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A 2.4/5.8 GHz 10 µW Wake-Up Receiver With -65/-50 dBm Sensitivity Using Direct Active RF Detection

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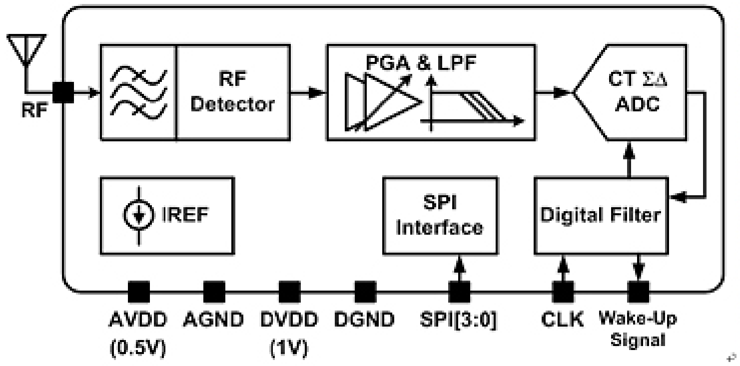
K.-W. Cheng, X. Liu, and M. Je, “A 2.4/5.8 GHz 10 µW Wake-Up Receiver With -65/-50 dBm Sensitivity Using Direct Active RF Detection,” in IEEE Asian Solid-State Circuits Conf. (ASSCC), Nov. 2012, pp. 337-340.

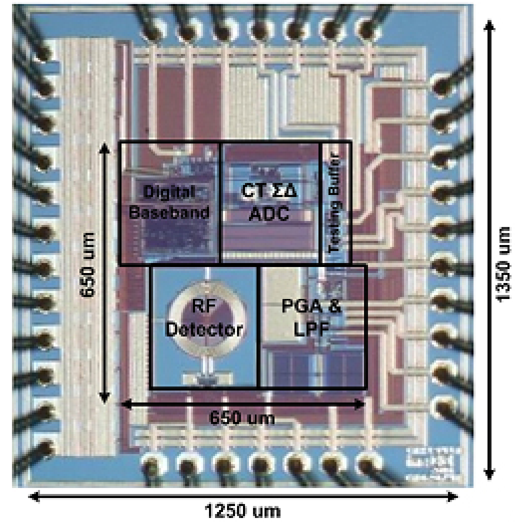
Wireless sensor network (WSN) requests very compact design in size and robust wireless communication between neighboring sensor nodes. Reducing power consumption for a smaller battery size and an extended battery lifetime in highly integrated electronics is always of the essence for WSN applications. In order to reduce power consumption, sensor nodes in low-activity-rate systems are typically heavily duty-cycled, spending most of the time in a low power sleep mode. However, this introduces a challenge for synchronization in order to communicate two neighboring nodes for activating their wireless communication simultaneously. However, this introduces a challenge for synchronization in order to simultaneously activate the wireless communication of two neighboring nodes. The transmitter must send the wake-up request many times and the receiver should listen more often in order to guarantee the communication coincides in time. An always-on wake-up receiver (WuRx) can break this trade-off between power consumption and system latency.

Energy autonomous sensors that could harvest ambient energy from sources such as light, heat, vibration and radiation are promising solutions to provide long-term self-sustaining sensor operations without battery replacement. However, either the inefficiency of the energy harvesting or the power-hungry radio in the sensor node make autonomous sensors still unpractical. If the WuRx consumes less than 10µW, infinite standby time, as a pioneer step, can be realized by ambient energy harvesting. However, the reported ultra-low-power WuRx’s consume much more than this desired target and more than 50% of their power is dissipated by either RF amplification before RF envelope detection, or LO generation for downconversion before amplification and envelope detection at IF. Many approaches have been implemented to overcome the limited sensitivity of the envelope detector and improve overall receiver sensitivity. However, the power inefficiency of RF amplifiers and LO generators makes their use more prohibitive at high carrier frequencies when forced by antenna size constraint and/or specific application standards.

This work presented a fully integrated wake-up receiver (WuRx) with direct active RF detection. The RF front-end features a high-sensitivity RF detector embedded with input matching network, obviating the need of RF amplification and LO generation for frequency downconversion. This complete receiver contains an RF detector, IF amplifiers, and a continuous-time ΣΔ ADC to provide inherent anti-alias filtering, which simplifies the overall design in 0.18-µm CMOS process. It achieves a sensitivity of -65 dBm for data rate of 100 kbps, operating in 2.4 GHz ISM band with only 10 µW. By adjusting the input matching, it can also operate for 5.8 GHz band, providing -50 dBm sensitivity without additional power consumption. This highly integrated WuRx prototype proves the excellent power efficiency using direct active RF detection and architecture simplicity with continuous-time oversampling ADC. Since such low-power consumption can be supplied by ambient energy harvesting, future work will consider the integration of power management to realize a self-powered autonomous wireless sensor node.



Block diagram of Wake-Up Receiver



Chip photo of Wake-Up Receiver