

TU3E-4

A Fast and Highly-Linear Phase-Frequency Detector with Low Noise for Fractional Phase-Locked Loops

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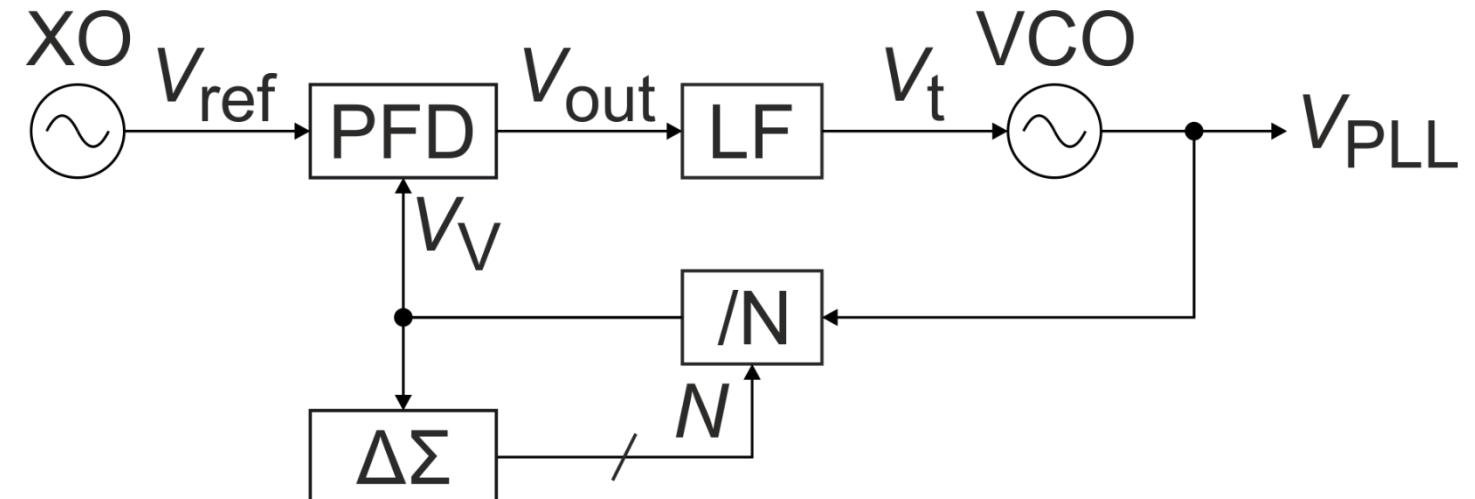
³Infineon Technologies AG, Germany

- Material characterization at THz
- High-performance electronics
- Ultra-low phase noise :
 $10^\circ @ 4 \text{ THz} \rightarrow \text{Jitter } 7 \text{ fs}$
- Ultra-wideband: > 30 %



