Bluetooth Dual Mode Transceiver in 22 nm CMOS

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The emergence of TWS is driving rapidly increasing demand for low power Bluetooth wireless. CSEM's Bluetooth Dual Mode transceiver provides Bluetooth Classic performance on a Bluetooth Low Energy power budget, offering the possibility of radically increased autonomy, along with enhanced audio streaming quality thanks to its superior link budget and robustness to interferers.

Wireless audio is today the biggest single market for Bluetooth. According to the Bluetooth SIG (Special Interest Group) 1.2 billion Bluetooth audio chips were shipped in 2020. Driven partly by smartphone manufacturers removing the jack plug from latest models, a large part of this growth is coming from True Wireless System (TWS) earbuds, which is estimated today to account for 38% of the headphone market. Furthermore, Apple have announced they would no longer deliver headphones as standard with new I-phones (Android is set to follow), creating a huge opportunity for TWS earbuds: the market is estimated to be 400m units in 2021.

While the demand is clear, TWS is not without its challenges, particularly due to the tiny space available for batteries and electronics. Early models suffered from short playtime, as well as poor audio performance. The race is now on to extend battery lifetime to several hours, as well as improving the user experience with audio enhancements and features such as integrated voice assistants. All these features however consume energy, and wireless is one of the main contributors.

CSEM has developed a Bluetooth Dual-mode (DM) transceiver combining Bluetooth Classic EDR for streaming audio along with Bluetooth Low Energy (BLE) for low power data transfer, as well as for future LE Audio streaming. This transceiver, named IcyTRX-DM, offers game-changing autonomy on a battery cell, an industry-leading budget link for reliable audio streaming and excellent resilience to interferers [1]. IcyTRX-DM uses GlobalFoundries' 22 nm FD-SOI CMOS process which offers extremely low leakage and low supply voltages. Indeed GlobalFoundries (GF) has partnered with CSEM to accelerate the availability of this outstanding silicon IP. CSEM is part of GF's Global Ecosystem of partners, allowing preferred access to engineering support and shuttle runs, as well as marketing promotion via GF's worldwide channels.

While CSEM is already a leading supplier of BLE transceivers, the requirements for ultra-low-power dual-mode operation required significant modifications of the architecture; the use of 22 nm CMOS allows use of a highly digital architecture including an all-digital PLL. Additional innovations include a rapid crystal oscillator to support highly duty-cycled power management schemes, as well as integrated low-drop-out regulators (LDOs) and an enhanced digital interface for support of multiple Bluetooth controller topologies. The radio offers 2Mbps for a flexible audio experience, as well as full BT5.2 compatibility including Long Range (coded S2 & S8) and Direction Finding (DF) BLE options, along with a flexible modem compatible with 802.15.4 2015 and other modulations. BLE only or BT Dual Mode options are available.

A partial test chip was fabricated at the end of 2019 in order to validate critical block functionality, in particular for the new functions, and a full test-chip is now available (see Figure 1).

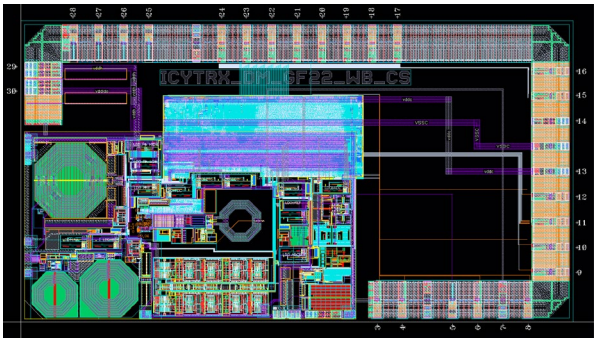

Figure 1: IcyTRX-DM chip.

The radio features a 0.8 V RF core voltage and two power modes: a 0.8 V low-power mode with +3 dBm output power, and a 1.6 V high-power mode up to +10 dBm. A single ended 50Ω RF port with integrated matching means the RF XTAL is the only external component needed. The GFSK transmission modulation spectrum is shown in Figure 2. This plot results from a max hold measurement done on several BLE packets sent at +10 dBm output power with fast ramp-up/down.

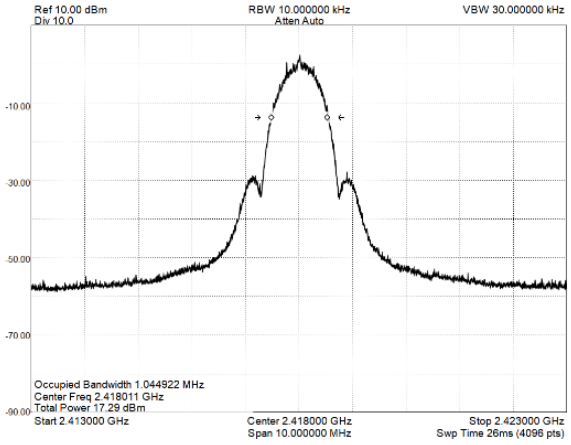

Figure 2: Tx GFSK modulation spectrum.

Lead customer reaction so far has been excellent, confirming the outstanding performance of IcyTRX-DM. Some lead-customers are already looking ahead to next generation products for which additional features are required: certain customers prefer TSMC to GlobalFoundries for their CMOS foundry, and CSEM is planning to introduce a TSMC-22 version later in 2021. In addition, several customers have requested higher output power to allow improved compatibility with streaming audio from mobile phones; while by no means trivial, a modification of the transmitter architecture is being trialed to allow to increase output power by 3-10 dB without degradation of other parameters.

[1] N. Raemy, "Dual-mode Bluetooth Silicon IP in 22 nm CMOS", CSEM Scientific and Technical Report (2019) 108.