A miniaturized low-power radio frequency identification tag integrated in CMOS for biomedical applications

Juan Sebastian Moya Baquero, Fabian L. Cabrera, Fernando Rangel de Sousa

Wednesday 31st August, 2016

Table of contents

Table of contents

Context

Figure: 1950-2050 Population Pyramid [1].

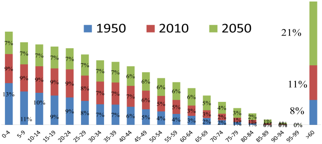


Figure: More old people in the society.

Figure: Hospital High Demand.

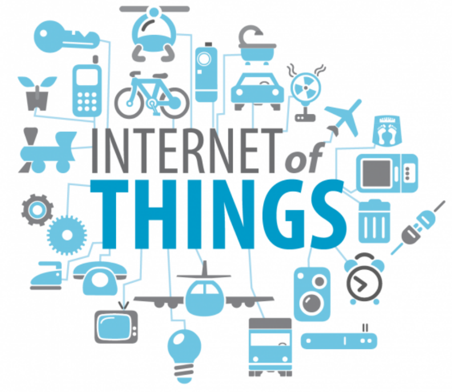
Source:http://mathisworks.com/

Some informations

- Susceptible to chronic diseases.
- 80$\%$ of health-care system spending is on chronic condition management. [2]

Motivation

Figure: Internet of Things.



Benefits

- Tracking people at hospitals (Better organization).
- Information analyzed by IoT.
- Patient can access its personal health record (know the identification of doctors and professionals that have treated the patient).
- Patient active role in its treatment decision-making.
- Guarantee a patient adequate assistance.

Table of contents

Proposed system for monitoring

Figure: Energy and Information exchange via inductive link.

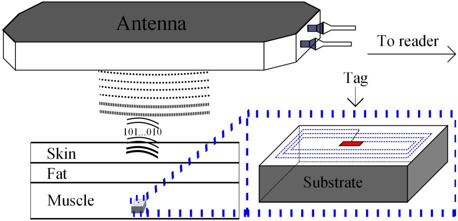
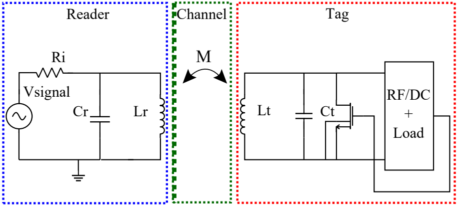


Figure: Block diagram of the system.



System main components

- Reader.
- Tag.
- Channel.

Previous works at LRF

Inductive link characterization

- *Extending the Inductor Operating Frequency for Optimally-coupled Wireless Power Transfer Systems.*[3]
- *Contactless Characterization of a CMOS Integrated LC Resonator for Wireless Power Transferring.* [4]

Figure: Link EM simulation.

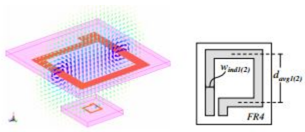


Figure: Link test setup.

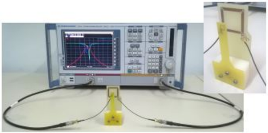
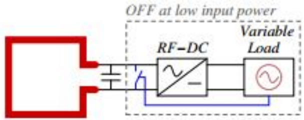


Figure: Variable load for link characterization.

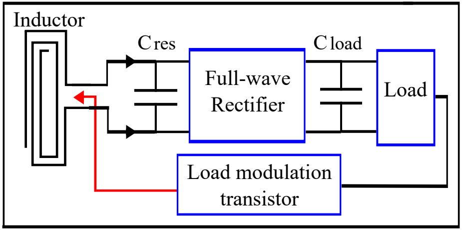


Proposed Tag

Characteristics of the Tag

- Miniaturized.
- Low-cost.
- Information extracted wirelessly.
- Low-power for biological compatibility.

Figure: Tag block diagram.



