RF-powered Transceivers for Long and Short Range Communications

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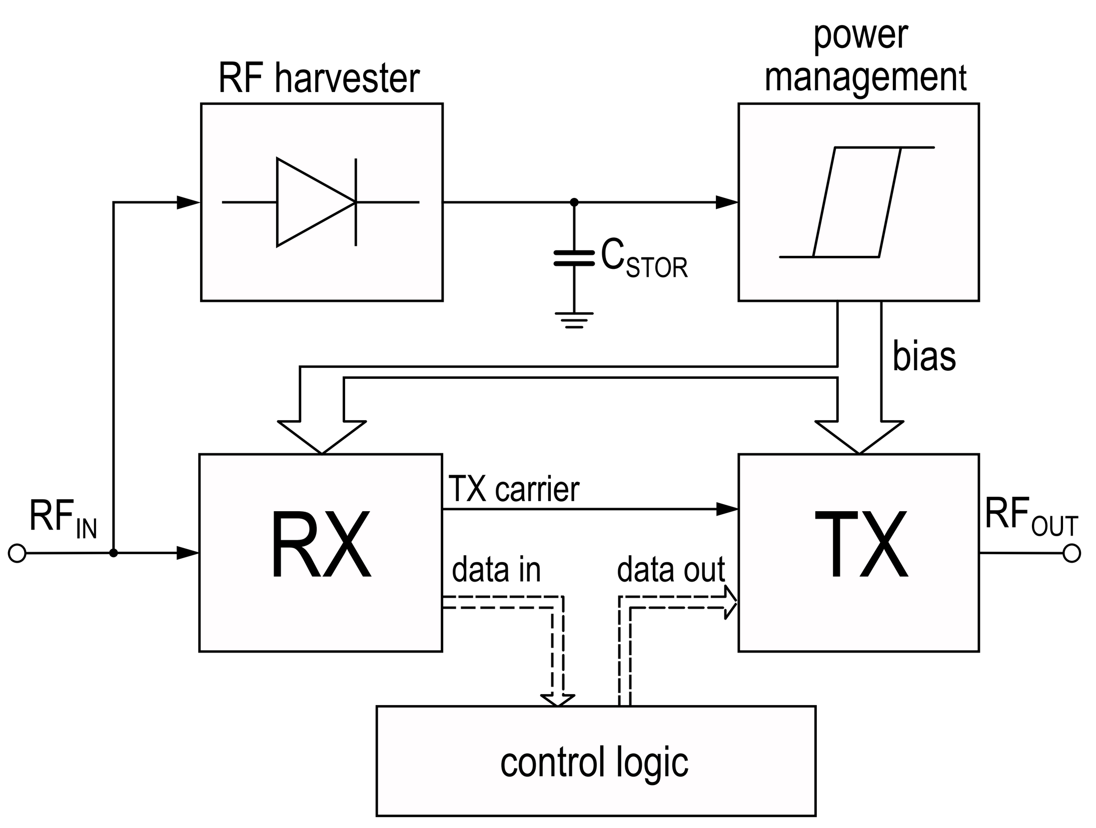
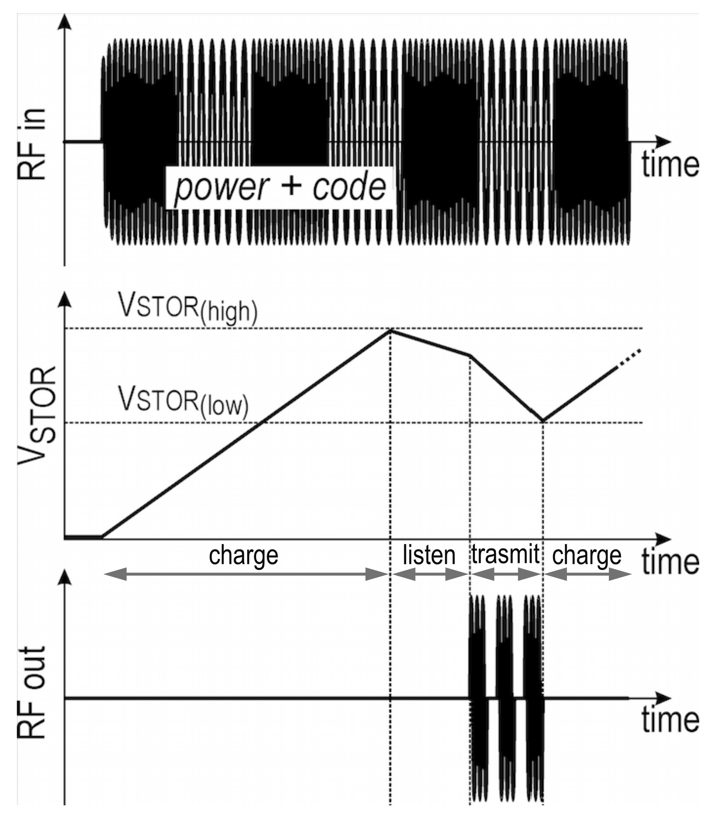
I. *Introduction*

