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種別(和文)	要約
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This thesis analyzes a working principle of the rotary traveling wave oscillator (RTWO) and proposes an all-digital phase locked loop (ADPLL) using the RTWO.

The thesis starts from the phase error calibration technique and its analysis. By introducing non-uniform distributed capacitors in the resonator, the phase relationships among multiphase outputs available from the RTWO are adjusted to compensate for physical asymmetries. To have a better understanding of the proposed method, a new model, in which the RTWO is described as injection locked multiple standing wave oscillators (SWOs), is developed. The proposed model reveals possible modes of oscillation, their stability, and provides better design insights.

The proposed model is then used for the phase noise analysis. Treating the RTWO as a superposition of multiple SWOs, a phase noise formula for the SWO is first derived, and then is extended to the RTWO. The physically based approach and simple resulting expressions make it possible for circuit designers to optimize the RTWO for a given phase noise without lengthy simulations.

The thesis also presents a low-noise ADPLL where the RTWO is used as an oscillator core. By using multiphase signals available from the RTWO, the analog phase information is directly converted into the digital domain. Unlike the conventional time-to-digital converter (TDC) based approach, it eliminates power hungry inverter delay chains as well as real-time period normalization. The proposed approach significantly simplifies the ADPLL architecture while maintaining excellent phase noise. The PLL is implemented in a 65 nm CMOS process. The 32-phase embedded phase-to-digital converter (PDC) achieves $2\pi/64$ phase resolution, achieving excellent in-band phase noise of -108 dBc/Hz at 4 GHz with a 78 MHz reference and a 1 MHz loop bandwidth.

Related publications:

1. Koji Takinami, Richard Strandberg, Paul C. P. Liang, Grégoire Le Grand de Mercey, Tony Wong, and Mahnaz Hassibi (2011) A Distributed Oscillator based All-Digital PLL with a 32-phase Embedded Phase-to-Digital Converter, *IEEE Journal of Solid-State Circuits,* Vol. 46, No. 11, pp. 2650-2660
2. Koji Takinami, and Rich Walsworth (2010), Phase Error Calibration Technique for Rotary Traveling Wave Oscillators, *IEEE Journal of Solid-State Circuits,* Vol. 45, No. 11, pp. 2433-2444
3. Koji Takinami, Rich Walsworth, Saleh Osman, and Steve Beccue (2010) Phase Noise Analysis in Rotary Traveling Wave Oscillators using Simple Physical Model, *IEEE Transaction on Microwave Theory and Techniques,* Vol. 58, No. 6, pp. 1465-1474