Phase-Locked Loop

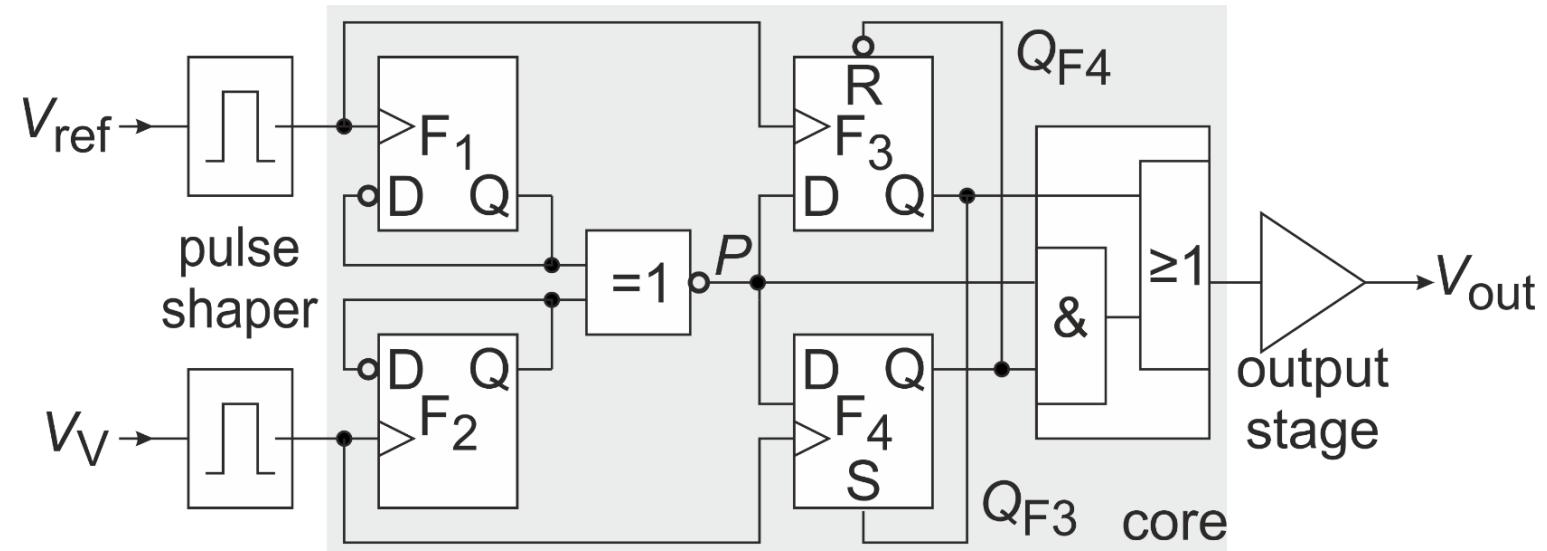
- Phase-Locked Loop (PLL) combines advantages of XO and VCO
- Phase-Frequency Detector (PFD) compares signals
- PFD requirements:
 - High input frequency
 - Low phase noise
 - High linearity



Outline

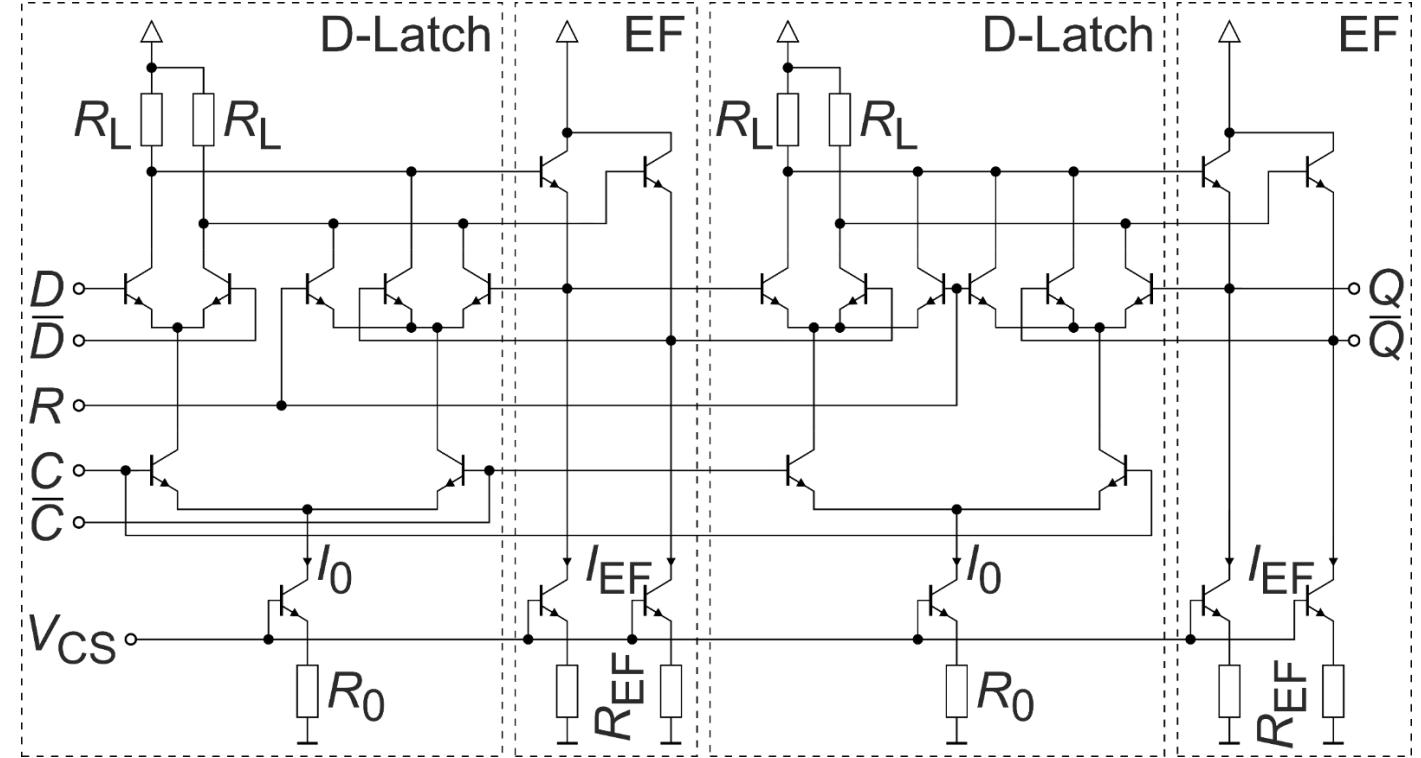
- Motivation
- Architecture
- Circuit Design
- Realization
- Results
- Conclusion

