

Energy optimization of radio transmission using wake-up radios

Invited paper

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Now, more than ever, the time to hasten the efforts made to reduce the energy consumption, especially in the field of radio communications has come. Wireless transmission was often blamed as being energy inefficient. It is well known that, in radio communications, approximatively 80% of the consumed energy is used only to maintain the network connections during standby periods. Moreover, the number of connected devices is continuously growing: as estimated by the International Energy Agency, in 2030 the number of connected devices will be multiplied by eight and, as a consequence, the energy consumption will double.

Several recent works have proposed some solutions to increase the energy efficiency of the radio transmissions and several approaches are highlighted in the literature. The most common one is to optimize the energy efficiency of each parts of a radio transceiver, especially the efficiency of the power amplifier, the most energy greedy part. Another emerging technique is to harvest different forms of ambient energy in order to supply short range communications. Compared to a classical stack up solution, sharing different functional blocks of different receiver chains is another way to reduce the energy consumption. A different approach is to shut down the radio transceiver during the inactivity periods and software or hardware methods are developed in order to wake it up when a communication demand occurs. At the hardware level, ultra-low power consumption receivers (wake-up radios) are proposed to control the state of the main radio front-ends.

Several categories of wake-up radios are presented in literature. The first group is represented by rectenna systems first presented by Lin Gu and John A. Stancovic. (*Radio-Triggered Wake-Up for Wireless Sensor Networks*, Real-Time Systems, 10th IEEE RTAS, 27-36 2004). This kind of wake up radio detects only a certain power level on a radio channel. Despite its very low power consumption, the main drawback is that it cannot make the difference between a noisy channel and a real wake-up signal and consequently, its sensibility is much degraded. The wake up signal is transformed into a DC one by using charge pumps or voltage multipliers. In order to increase the wake-up radio sensitivity, a heterodyne receivers are propose as in Pletcher et al., *A 52 μ W Wake-Up Receiver with 72 dBm Sensitivity Using an Uncertain-IF Architecture*, IEEE Journal of Solid-State Circuits, 44(1) :269–280, January 2009. In S. Marinkovic and E. Popovici, *Nano-Power Wireless Wake-Up Receiver With Serial Peripheral Interface*, IEEE Journal on Selected Areas in Communications, 29(8), 2011, OOK modulation is used in order to send the information on the main node to wake up. Depending on the application, some other variation of these architectures have been developed.

This paper will focus on the presentation of the different wake up radio architectures with an emphasis on a solution proposed by the authors (Hutu et al., *A new wake-up radio architecture for wireless sensor networks*, JWCN 2014). The proposed wake-up radio is quasi-passive and the decision to activate the main radio front end is taken at the RF level, compared to the classical approach consisting in taking this decision at the baseband level. Indeed, in order to identify which radio interface should be waked up, an identifier, formed using a particular combination of subcarriers from a classical OFDM signal is associated to the radio interface. A differential structure containing multiband filters, a subtractor and a Schmidt trigger receives this signal and takes the decision to activate or not the main radio front-end. The active parts are implemented using ultra low power operational amplifiers and so, the overall energy consumption of the wake up radio is estimated to be lower than the state of the art.