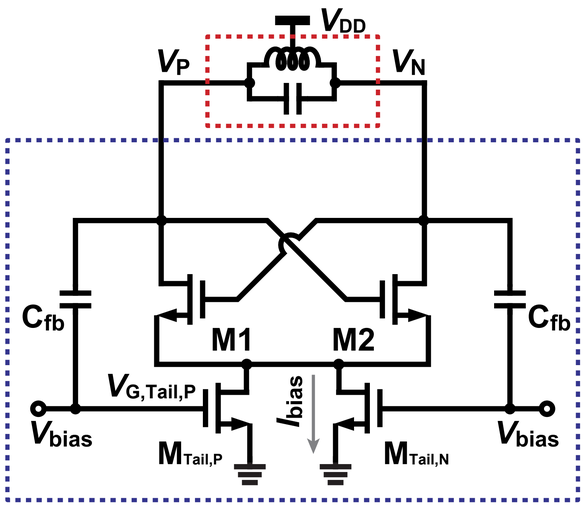
**AIM: High performance VCO with minimum area/power overhead.**

## 2. Design for High Performance

### Class-C VCO

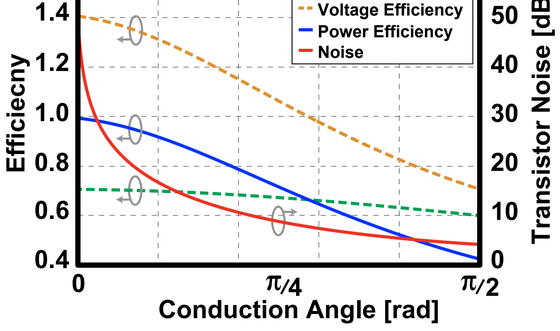


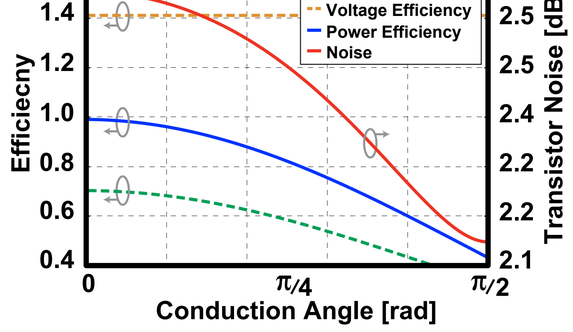

### Tail-Feedback VCO




$ENF = FoM_{MAX} - FoM$ $\quad FoM_{MAX} = 174 + 10\log(2Q^2)$ $\quad ENF = \left[\frac{1 + N_{L,tr}/N_{L,tank}}{\eta_P}\right]$

**Isolating the noise generated by active circuitry facilitates fair comparison of various VCO architectures.**



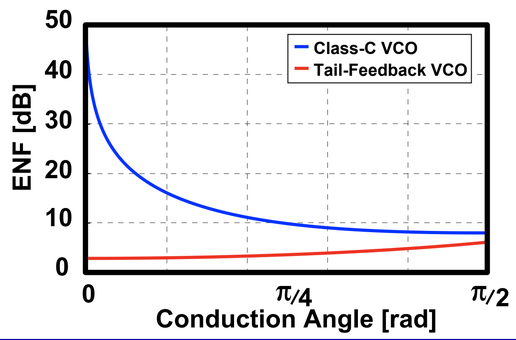




**Class-C VCO**

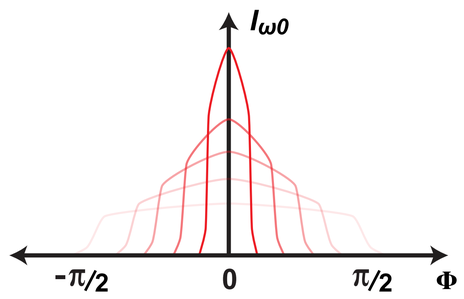
- Small Φ results in larger transistor noise.