- $F_{1/2}$ divide-by-2 → unambiguously range: $0 \leq \Delta\phi \leq 2\pi$
- XOR based phase detector (PD) → high linearity
- $F_{3/4}$ frequency detector (FD) → force V_{out} to high/low



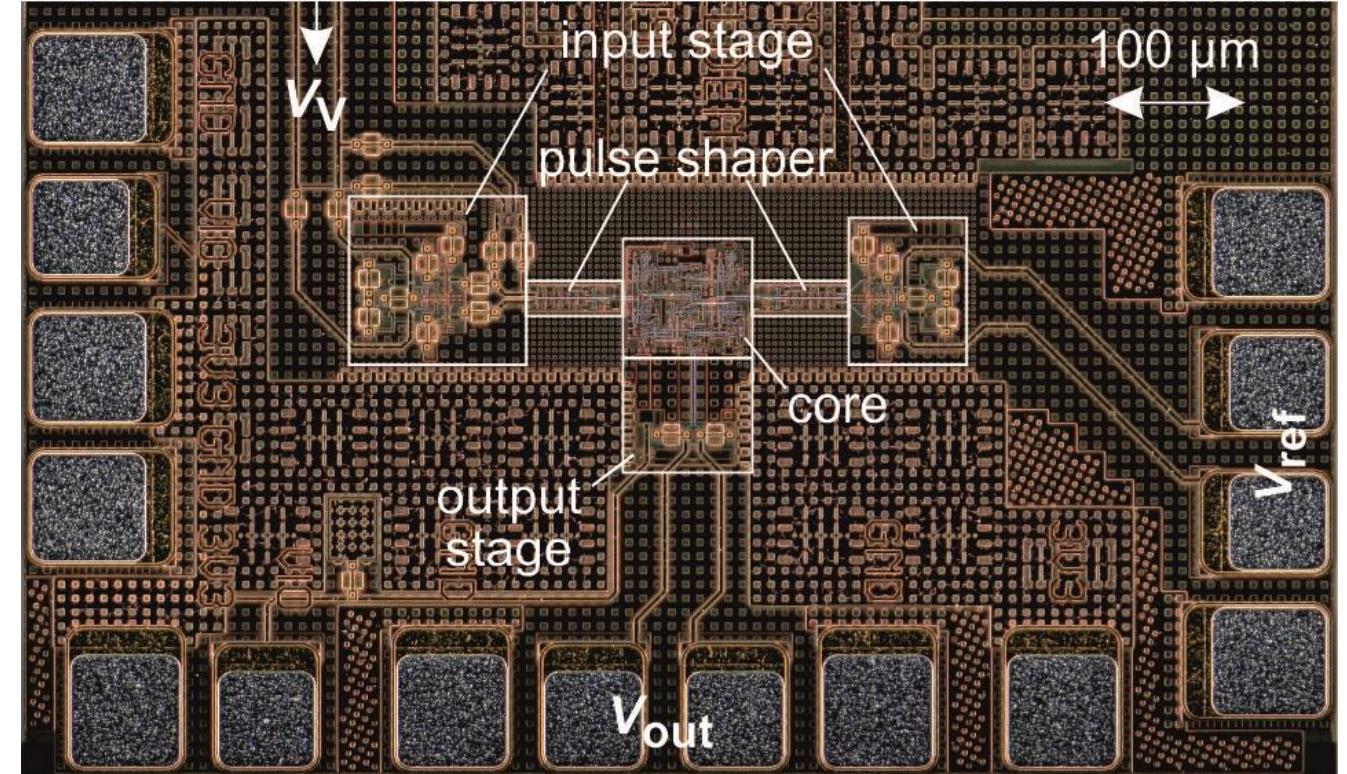
Circuit Design

- D flip flop with asyn. reset