RF-powered devices provide an enabling technology for the deployment of low-cost free-of-maintenance wireless sensor network. Long range RF-powered devices rely on a network hub that besides collecting data supplies both power and TX carrier to the node. In this scenario, extending the hub coverage area is mandatory. This network achieves a reading range up to 10 m and is used to track assets for UHF RFID commercial solutions. On the other hand, the communication in a short range network is guaranteed in elettromangnetic near field conditions, where there is a magnetic coupling between the reader and tag antennas. This architecture addresses control and security acces for the so-called smart cards, where the reading range is up to 1 cm. In this work, an integrated short range antenna was designed using the metal layers of the available CMOS technology to address both long and short range applications.

II. *System Description*

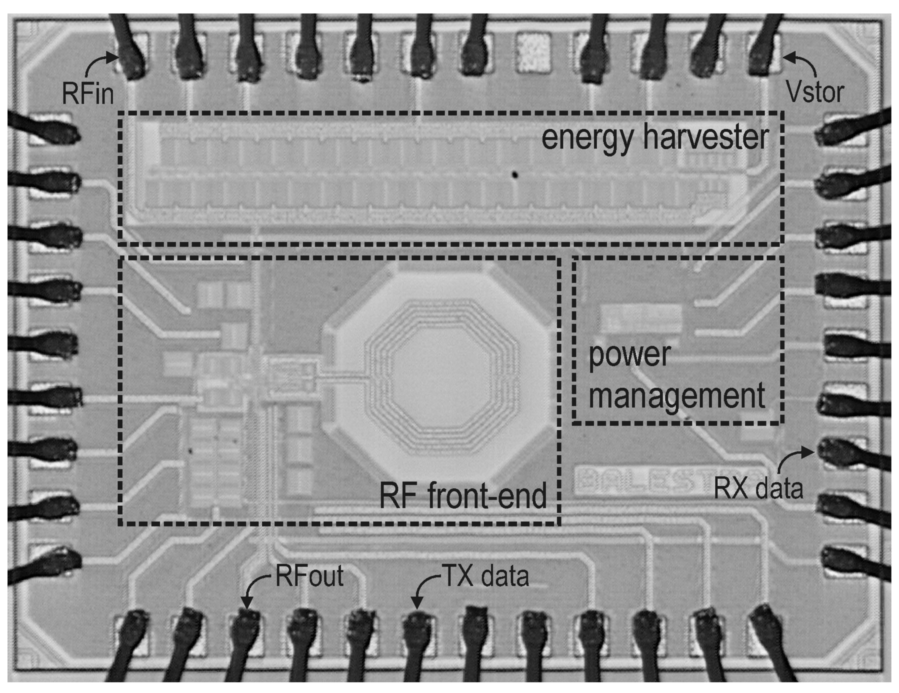


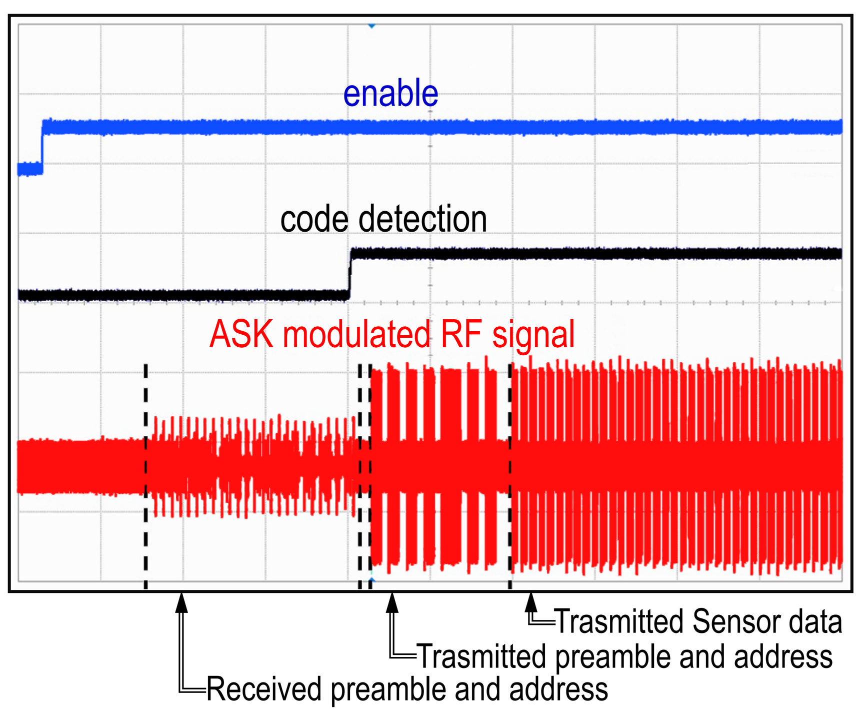


A typical architecture of the proposed transceiver consists of an RF energy harvesting module implementing an RF to DC power conversion, a power management unit for power control, and a PLL based RF front end performing both data recovery and TX carrier synthesis from the received RF signal. The proposed solution adopts a charge & burst operating strategy, which means first collecting the RF energy coming from the antenna and then providing communication. The IC power up threshold is considerably reduced and the hub coverage area extended provided that the needed energy is collected with the RF front end off. The reading range is further improved by exploiting innovative threshold compensated rectifiers for the RF harvester. Differently from conventional RFID devices, which rely on backscattering transmitters, the proposed transceiver adopts an active ASK trasmitter. This allows overcoming the reader self jamming limitation that greatly reduces reading range. However, adopting different frequencies for uplink and downlink functionalities entails a more complex antenna. To overcome this drawback, a solution exploiting a carrier capture on the received carrier was also designed. This allows the same frequency to be used for both RX and TX sections.

III. *Experimental results*

The circuit was implemented in a standard CMOS process and operates with a minimum input power around -19 dBm. It is able to support FSK/ASK demodulation and ASK data transmission. The transceiver synthesizes a 2.4 GHz TX tag carrier from the 900 MHz input signal. The experimental results report the measured waveforms of the 1 Mb/s ASK modulated RX and TX signals. Achieved performance and comparison with state of art solutions are reported in the Table.