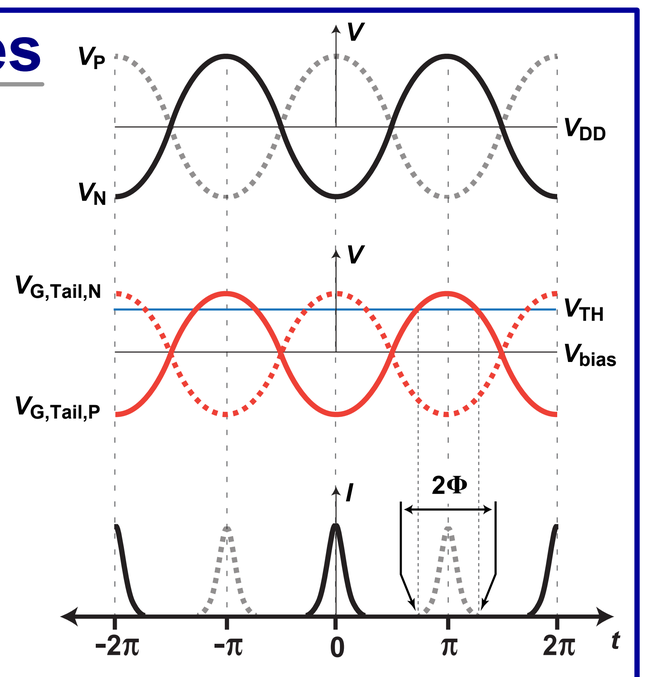
**Tail-Feedback VCO**

- Φ can be reduced without incresing transistor noise.




## 3. Reliability Issues

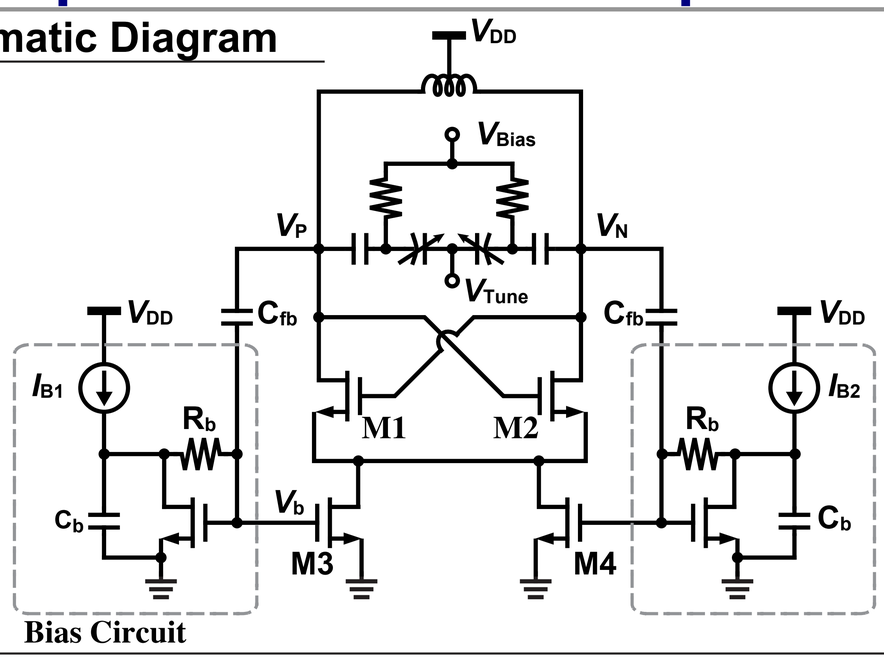


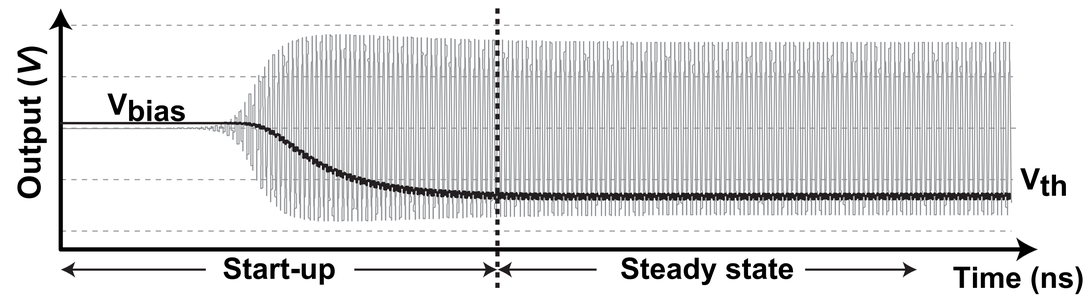

- Small Φ required for high efficiency.
- $V_{bias}$ must be reduced for small Φ.
- VCO fails to start-up at low $V_{bias}$. *ie.* $V_{bias} < V_{th(M_{TAIL,P}/M_{TAIL,N})}$