- Emitter-Coupled Logic



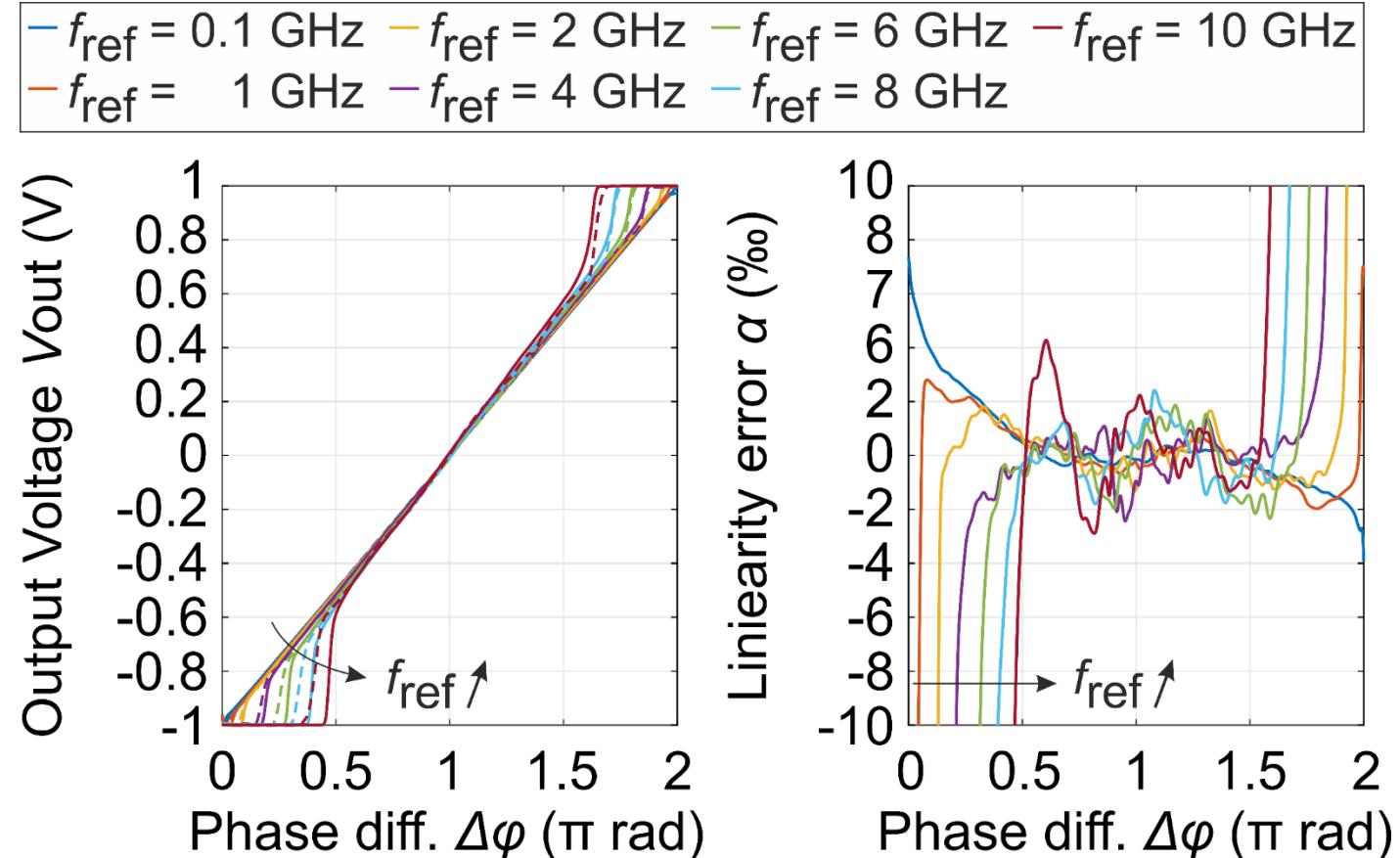
Realization

- Implemented in Infineon B11HFC
- SiGe:C HBTs with $f_t/f_{max} = 250/370$ GHz
- Power supply
 - $V_{cc} = 3.3$ V
 - $I_{cc} = 43$ mA
- Occupied area: $150 \times 430 \mu\text{m}^2$