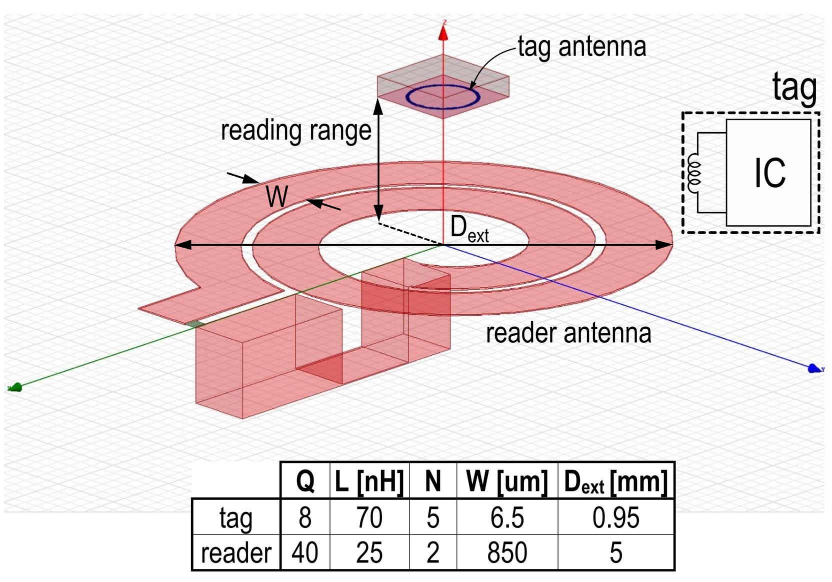


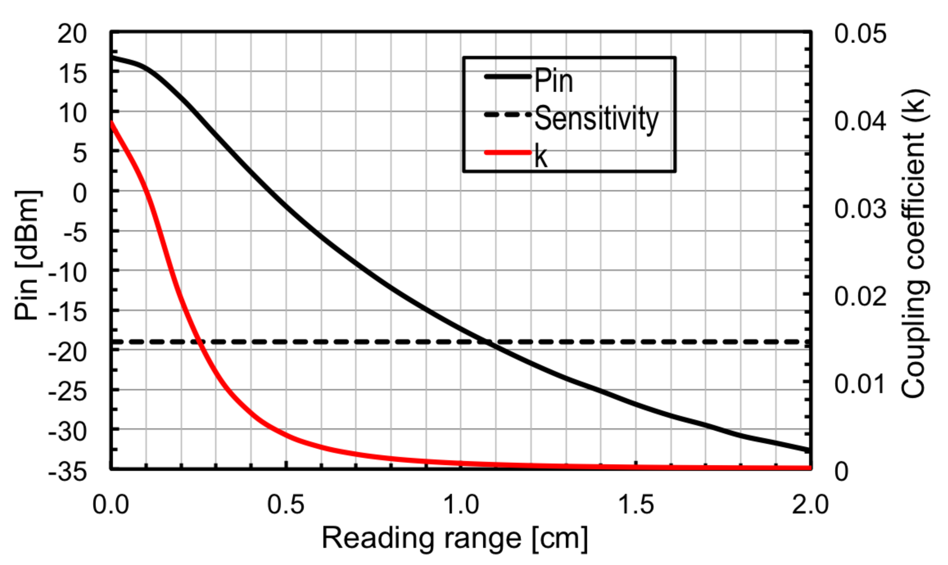
Reference	This work	Daniel Yeager ISSCC 2010	Hannes Reinisch ISSCC 2011
Process	CMOS	CMOS	CMOS
Sensitivity	-18.8 dBm	-12 dBm	-10.3 dBm
Operating frequency	900 MHz	900 MHz	860 MHz
Data rate	up to 5 Mb/s	640 kb/s	640 kb/s
Modulation	FSK/ASK	ASK	ASK
Transmit mode	active	backscattering	backscattering

IV. *NFC VS proposed solution*

NFC is the communication standard for short range RF-powered appications. It operates at 16.56 MHz and uses on-board tag antenna. An RFID tag with an UHF antenna drastically reduces the area of the coil and allows a monothic implementation to be achieved, which in turn means significative cost reduction. Moreover, an on-chip antenna can be magnetically coupled with a far field tag antenna to perform a far field communication with the hub. The UHF tag antenna along with a test antenna for a sub-Watt reader are illustrated below.

- UHF near field proposed solution:





- Alternative UHF far field solution: