RF-powered UHF-RFID analog sensors platform

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***Abstract*—An RF powered UHF-RFID passive sensors platform was realized using discrete components and printed antennas designed to resonate at 868 MHz, used both for energy harvesting and data transmission. The tests demonstrate the possibility for the system to operate autonomously within the reading range of a standard RFID reader, that acts both as the RF power source and the receiver of the data stored in the tag user memory. The microcontroller can be interfaced on the same substrate with a sensor made of polymeric materials, sensible to physical parameters or chemical agents.**

Keywords—RFID Platform; Energy Harvesting; Analog Sensors; Temperature Sensors;

I. Introduction

New technologies allow to make RFID (Radio Frequency IDentification) tags with embedded sensors that can be remotely activated and powered by RF fields.

These tags integrate a sensing stage, an antenna, a transceiver, and a data memory. Active tags also include a battery, whereas passive tags are supplied though different forms of energy harvesting methods (RF fields, sunlight, thermal gradients, mechanical) that eliminate the need of battery replacement or maintenance. Batteryless powered devices are used in passive RF tags [1]-[2] that work in a range of 1–3 meters.

RFID tags have a wide range of sensing and monitoring applications, allowing to know the state of a product at any time. The platform allows to acquire sensors data, send and store measurements and events inside the embedded memory.

This paper presents an RF powered UHF-RFID low-power passive sensor platform realized using discrete components and printed antennas, the latter used for energy harvesting and data transmission. The microcontroller on the platform governs temperature acquisitions, either from the sensor integrated inside the tag, or from analog sensors fabricated onto the PCB, e.g. based on organic materials, and eventually stores data inside the tag memory. The system was tested in a specific application for temperature reading.

The paper is organized as follows. Section II describes the architecture of the platform. The components used in the platform are presented in section III. The platform was used to perform temperature measurements and this application is discussed in section IV. The conclusion are presented in section V.

II. System Description

The system has been realized on a 400 µµm tick FR4 substrate. The main antenna is a medium size (38 x 25 mm), low cost Meandering monopole [3], used for energy harvesting from the RF source that fully powers the circuit. The antenna is coupled to a pi-matching network and matched to the energy harvesting circuit using the complex conjugated method [4]. An RFID tag chip placed on the same platform uses a miniature helical PCB Antenna (19 x 11 mm) [5] matched to the input impedance of the RFID tag chip.

Figure 1 shows a block diagram of the platform. As soon as the circuit enters into the RF field of a reader, the platform is activated, harvesting the RF energy and activating the rectifier circuit that provides a regulated DC supply voltage (1.8Vdc) to the microcontroller (MCU) and to the tag IC.

The tag microchip is connected to a dedicated antenna used for data transmission. When the microcontroller is active, it provides the energy to the tag microchip, using the energy harvested by capturing the electro-magnetic (EM) field generated by RFID reader. The supply system powers up the microcontroller and the tag chip when data are transferred from the microcontroller to the tag through the SPI (Serial Peripheral Interface) bus. Otherwise, the tag IC is passively powered by the RFID reader and its own antenna to ensure remote data acquisition.

The microcontroller captures the data from an analog sensor, and stores them on the user memory of an RFID tag at a user selectable rate. The tag transmits the stored data according to the EPCglobal Class-1 Gen2 standard.

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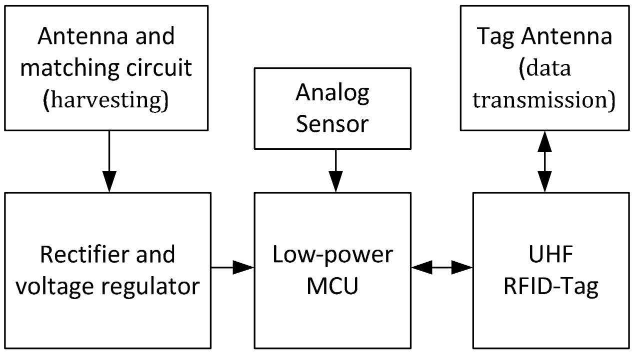

Fig. 1. Block scheme of the sensor platform.

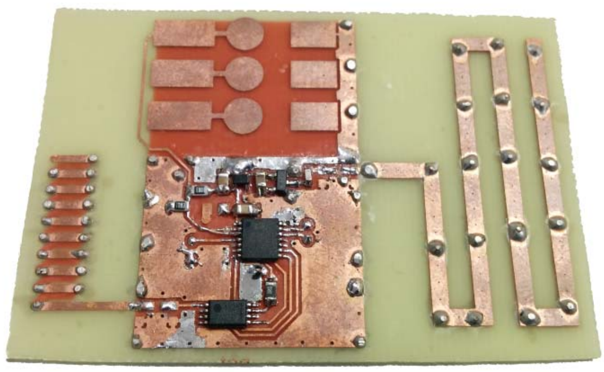

Fig. 2. Picture of the prototype.

