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► **To cite this version:**

Jesus Argote-Aguilar, Mickaël Le Gentil, Matthieu Gautier, Olivier Berder, Florin-Doru Hutu, et al.. Demo Abstract: Online QoS adaptation in RF energy powered Wake-Up Radios. IEEE International Conference on Electronics Circuits and Systems (ICECS), Nov 2024, Nancy, France. hal-04806242

HAL Id: hal-04806242

<https://hal.science/hal-04806242v1>

Submitted on 27 Nov 2024

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Demo Abstract: Online QoS adaptation in RF energy powered Wake-Up Radios

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Abstract—Wake-up radios (WuRx) are ultra-low power devices designed to listen for incoming messages and activate the main transceiver when needed. Their low power consumption allows for potential operation using only harvested Radio-Frequency (RF) energy. This demonstration shows the integration of an RF harvester alongside a WuRx and explores optimizing its quality of service based on the available energy. The number of messages processed by the WuRx microcontroller is adjusted according to the battery status, ensuring efficient power use and sustainability. It is demonstrated that the RF harvester can sustain WuRx operation with input power levels as low as -18 dBm.

I. CONTEXT AND SCIENTIFIC CONTRIBUTIONS

In the growing field of the Internet of Things (IoT), the long-term operation of connected devices is often constrained by the battery lifetime. To address this, Wake-up Radio receivers (WuRx) can help minimizing the energy consumption by keeping the main transceiver in a deep sleep state until needed. Enhancing sustainability further, making WuRx independent of the main battery, potentially powered by harvested Radio Frequency (RF) energy, is being explored.

WuRx with power consumption as low as nanowatts (nW) are now available. Powering such devices with RF energy harvesting is currently investigated, where an RF harvester circuit supplies regulated Direct Current (DC) voltage. However, the input RF power is often low and unstable, requiring WuRx power consumption to be adapted based on available energy. The WuRx described in [1] can consume as little as 152 nW when idle but may exceed $100 \mu\text{W}$ when processing incoming signals. To optimize sustainability, the number of processed signals (address packet) must be adjusted according to the available harvested energy. This is managed by an energy manager embedded in the WuRx microcontroller (MCU) firmware.

Several energy management algorithms exist for IoT nodes, mainly aimed at optimizing quality of service (QoS), which can include factors like the frequency of sensor measurements or radio activations. In this work, QoS is directly managed within the WuRx, defined as the ratio of processed addresses relative to received ones. This adjustment strategy is computationally efficient, making it ideal for resource-limited systems like WuRx. Additionally, it leverages harvested RF energy, representing a novel approach in energy harvesting-based IoT devices.

This demonstration aims at highlighting both the efficiency of the RF harvester proposed in [2] and designed to be efficient

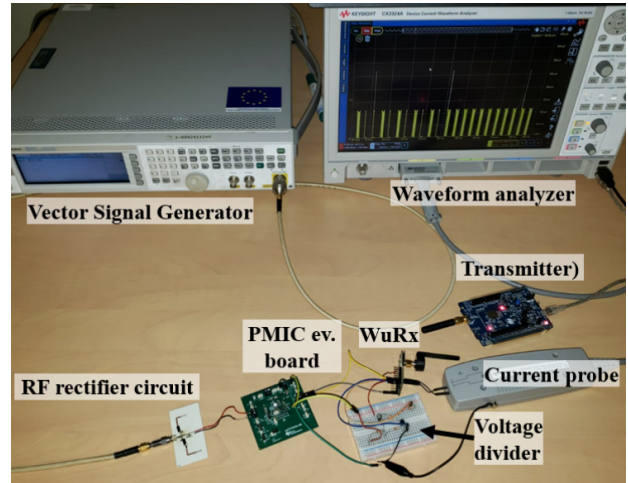


Fig. 1. Setup for showing WuRx QoS adaptation for different RF energy.

over a wide power level range, and the adaptation achieved by the energy manager proposed in [3] and implemented in the ULP WuRx used in [1].

II. DEMONSTRATION SETUP

Fig. 1 presents the experimental setup. It is first composed of the RF harvester fed with an 888.7 MHz continuous wave signal using an N5182A vector signal generator. The RF harvester power supplies the WuRx with a regulated voltage of 1.8 V. A STM32L0 Discovery kit is used to transmit address packets towards WuRx. A CX3300A waveform analyzer is used to measure the current profile of the WuRx.

The proper operation of the WuRx with QoS adjustment based on the RF harvested energy is verified with measurements.

To observe two slots as well as the duration of received signals, the packet rate is fixed to 30 packets/s, and adaptation time slot T_S is defined by the reception of 10 packets. Fig. 2 shows an example of the WuRx current profile over two slots. It shows the different ratio $r[k]$ of processed addresses depending of the received RF power.

ACKNOWLEDGEMENT

This work is part of the project U-Wake funded by the French National Research Agency (ANR-20-CE24-0005).

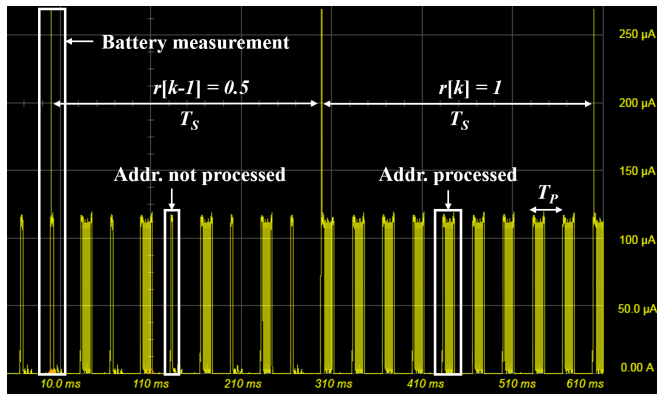


Fig. 2. QoS adjustment for two received power levels: -15 dBm and -5 dBm.

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