IMEC's ULPWIFI Radio is a pre-standard design for the upcoming IEEE 802.11ah standard (draft D5.0) and supports the mandatory 1MHz and 2MHz channel modes, optimized for low-power as well as extended range. OFDM-based BPSK/QPSK/QAM16 modes are supported. It achieves excellent performance at ultralow-power consumption and operates in the sub-1GHz industrial, scientific and medical (ISM) and short-range devices (SRD) bands, from 863MHz to 930MHz.

The design focuses on the mandatory low-power modes in the IEEE 802.11ah standard foreseen for low-power sensor node devices. Hence, it is optimized for ultralow-power consumption, large link budget, as well as robustness to interference. It has been designed and taped out in 40nm LP CMOS technology.

The Rx AFE comprises a complete ultralow-power zero-IF receiver chain from LNA to ADC. The Tx AFE contains a highly optimized class-D power amplifier, all-digital PLL for carrier generation and modulation, digital front-end and XO-based clock generation. A peak-to-average-power reduction technique is implemented to achieve a combination of excellent power efficiency and EVM. The FPGA digital baseband / PHY comprises complete framing / de-framing functionality (OFDM modulation / demodulation, synchronization, channel estimation, error correction, etc.) and is also optimized for low-power and low-area implementation. It provides third party MAC interfacing and seamlessly integrates with the MCU system by AMBA bus.

### Key Features

<table>
<thead>
<tr>
<th>Standard</th>
<th>IEEE 802.11ah (Draft D5.0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption</td>
<td>Rx: &lt; 6.0mW, Tx: &lt; 8.5mW</td>
</tr>
<tr>
<td>(Afe+dbb spec. for 40nm lp @ 1.0V)</td>
<td></td>
</tr>
<tr>
<td>Frequency band</td>
<td>863-930 MHz</td>
</tr>
<tr>
<td>Modulation</td>
<td>OFDM-based BPSK, QPSK and QAM16 (SISO modes)</td>
</tr>
<tr>
<td>Data rate (phy)</td>
<td>150kbps—3.9Mbps</td>
</tr>
<tr>
<td>Channel bandwidth</td>
<td>1MHz &amp; 2MHz</td>
</tr>
<tr>
<td>Tx evm (for all supported modes)</td>
<td>&lt; -27dB</td>
</tr>
<tr>
<td>Tx output power</td>
<td>0dBm average (8dBm peak)</td>
</tr>
<tr>
<td>Rx sensitivity (10% Per, mc10)</td>
<td>-104dBm</td>
</tr>
<tr>
<td>Rx adj. And alt. Channel re-jection</td>
<td>34dB and 50dB</td>
</tr>
<tr>
<td>Tolerable out of band blocker power</td>
<td>-20dBm</td>
</tr>
<tr>
<td>Nominal supply</td>
<td>1V</td>
</tr>
<tr>
<td>Technology</td>
<td>TSMC 40nm LP CMOS</td>
</tr>
</tbody>
</table>

Note: Preliminary specifications.
The ARM® Cortex™-M0+ based system enables SW development and testing of the analog front-end and digital baseband features. It includes 128kB of memory and peripherals like SPI, I2C and UART.

For demonstration, the PHY implementation is combined with a 3rd party 802.11ah MAC from Methods2Business B.V. The MAC adapter is comprising internal / external hardware as well as software interfaces. The ULPWIFI SW provides a hardware abstraction layer (PHY HAL) to get access to the basic functions of the AFE transceiver such as packet receive, transmit, set channel, etc. as used by the MAC SW stack layer.

KEY FEATURES

- IEEE 802.11ah (Sub-1GHz) Wi-Fi support
  - 1MHz / 2MHz channel support
  - OFDM BPSK, QPSK & QAM16 (SISO modes)
  - 0.15-3.9Mbps PHY data rates
- TX/RX Analog Front-End (AFE)
  - Tuning range: 863-930 MHz
- FPGA Digital Baseband / PHY (DBB)
- Ultralow-power consumption (AFE)
  - Rx: < 4.0mW
  - Tx: < 7.5mW for 8dBm peak output power
- Integrated microprocessor platform
  - ARM Cortex™ M0+ core, w. memory and peripherals (SPI, UART, GPIO, IC)
- Third-party MAC integration ready
  - MAC–PHY interface (PHY_SAP, PLME_SAP)
- Designed for 1V nominal supply

APPLICATIONS

- Low-power wireless sensor networks
- Machine-to-machine
- Extended range Wi-Fi
- Internet of Things

EVALUATION BOARDS

Imec provides evaluation boards on request to prospective customers and partners interested in licensing imec’s radio designs and IP.

HELIOS PCB + ARTIX7 FPGA BOARD

Enables complete evaluation of the ULPWIFI IEEE802.11ah radio and further development and testing of DBB/PHY features.

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