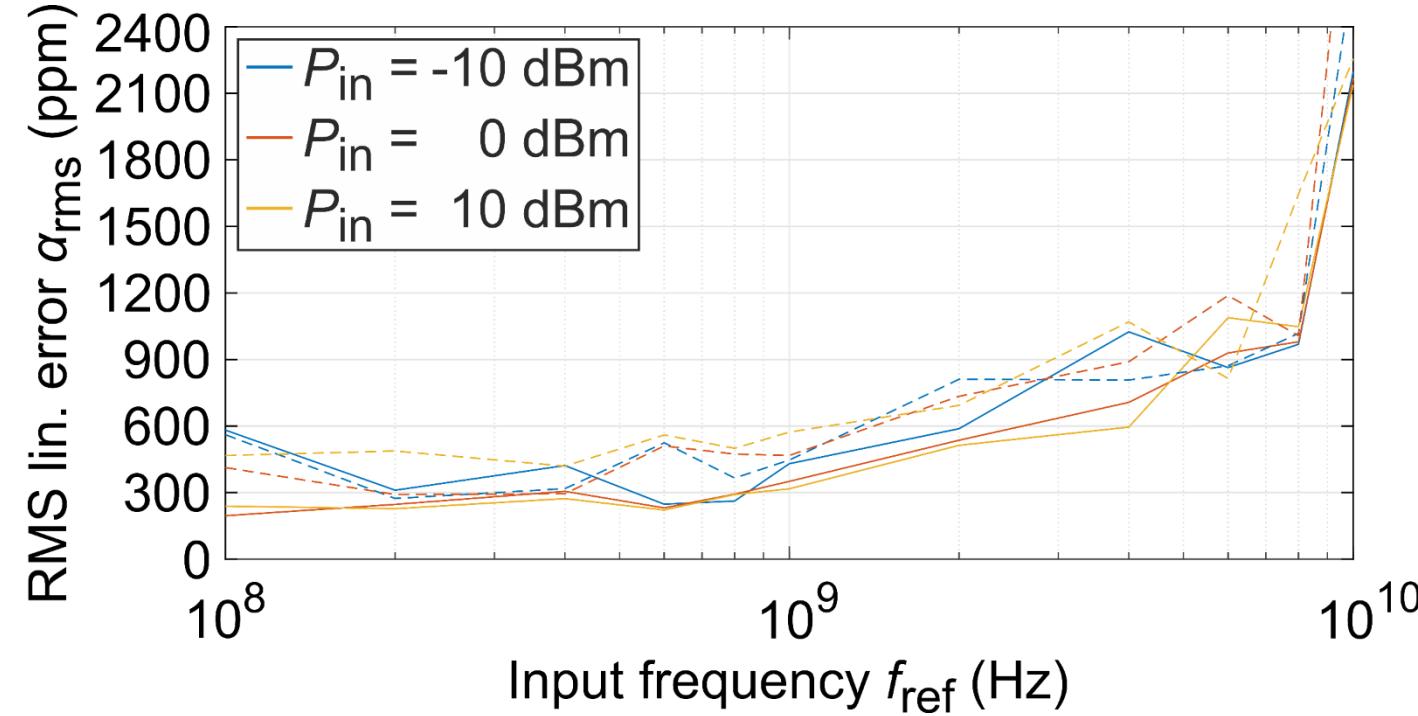
Output Characteristic

- Operation range $\Delta\phi$ decreases with f_{ref}
 $\rightarrow \tau_{p,xnor} \approx 25 \text{ ps}$
- Operation range $0.5\pi \leq \Delta\phi \leq 1.5\pi$
 $f_{\text{ref,max}} = 10 \text{ GHz}$



