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Imec demonstrates low-power phase-locked loop for short-range automotive and industrial radar applications

Duty-cycled phase-locked loop enables fast generation of high-quality frequency-modulated signals relevant for 140GHz radar applications

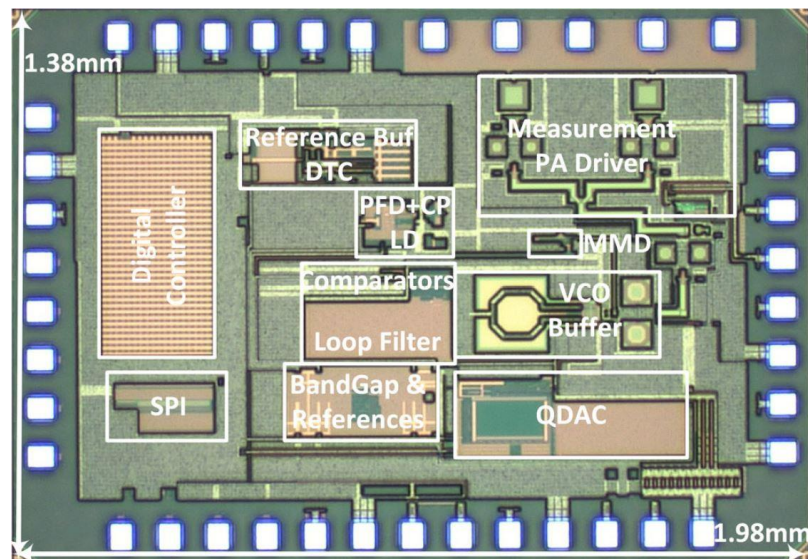
LEUVEN (Belgium), FEBRUARY 20, 2023— This week, at the 2023 International Solid-State Circuits Conference, imec, a world-leading research and innovation hub in nanoelectronics and digital technologies, presents a novel digitally calibrated charge-pump (CP) phase-locked loop (PLL) that can generate high-quality frequency-modulated continuous-wave (FMCW) signals for mmWave radars at low power consumption. The novel PLL is a critical building block for future short-range automotive (in-cabin and out-of-cabin) and industrial (e.g., on-cobot sensing) radar applications.

FMCW mmWave-based radar sensors are becoming increasingly popular for multiple automotive, healthcare, and industrial applications. FMCW radars transmit a sinusoidal wave whose frequency increases linearly in time, a sweep referred to as ‘chirp.’ After being reflected by the object, the signal is picked up by the receiver and mixed with the original chirp signal, after which the object’s distance and speed can be extracted. The quality of the radar signal depends largely on the performance of the PLL used to generate the chirp signal.

Imec’s novel PLL generates highly linear, high-quality chirp signals centered around 16GHz with a chirp bandwidth of 1.5GHz. A key achievement is reaching chirp speeds down to 12 μ s, with as low as 41kHz_{rms} error in frequency modulation (rms-FM-error). The PLL enables extremely fast startup (below 1 μ s) and minimal reset time between chirps (1 μ s reset time). The chirp generator operates in duty-cycled mode – synthesizing N chirps in one burst before powering down – providing significant power savings. For example, the PLL consumes only 9.2mW and 1.48mW when operating in a 50 percent and one percent duty-cycled mode, respectively. Even after power-down mode, the rms-FM-error of the first chirp remains below 41kHz. The duty cycling performance was enabled by adopting a charge-pump (CP)-based PLL architecture, fabricated in 28nm CMOS technology and extended with a phase-offset compensation time-to-digital convertor (POC-DTC) to facilitate fast self-calibration.

These excellent performance parameters make the PLL highly suitable for short-range automotive radar applications ranging up to several tens of meters. “Applications include in-cabin radar sensors to monitor presence, movements, and well-being of driver and passengers, as well as out-of-cabin sensors for parking assistance or vehicle detection,” explains Ilja Ocket, program manager at imec. “Our PLL also opens doors to robotics radar applications – think of on-cobot radar sensors to enhance safety and efficiency of human-robot interaction in industrial environments – as well as to radar sensors mounted on small moving objects or vehicles such as drones. At ISSCC, we are presenting a functional demo that integrates our CP-PLL with imec’s existing 140GHz radar receiver and transmitter blocks to showcase the potential of the technology for future automotive and industrial applications. The PLL can also be used for up-conversion to mmWave radar signals with other carrier frequencies, e.g., 80GHz.”

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Micrograph of the CP-PLL die with below 0.6mm² active core area (PFD=phase-frequency detector; VCO=voltage-controlled oscillator; QDAC= charge-integrating digital-to-analog converter).

About imec

Imec is a world-leading research and innovation center in nanoelectronics and digital technologies. Imec leverages its state-of-the-art R&D infrastructure and its team of more than 5,500 employees and top researchers, for R&D in advanced semiconductor and system scaling, silicon photonics, artificial intelligence, beyond 5G communications and sensing technologies, and in application domains such as health and life sciences, mobility, industry 4.0, agrofood, smart cities, sustainable energy, education, ... Imec unites world-industry leaders across the semiconductor value chain, Flanders-based and international tech, pharma, medical and ICT companies, start-ups, and academia and knowledge centers. Imec is headquartered in Leuven (Belgium), and has research sites across Belgium, in the Netherlands and the USA, and representation in 3 continents. In 2021, imec's revenue (P&L) totaled 732 million euro.

Further information on imec can be found at www.imec-int.com.

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