

Evaluation of Digital Crosstalk Noise to Fully Differential VCO

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Background

SoC(System-on-Chip)

Analog and Digital Circuits on One Chip
 ⇒ Production process simplification and low cost

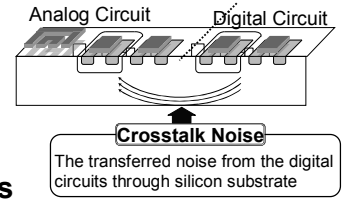
VCO(Voltage Controlled Oscillator)

The key-component of mixed signal LSI
 ⇒ High-accuracy outputs are required

VCOs in SoC are influenced by **Crosstalk noise** from noisy circuit.

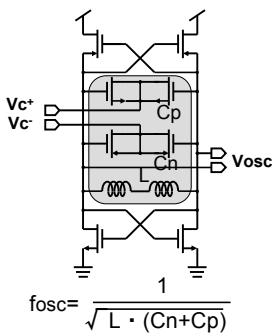
⇒ Performance degradation of VCOs is induced

Crosstalk noise is one of the big problems when designing VCOs

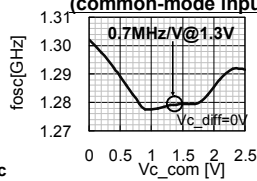


VCO design and measurement results

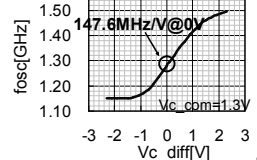
VCO1 Differential input VCO (proposed)



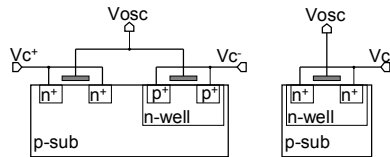
f-V characteristic (common-mode input)



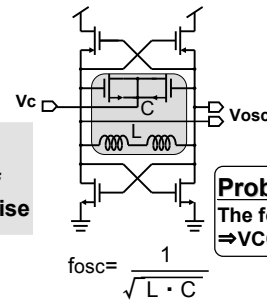
(differential-mode input)



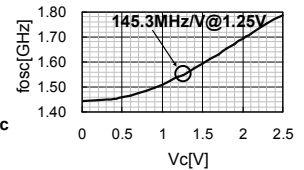
Structure of MOS varactor



VCO2 Single Input VCO (commonly used)



f-V characteristic



Problem

The fosc varies with Noise on Vin.
 ⇒ VCO2 is easily influenced by the noise

To improve the tolerance of common-mode noise

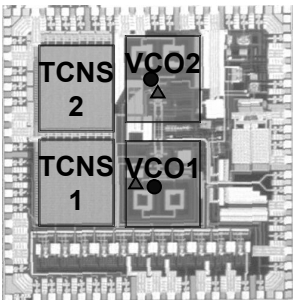
$$f_{osc} = \frac{1}{\sqrt{L \cdot C}}$$

Performance of VCO1 vs. VCO2

Performance index	VCO1	VCO2
Oscillation frequency [GHz]	1.28	1.54
VCO Gain [MHz/V]	147.6 (differential-mode input) 0.7 (common-mode input)	145.3
Phase noise @ 100kHz offset [dBc/Hz]	-104.0	-94.0
Cycle jitter [psec]	σ: 3.00 p-p: 18.7	σ: 2.59 p-p: 16.6
Cycle-to-cycle jitter [psec]	σ: 4.21 p-p: 30.2	σ: 5.07 p-p: 42.1

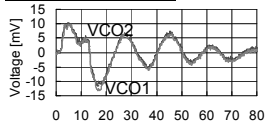
Test chip and noise measurement

Test chip



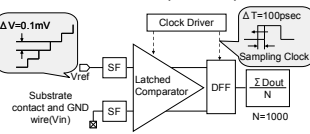
- sensing point on Substrate
- ▲ sensing point on GND wire

noise on Substrate

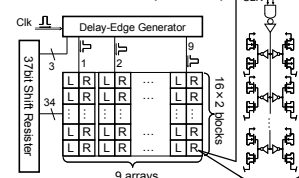


Both VCO are influenced by same level of noise

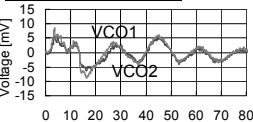
Noise Detector (NDET)



Noise Source (TCNS)



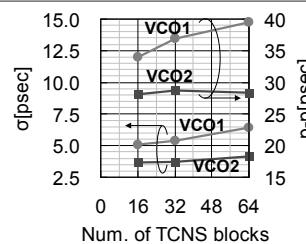
noise on GND wire



Jitter vs. number of TCNS blocks

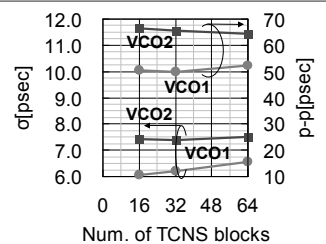
Cycle-jitter :

the variation of the period of a signal from the average period
 The index of influence by low frequency noise



Cycle-to-cycle jitter :

the variation in the period of a signal from one period to the next
 The index of influence by high frequency noise



Conditions: The TCNS clock is 27MHz
 The number of TCNS's active blocks are 16, 32 and 64

Compared with VCO2,

- The cycle jitter of VCO1 is over 10% larger
- The cycle-to-cycle jitter of VCO1 is over 30% smaller.

⇒ VCO1 is affected by low frequency noise.

The reason :

the back-gate of NMOS varactors is connected to the substrate directly.

Conclusion

Compared with the conventional single-input VCO,

The phase noise was improved by 10dB at 100kHz offset frequency.

The cycle-to-cycle jitter of the differential-input VCO was reduced by more than 30%.