

Preliminary specifications of BLIM4SME: Bluetooth Smart from IC to application

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BLIM4SME FP7-SME-2013 project (605264) aims at developing an optimized solution targeting the rapidly increasing landscape of EU SME's and industries that require beyond state-of-the-art, highly integrated and ultra-low-power BLE radios for their next generation healthcare, sports and fitness products. BLIM4SME will develop RF IP blocks which will be embedded into a single "antenna-and-radio" miniaturized module.

The **BLIM RF IC** integrates the hardware part of an RF transceiver compliant with Bluetooth 4.1 (c.f. Fig. 1). The software part is intended to be implemented into a companion microcontroller communicating with the BLIM RF IC via SPI and IRQ.

The BLIM RF IC is the assembly in TSMC 65 nm of two pre-existing IPs:

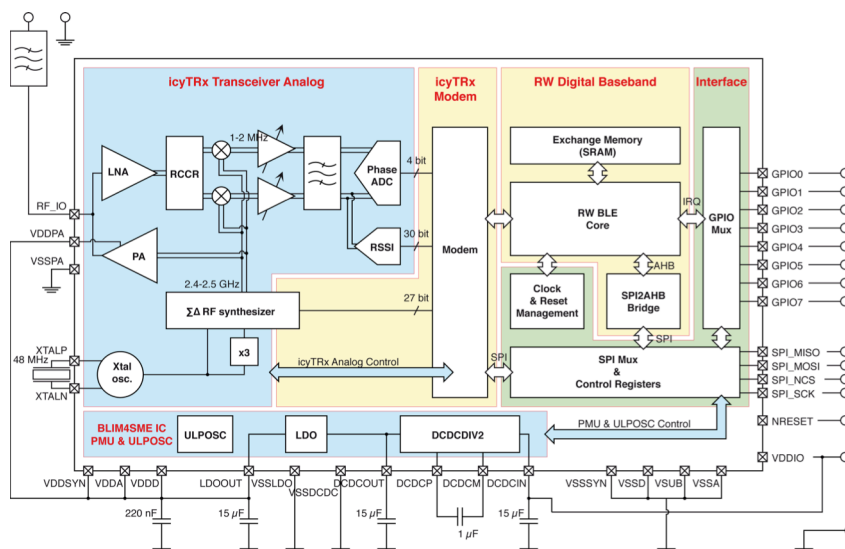
- **CSEM's icyTRX-65** Bluetooth Low Energy RF transceiver implementing the Physical Layer, Bit Stream Processing and Air interface Packet assembly and disassembly (i.e. Packet Data Unit insertion / extraction with Access Address recognition and CRC check). It also addresses IEEE802.15.4 and proprietary standards from 62.5 kbps to 4 Mbps.

- **RivieraWaves' Bluetooth Low Energy 4.1** protocol engine implementing the Bit Processing, Advertising / Data / Control Packets type support, Encryption, Frequency Hopping management, Time Division Multiple Access events formatting and synchronization, Broadcast / Central / Observer / Peripheral classes support and Real-Time-Clock management. A simple and optimized hardware interface is implanted for the software-implemented protocol part. The BLE software stack, running in "full-embedded mode" where the lower, upper, profile and protocol stacks run on the same microcontroller, is divided into the following components:

- LL: Link Layer
- L2CAP: Logical Link Controller and Adaptation Protocol
- SMP & ATT: Security Manager Protocol and Attribute Protocol
- GATT / GAP: Generic Profiles
- LE Profiles: BLE specific profiles

The resultant IC also implements dedicated power management and ultra-low-power time keeping functionalities:

- A capacitive DC-DC voltage converter supplies the IC core from the 2.4-3.6 V supply voltage for minimum peak current and component size and cost.
- A fully-integrated 32 kHz oscillator to eliminate the need for a Crystal Oscillator for minimum size and cost.



Operation frequency	2.36-2.5 GHz	
IC dimensions	1.65 x 1.45 x 0.38 mm	
External components	One 48 MHz quartz Xtal, down to 1.2 x 1.0 x 0.3 mm, two 220 nF 01005 ceramic capacitors, three 1 μF 0201 ceramic capacitor.	
Interface	RF: single 50 Ω interface, Digital: SPI & GPIO	
Voltage supply	2.4-3.6 V	
Transmission	0 dBm, 4.5 mA, 5 μs transient	after 0.5 ms crystal oscillator startup
Reception	-97 dBm, 3.0 mA, 15 μs transient	
Standby current	300 nA Including RTC based on 32 kHz osc.	

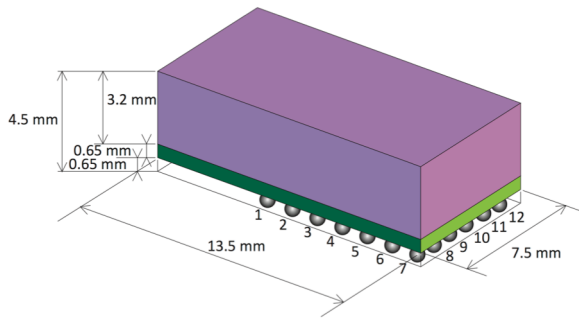
Figure 1: BLIM RF IC block diagram and preliminary specifications

The total assembly targets state-of-the-art performances with minimized power consumption in active and standby modes thanks to optimized architecture, clock gating, power domains, etc.

