# A 6-8 GHz IR-UWB Transceiver ASIC in 65 nm CMOS for Ranging Applications

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*Starting from an existing Impulse-Radio Ultra-Wideband (IR-UWB) wireless transceiver prototype crafted with off-the-shelf components and aiming at demonstrating roundtrip time-of-flight (RTOF) distance measurements, DENEB2 had the objective to develop a fully integrated ASIC in a CMOS 65 nm technology. Although optimized for point-to-point distance measurements, DENEB2 is very versatile and fits a wide range of applications.*

IR-UWB continues to gain momentum, mostly driven by the proliferation of location-aware applications and by the emergence of wireless indoor positioning systems for asset tracking, emergency, health monitoring, home and industrial automation, augmented reality, sensor networks and the Internet of Things (IoT).

CSEM has been active for many years in the field of UWB with its proprietary FM-UWB solution for communication [1]. The latter solution is now complemented with activities in low-power IR-UWB radio technology for distance measurements conducted in collaboration with 3DB ACCESS AG (3DB), a start-up company based in Zurich. After a successful FPGA-based demonstrator, CSEM and 3DB have now developed a highly integrated and low-power solution addressing the worldwide UWB frequency bands between 6 and 8.5 GHz.

In order to cope with the challenges posed by the generation and the reception of impulses a couple of nanoseconds long at multi-GHz center frequencies, CSEM developed a new complete IR-UWB RF front-end and investigated several new radio components such as: a) wideband carrier synthesis with digital control; b) fully programmable UWB impulse transmitter and wideband power amplifier; c) high-gain and low-power wideband analog radio-frequency front-end; d) high-speed and low-power analog-to-digital converters (ADC).

To ensure a maximum flexibility in the generation of UWB impulses, the radio-frequency synthesis is based on a digital transmitter. This transmitter is able to accurately generate impulses of lengths ranging from less than a nanosecond to more than 10 ns, with controlled envelope shape and with a carrier frequency that covers a range of approximately 2 GHz from 6.0 GHz to 8.0 GHz. An example of the pulse shaping capability of the transmitter is depicted in Figure 1.

The transmitter also features several modulation modes such as amplitude modulation, frequency modulation enabled by the frequency agile synthesis and phase-shift modulation.

The receive path consists of a frequency down-conversion circuit (RF front-end) comprised of low-noise amplifiers and mixers, a digitally controlled variable gain wideband amplifier with an automatic gain control and an analog-to-digital conversion. The latter features ADC's operating at up to 1 gigasample per second. This high sampling rate enables distance resolution in two-way time-of-flight ranging down to 15 cm. The DSP implementation is able to process the sampled IR-UWB signals in a power-efficient way and allows signal synchronization with an accuracy down to one nanosecond for physical distance measurement and data communication.

Figure 2 shows results of distance measurements conducted in an indoor environment with dense multipath (hallway). With an energy consumption of a few tens of micro-Joules per measurement and a latency of a few milliseconds, DENEB2 demonstrates that real-time ranging with decimeter accuracies is feasible at very low-power consumption.

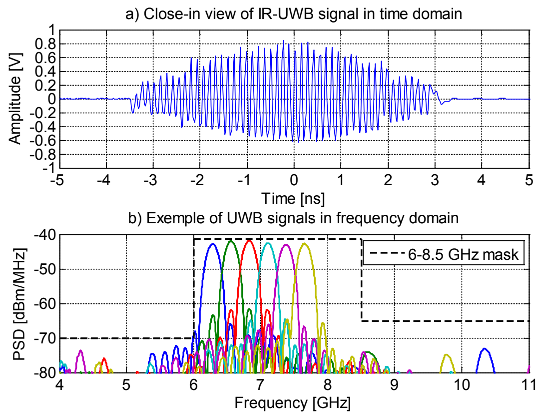


*Figure 1: IR-UWB signal in time and frequency domain vs. ETSI mask (example for impulses having -10 dB bandwidth of approximately 300 MHz and six different center frequencies ranging from 6 to 8 GHz).*

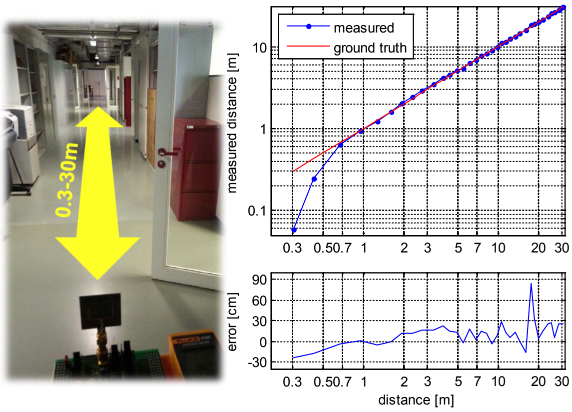


*Figure 2: 30 cm to 30 m indoor measurement in a CSEM hallway. The mean absolute error is 15 cm.*

Owing to its strong performance, the ASIC is suitable for use in a wide variety of applications, especially, where real time and energy consumption are at a premium, for example, electronic tags and key-fobs, wrist-watches, three-dimensional indoor localization for micro-robots and/or drones.

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[1] J. F. M. Gerrits, *et al.*, "Principles and limitations of ultra-wideband FM communications systems", EURASIP Journal on Applied Signal Processing, 3 (2005) 382