Tag main components

- Inductor.
- RF/DC Front-End (Cres, Full-Wave Rectifier and Cload).
- Load.
- Load modulation transistor.

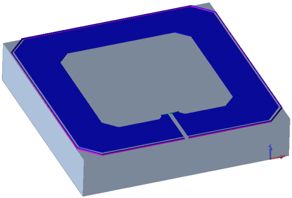
Table of contents

1.04 GHz Inductor

Full-custom Inductor from a previous work

- *Contactless Characterization of a CMOS Integrated LC Resonator for Wireless Power Transferring.* [4]

Figure: Inductor in EMPro.



Inductor parameters

$$R_s = 0.593\ \Omega$$

$$L_s = 2\ nH$$

$$Q = 22.09$$

$$C_{auto} = 88\ fF$$

Full-wave voltage rectifier

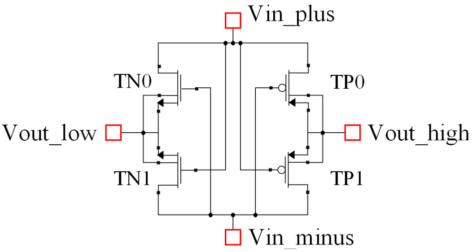


Figure: Full-wave voltage rectifier cell

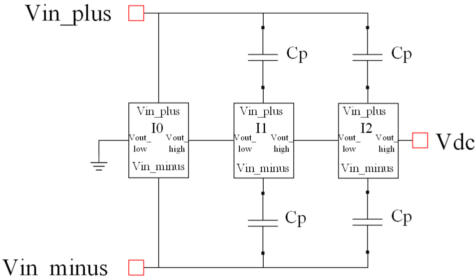


Figure: Full-wave voltage rectifier

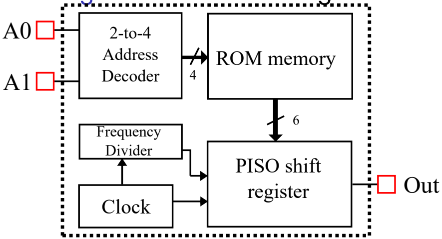
$$Vdc = N(2Vin - Vdrop) \quad (1)$$

Load Block diagram

Load main components

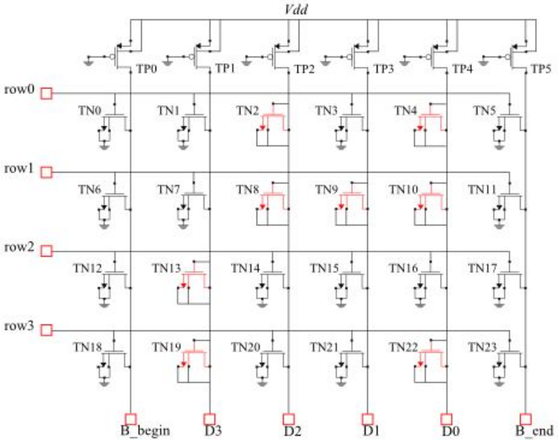
- ROM memory.
- PISO shift register.
- Ring Oscillator.
- Frequency Divider.
- Address Decoder

Figure: Load block diagram.