State-of-the-art platforms [6]-[7] use the EM field generated by the RFID reader for powering the platform, permitting a one-way communication from tag to reader. The benefit of the platform presented here is that a bidirectional communication channel for remote sensing applications is implemented by using an RFID tag and a microcontroller [8]. The user memory of the tag can be used by both the microcontroller and an the RFID reader. It is therefore possible to read/store measurements and to update "over-the-air" the configuration of the system by modifying, thought a RFID reader, the parameters stored in the user memory of the tag. The parameters can be read by the microcontroller to modify the time intervals between sensor readings in order to adjust the power budget of the platform according to the required application conditions.

III. Platform Components

The microcontroller is an 8-bit XLP (eXtreme Low Power) MCU from Microchip Technology (PIC16LF1503) that supervises the whole operations of the circuit. It integrates a 10-bit ADC that allows to acquire the measurements from an analog sensor. It uses the SPI bus to communicate with the tag chip and store the measurements into the tag EEPROM memory.

The RFID tag is an EM4325 (EM Microelectronics) that allows data transmission according to EPCglobal Class-1 Gen2 standard protocol. The chip has 3072 bits of user programmable memory, and also includes a digital temperature sensor that can be accessed using the SPI protocol. Temperature readings can be made on demand by a reader, or the chip may be programmed to perform self-monitoring with alarm conditions.

The EM field collected by the antenna is rectified by means of HSMS2852 Schottky diodes (Avago), implementing a Voltage Doubler rectifier, whereas a linear voltage regulator (ON Semiconductor NCP583) is used to regulate and stabilize the voltage at 1.8V. Figure 2 shows a picture of the prototype.

The PCB includes some pads, connected to the ADC port of the microcontroller. These pads can be used e.g. to deposit a polymeric material sensible to physical parameters (e.g. temperature) or chemical agents. These pads are connected, through a voltage divider, to a pin of the microcontroller; the voltage is acquired and converted by the integrated Analog-to-Digital converter of the MCU and the value can then be converted to a resistance measurement proportional to the physical monitored parameter.

IV. Applications

As a proof of principle, the platform has been used to perform temperature measurements from the sensor integrated in the RFID tag. The set-up includes an UHF Impinji Reader (model R420) that read the measured data and also acts as RF power source. A commercial temperature sensor has been used as reference (Magiant Serverflu).

Figure 3 shows the results of the measurement campaign. The measurements have been carried out in a 24-hour session, in an office room with temperature controlled by an air conditioner unit. The reader antenna was used to interrogate the platform and to collect the sensor data. Results show how the performed measurements are consistent with the events occurred over the course of the day and with the measurements of the reference sensor used.

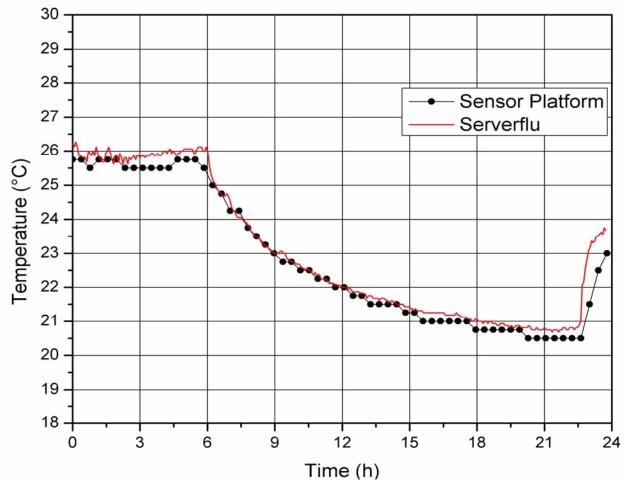

Fig. 3. Temperature measurements from the sensor integrated in the platform compared with a commercial temperature sensor (Magiant Serverflu).

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V. Conclusions

A Wireless Sensor Platform was designed and realized. It has been tested to perform temperature measurements to demonstrate the feasibility of the platform in a typical application scenario.

The low power microcontroller ensures power consumption below 480 nW in sleep mode, allowing an optimal energy harvesting and storage from the RF source.

Hardware improvements have been investigated for future enhancement of the power consumption and the energy transfer efficiency.

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