The choice has been made to not integrate the companion microcontroller in order to provide maximum flexibility and evolution of controller choice with minimum silicon footprint for cost minimization. Two different module implementations are then considered in the project:

- The **BLIM module**, which uses the BLIM RF IC, and an off-the-shelf ARM Cortex M0 with 128 kB of Flash memory running the RW BLE SW Stack and very limited component count.

- The **COTS module**, which uses off-the-shelf radio components. Besides being a direct outcome, it also serves for benchmark purposes for the BLIM module.



Communication standard	Bluetooth 4.1 Low Energy (2.45 GHz)	
Dimensions	13.5 x 7.5 x 4.5 mm (without additional surface for additional ground plane or exclusion volume)	
Interface	UART / SPI / I2C / ADC / PWM / GPIO	
Voltage supply	2.4-3.6 V	
Tx / Rx Peak current	4.4 / 4.8 mA COTS module	4.5 / 3 mA BLIM module
	Typ. 2.7 V Li-MnO ₂ coin cell	
Communication range	300 m free-space typical	

Figure 2: BLIM module dimensions

The goal is to make these modules upward compatible, in terms of functionality, interface, as well as mechanically. Both are integrating the same antenna and Integrated Passive Device component, designed by **VTT**, that implements filtering and antenna impedance matching.

The antenna does not constrain the supporting PCB outside the underlying 13.5 x 7.5 mm footprint with a 7.5 x 4.5 mm ground plane and > 0.2 mm surrounding ground ring.

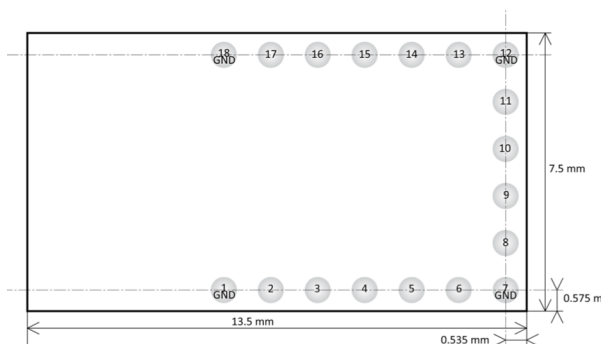


Figure 3: BLIM module interconnection top view

The application challenges are standardized connectivity for plug-and-play interconnection with other devices, ultra-portability with tiny modules for maximal comfort for the wearer, ultra-low-power consumption for long autonomy and

flexibility for simple integration with a heterogeneous set of other components like sensors, signal processors, energy harvesters.

The BLIM4SME project addresses those challenges by developing this ultra-low-power Bluetooth Low Energy (BLE or Bluetooth Smart) module focusing on healthcare and wellness applications as a stand-alone module.

Furthermore when implemented on a **Generic module** board with various sensors, extra memory, and maybe a separate application processor, it will also serve well in industrial applications. Indeed, **PRISMA** is active in remote monitoring and predictive maintenance and intends to expand the capabilities of its wireless sensor nodes, introducing a new series of devices where the BLE module will replace the existing wireless module. This will provide to end users the ability for in-situ machinery inspection with the use of their own mobile device (smartphone or tablet).

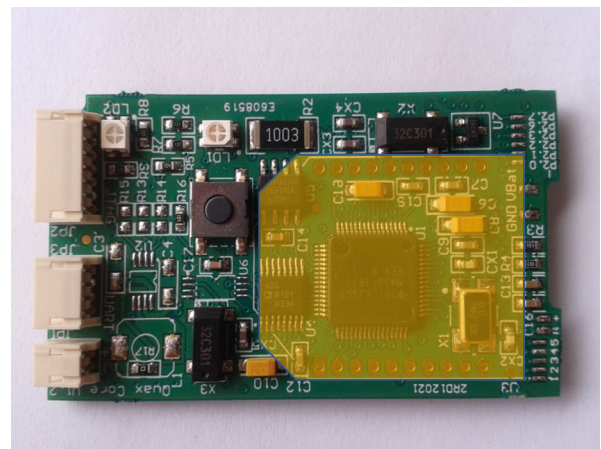


Figure 3: Placement of Generic Module on existing product

The **BLIM4SME project** aims then to develop optimized solutions for Bluetooth Low Energy connectivity with design of:

- An ultra-low-power **BLIM RF IC** intended to flexibly operate with off-the shelf microcontrollers.
- A miniature **BLIM module** implementing the BLIM RF IC, a companion microcontroller but also minimum footprint antenna and associated Integrated Passive Device for impedance matching and filtering.
- A similar miniature **COTS module** for benchmark purpose.
- A retro-compatible **Generic module** with multi-sensing capability for in-situ machinery inspection and predictive maintenance.