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UC Irvine and TowerJazz present 9-element fully integrated W-band direct-detection-based receiver

Specialty foundry TowerJazz (which has fabrication plants at Tower Semiconductor Ltd in Migdal Haemek, Israel, and at its subsidiaries Jazz Semiconductor Inc in Newport Beach, CA, USA and TowerJazz Japan Ltd) says that, at the IEEE International Solid-State Circuits Conference (ISSCC 2014) in San Francisco (9-13 February), researchers from the University of California, Irvine's (UCI's) Nanoscale Communication Integrated Circuits (NCIC) Labs presented results from an integrated circuit operating in the W-band (75-110GHz) comprising a 9-element fully integrated direct-detection-based receiver (RX) array. The fully integrated solution was fabricated in TowerJazz's 0.18µm SiGe BiCMOS process.

Since the early 1990s, W-band imaging systems have traditionally been designed and implemented in compound semiconductor materials. These III-V imaging solutions are typically in the form of multi-chip modules. The imaging receiver chip designed by NCIC Labs and manufactured by TowerJazz is claimed to be the world's most complex W-band imaging IC, with the lowest noise temperature and highest performance. The fully integrated receiver uses a new concept - spatial-overlapping super-pixels - for millimeter-wave (MMW) imaging applications (used for concealed-weapon detection, airplane navigation in low-visibility conditions, and satellite surveillance).

The use of spatial-overlapping super-pixels results in: (1) improved signal-to-noise ratio at the pixel level, (2) the same pixel density as a traditional focal-plane array, (3) partially correlated adjacent super-pixels, (4) a 2×2 window averaging function in the RF domain, (5) the ability to compensate for the systematic phase delay and amplitude variations due to the off-focal-point effect for antennas away from the focal point, (6) the ability to compensate for mutual coupling effects among the array elements, and (7) signal processing capabilities in the RF domain.

The receiver chip achieves a peak measured coherent responsivity of 1150MV/W, a measured incoherent responsivity of 1000MV/W and a front-end 3dB bandwidth from 87-108GHz, while consuming 225mW per receiver element. The measured NETD (noise equivalent temperature difference) of the SiGe receiver chip is 0.45K with a 20ms integration time. Finally, the imaging chip achieves what is claimed to be the lowest noise equivalent power (NEP) ever reported for any imaging receiver at W-band. This record performance means that, if commercialized, this imaging chip will achieve the best image resolution among all commercial products for security/surveillance applications, TowerJazz reckons.

"Our continued collaboration with TowerJazz through the years to support NCIC Labs at UCI has resulted in the success of a number of significant projects such as the development of several imaging receivers at W-band and the design of the first dual-band radar-on-chip covering 22-29GHz and 77-81GHz," says Payam Heydari, Full Professor of Electrical Engineering and Computer Science, UCI. "TowerJazz's dedicated support and its advanced technology enabled us to achieve silicon-based integrated circuits with comparable or better performance when compared to more expensive III-V technologies," he adds. Besides the ISSCC presentation, the new chip has been showcased as part of several invited talks including a keynote speech to the IEEE Global Conference on Signal and Information Processing (GlobalSIP 2013) in Austin TX, USA (3-5 December).

"UCI's results stem from very clever design architectures and highly optimized circuit block designs," comments Dr David Howard, executive director & fellow at TowerJazz. "These building blocks have methodically evolved over the span of our tight collaboration, and harness our best process and manufacturing technologies."

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