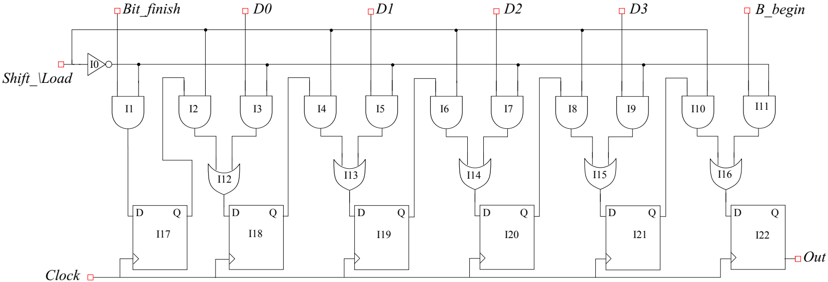
ROM memory block diagram

Figure: ROM memory



PISO shift-register block diagram

Figure: PISO Shift-register



Clock and Frequency divider block diagram

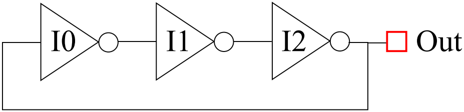
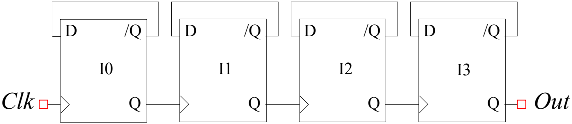


Figure: Clock

Figure: Frequency divider



$$F_{Out} = \frac{F_{Clk}}{2^N} \quad (2)$$

Modulation transistor and Tag block diagram

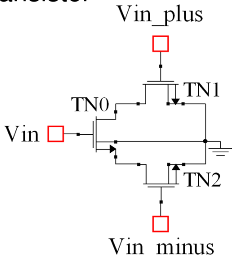


Figure: Modulation transistor

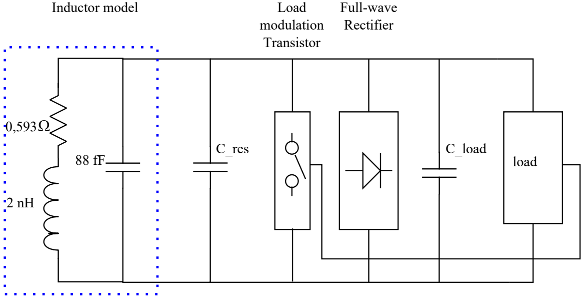


Figure: Tag with inductor model

Simulation results

Table: Address Bit words table.

A1 Value	A2 Value	Word Sequence
0 V	0 V	110101
0 V	1 V	110001
1 V	0 V	101111
1 V	1 V	101101

Figure: Post-layout transient simulation

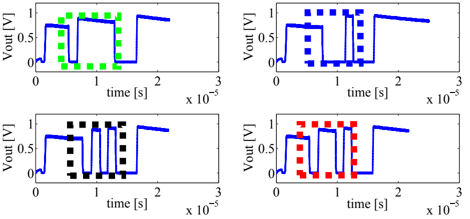


Table of contents

Tag Layout and Sample

Tag technology

1. GF180nm (Minimum length is 180 nm).
2. Available area: 1.5 mm × 1.5 mm.

Figure: Tag Layout

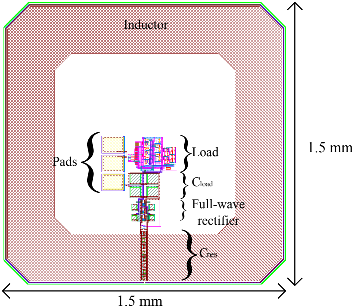
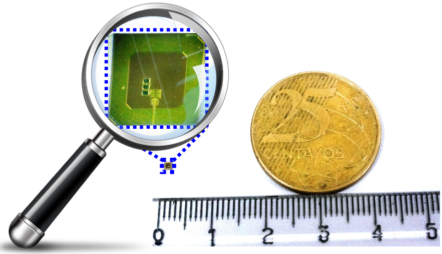


Figure: Die Dimensions.



Seal Ring post-layout process

Figure: Schematic diagram

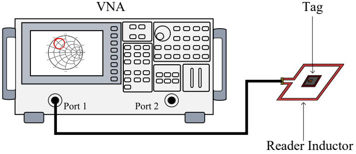
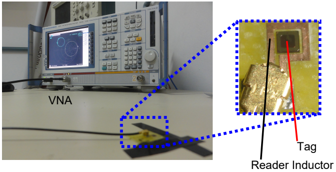
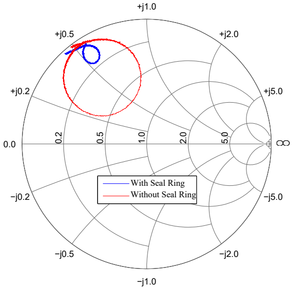


Figure: Experimental setup.



