A Power Management Unit for ULP SoC including BLE Radio

F. X. Pengg, N. Scolari, A. Vouilloz, E. Le Roux, N. Raemy, R. Godinho Caseiro, P.-A. Beuchat

The Bluetooth Low-Energy (BLE) transceiver icyTRX[1] has been successfully promoted as low-power and low supply-voltage IP over the last years. To render this IP even more attractive, the present project aims at optimizing the overall power consumption by adding a dedicated yet versatile power management unit (PMU).

In general the optimum operating voltage of a circuit integrated in an advanced CMOS technology does not coincide with the output voltage level of the available power supply. This is particularly true for most battery operated systems, where e.g., a lithium coin-cell with an output voltage in the range of 3.0 V to 2.4 V supplies a circuit operating around 1 V. An inductive or capacitive DC-DC converter makes the charge required to supply the system available at a level closer to its operating voltage thus avoiding the otherwise dissipative voltage drop.

The system PMU is developed as service block for the icyTRX transceiver while maintaining versatility for a wide range of systems on chip (SoC). Figure 1 presents a block diagram of the icyTRX transceiver co-integration with the PMU. The latter has three sub-units, one for the DC-DC conversion including its digital control, one for the icyTRX transceiver and one to manage a "customer" part of the IC. The following characteristics make the present development an attractive solution for a wide range of applications:

- High efficiency DC-DC conversion.
- Optimized power cycling of different parts of the circuit.
- Good isolation between individual circuit blocks.
- Very-low power standby mode.
- Reduced external component count.

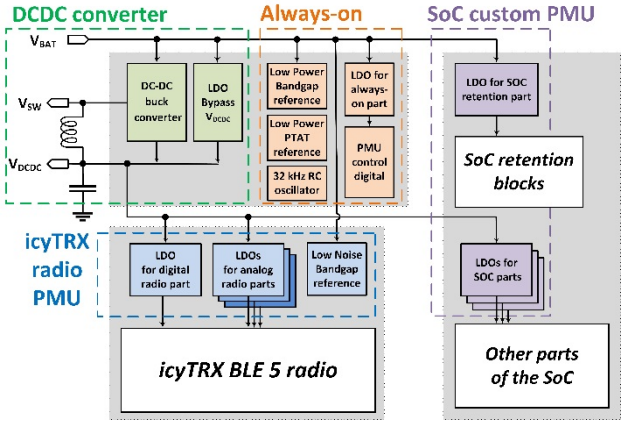

Figure 1: Block diagram of the integrated icyTRX with PMU.

The PMU can be operated in SLEEP-mode, when a minimum of low-power blocks is maintained operational, in LDO-mode, when the full system is operational but consumes low currents and in BUCK-mode, when some high current consumption operation is activated. In BUCK-mode an inductive DC-DC converter, nominally operated in pulse-width-modulation, converts a supply range between 1.7 V and 3.6 V down to an adjustable output between 1.2 V and 1.8 V (where the output has to be at least 0.3 V lower than the input). The switching frequency is configurable between 1 MHz for low noise operation during RF activity and 8 MHz when high efficiency is required. The converter quiescent current is about 300 µA. In LDO-mode a low drop-out linear regulator (LDO) with a quiescent current of only 10 µA replaces the buck converter. If needed, this LDO can also deliver more than 20 mA. In SLEEP-mode the only blocks still active are the digital PMU control which is supplied by an always-on low power LDO, a low-power 32 kHz RC oscillator for time-keeping and low-power voltage and current-references which reduces the overall current consumption to 500 nA.

Fast switching "cap-less" LDOs regulate the DCDC output voltage down to the different supply voltages of the respective circuit blocks. The icyTRX transceiver is partitioned into four power domains (analog, power amplifier, frequency synthesis and digital) for good isolation and optimized individual on-off timing. Figure 2 compares the current consumption of the receiver (RX) in LDO- and BUCK-mode respectively, which reduces from 6.1 mA to 3.2 mA while degrading the sensitivity by only 0.5 dB from -97 dBm to -96.5 dBm.

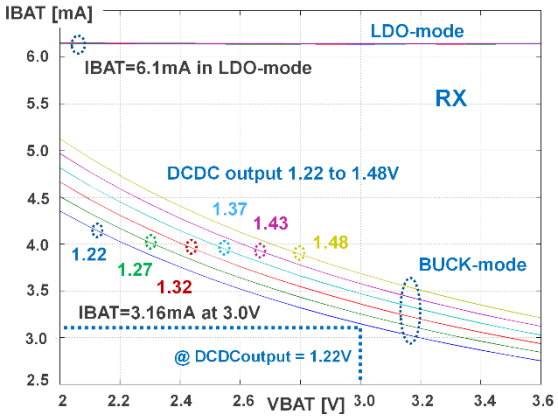

Figure 2: RX current consumption versus supply voltage.

In transmit mode (TX) the current reduces from 9.5 mA to 4.7 mA for an output power of 0.5 dBm.

[1] https://www.csem.ch/Doc.aspx?id=41379&name=flyer-icytrx-2017.pdf