## 4. Proposed VCO with Adaptive-Bias

### Schematic Diagram

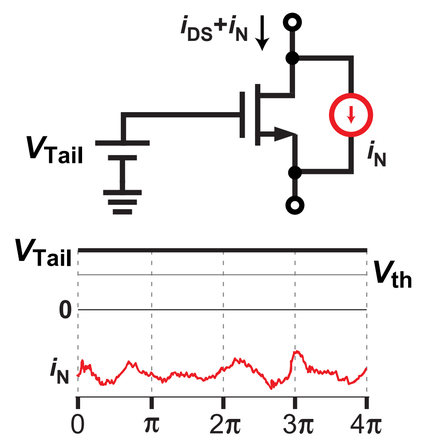



### Simulaion Results

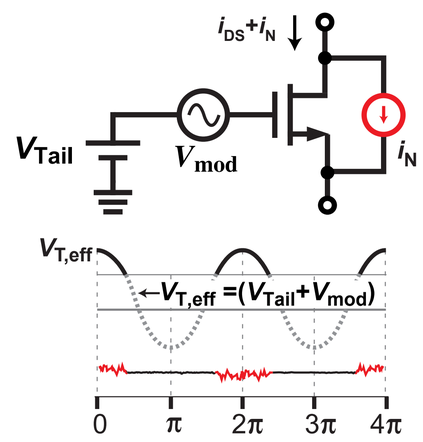



- High $V_{bias}$ ($>V_{th}$)during start-up.
- $V_{bias}$ is gradually reduced for optimum enhancing efficiency.

## 5. Tail-Noise Suppression




**Constant Tail-Bias**



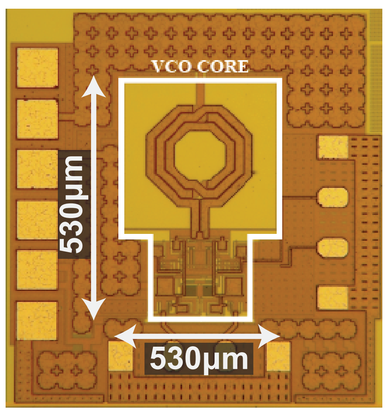

**Modulated Tail-Bias**

## 6. Results and Conclusions

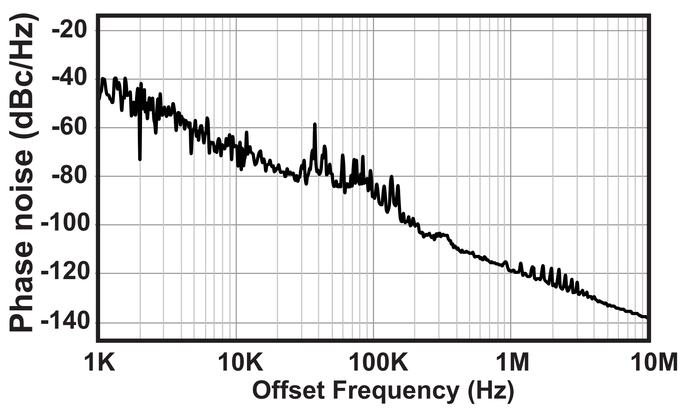
- The proposed adaptive start-up scheme achieves:
  - Reliable start-up.
  - Enhanced DC-RF conversion efficiency.
- These goals are achieved with very little overhead.

| | CMOS Process | Frequency[GHz] | Phase Noise [dBc/Hz] | Pdc[mW] | FoM [dBc/Hz] |
|---|---|---|---|---|---|
| JSSC2006 | 250nm | 1.75 | -125@1MHz | 2.25 | -186 |
| VLSI2009 | 180nm | 4.50 | -109@1MHz | 0.16 | -190 |
| JSSC2013 | 180nm | 4.84 | -125@1MHz | 3.40 | -193 |
| This Work | | | | | |
| Simulation | 180nm | 4.80 | -124@1Mhz | 7.20 | -189 |
| Measurement | 180nm | 4.60 | -119@1MHz | 6.80 | -184 |

**Performance comparison.**




**Chip micrograph.**




**Phase noise plot.**