- 40 samples.
- Break the seal ring (scribe line remainder).
- Methodology in [4] to extract Q factor.
- Mean Q factor obtained: 19.13

Figure: S11 results.



Frequency Response

Figure: Schematic diagram

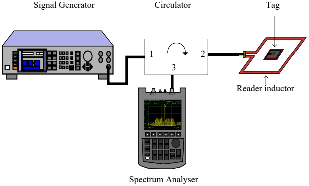


Figure: Experimental setup.

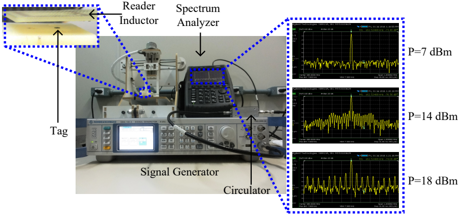
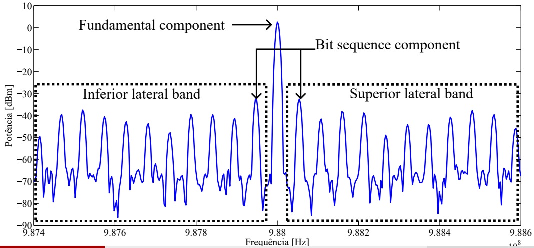


Figure: Frequency response



Data acquisition and processing

Figure: Experimental setup with SDR platform.

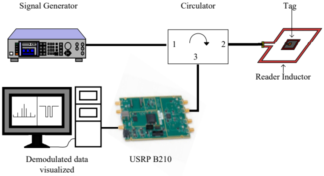


Figure: Data acquisition, amplification and recovery.

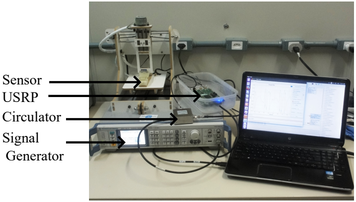
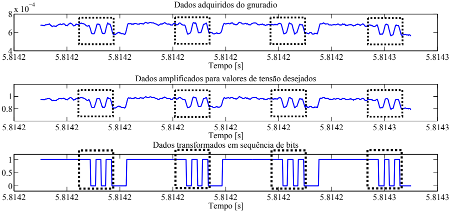


Figure: Data acquisition, amplification and convertion to digital bit sequences.



Characteristics of the tag

Table: Tag and system characteristics

Characteristic	Desired Value
Load Bias Voltage	1 V
Simulated Static Power (@ $27°$ C)	1 μW
RF Signal Frequency	1.04 GHz
Backscattering Bit Signal Frequency	1 MHz
Simulated post-layout available power at the Tag input	-4 dBm
RF power delivered by the reader generator (0 mm)	12 dBm

Table of contents

Remarks and Conclusions

- A miniaturized on-chip antenna RFID sensor that operates at 1.04 GHz, powered via inductive link with an embedded ROM reading circuit for IoT applications was designed and tested.
- The sensor was fully developed in a 2.18 mm^2 area.
- The corresponding integration of the ROM-reading circuit and the inductor was attained and validated with simulations and experimental results.

Bibliography

- UNDESA-Population-Division, "World population prospects: The 2012 revision," UN DESA, Tech. Rep., 2013.
- E. Jovanov and A. Milenkovic, "Body area networks for ubiquitous healthcare applications: opportunities and challenges," *Journal of medical systems*, 2011.
- F. Cabrera and F. Sousa, "Extending the inductor operating frequency for optimally-coupled wireless power transfer systems," *International Microwave and Optical Conference*, 2015.
- ——, "Contactless characterization of a cmos integrated lc resonator for wireless power transferring," *Microwave and Wireless Components Letters, IEEE , vol.PP, no.99*.

Thank You!

Email:j.s.moya@posgrad.ufsc.br

Site: Link