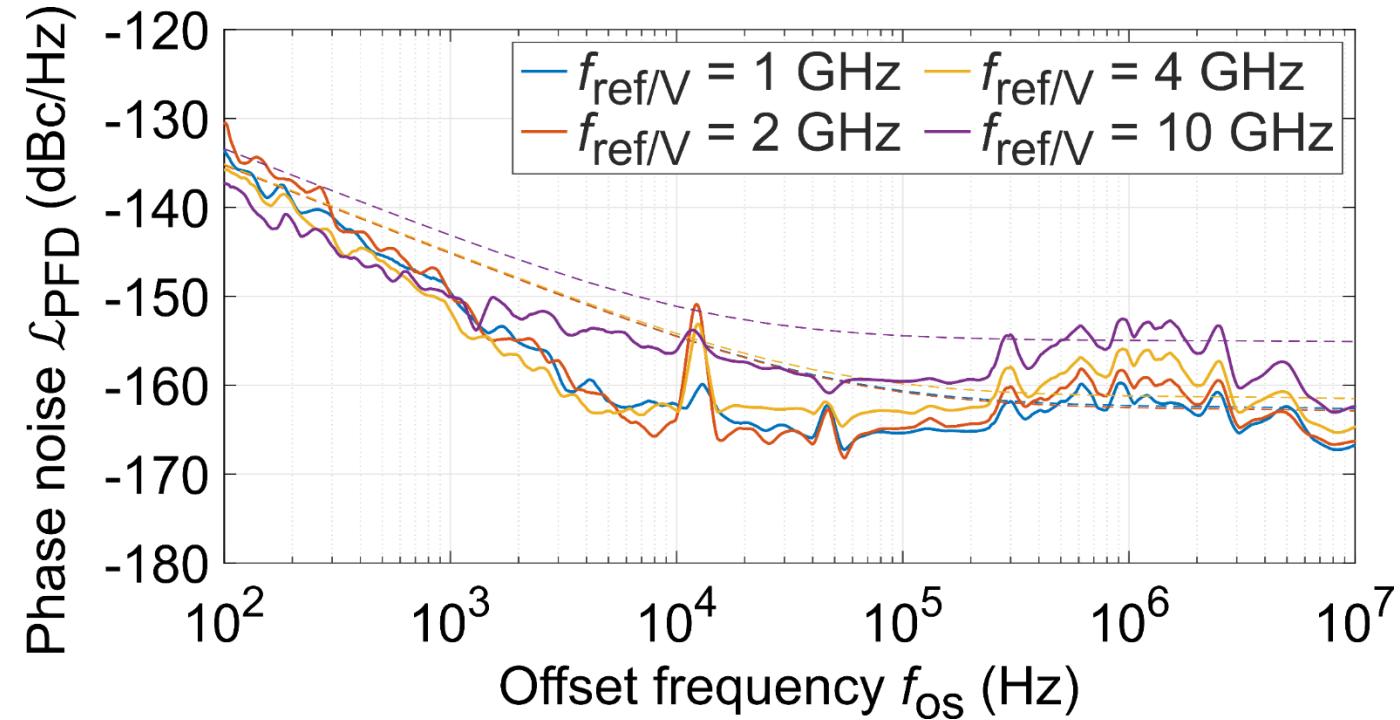
RMS Linearity Error

- Measured (solid) and simulated (dashed)
- Marginal influence of input power
→ proper shapers
- RMS error α_{rms} :
 - $\leq 600 \text{ ppm}$ for $f_{\text{ref}} \leq 2 \text{ GHz}$
 - Moderate increase up to 8 GHz



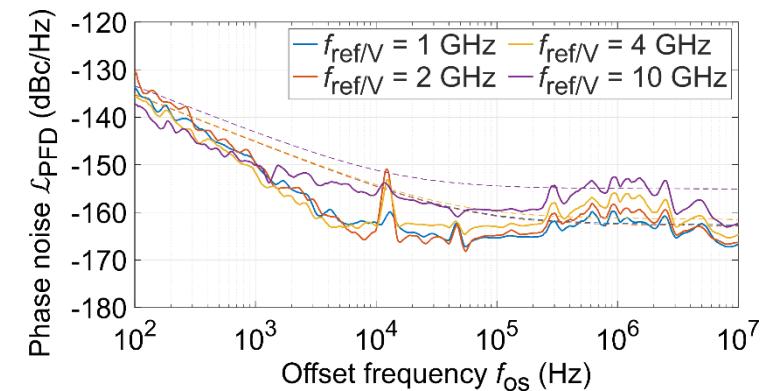
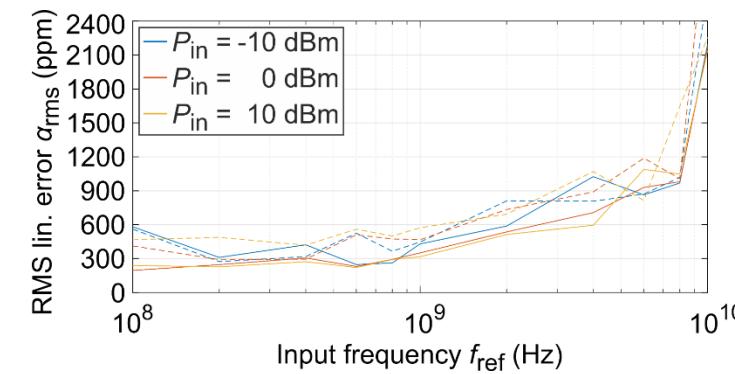
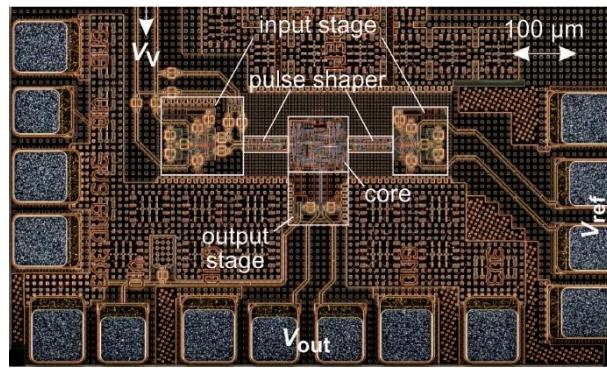
Phase Noise

- Measured (solid) and simulated (dashed)
- Noise floor
 $L \approx -163 \text{ dBc/Hz}$
 for $f_{\text{ref/V}} = 1 \text{ GHz}$
- Flicker noise corner
 $f_{1/f} \approx 13 \text{ kHz}$
- Spurs due to baseband measurement



Conclusion

- Phase-Frequency Detector for high performance PLL
- Maximum input frequency 10 GHz for $0.5\pi \leq \Delta\phi \leq 1.5\pi$
- Low linearity error ≤ 600 ppm for input ≤ 2 GHz
- Low additive phase noise -163 dBc/Hz at 1 GHz input



Thank you for your kind attention

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