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PlaCiTUS RTD 2010

FNSNF

Power Management and Communication for Remotely Powered Sensor Nodes

RFIC

EPFL

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Introduction

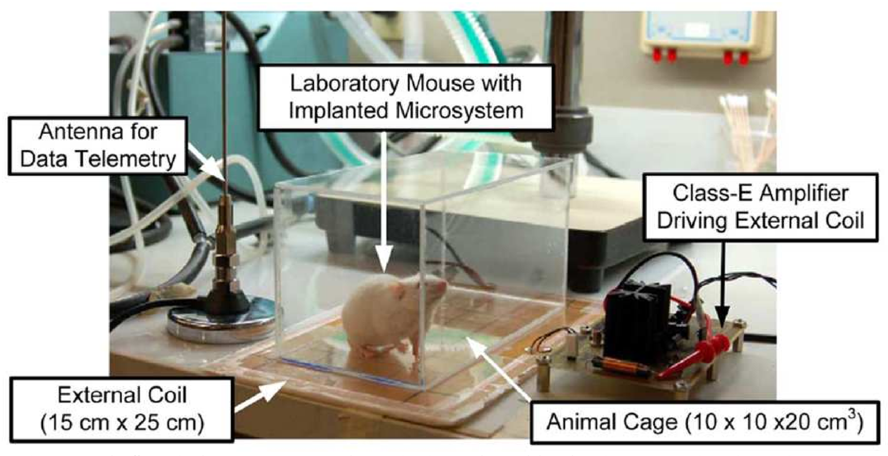
This research focuses on development of wirelessly powered integrated circuits (ICs). The circuits should be able to wirelessly communicate with the base station and read the data from various sensors or control different actuators.

The Main Challenges:

- *Implementing the internal circuits of the sensor node with low power consumption.*
- *Increasing the efficiency of wireless power transmission.*

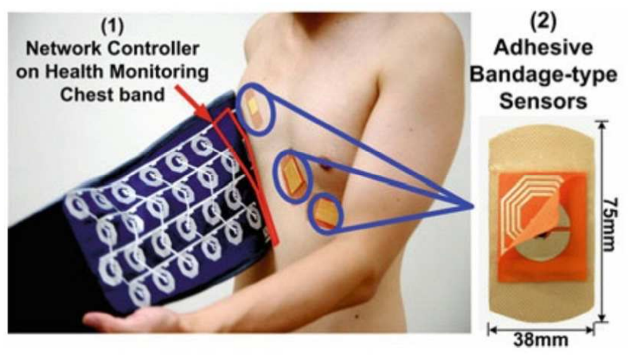
Example Applications

Blood Pressure Monitoring System



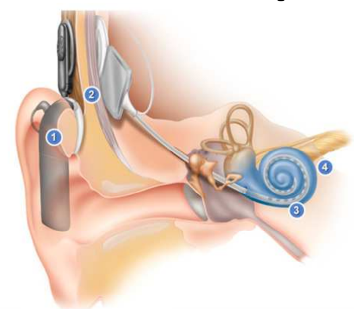
P. Cong et al., "A Wireless and Battery less 10-Bit Implantable Blood Pressure Sensing Microsystem With Adaptive RF Powering for Real-Time Laboratory Mice Monitoring," IEEE Journal of Solid State Circuits, Dec. 2009.

ECG Monitoring System



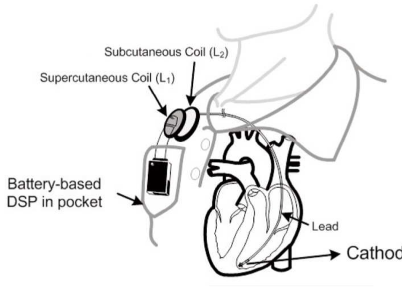
J. Yoo, et al., "A 5.2 mW Self-Configured Wearable Body Sensor Network Controller and a 12 µW Wirelessly Powered Sensor for a Continuous Health Monitoring System," IEEE Journal of Solid-State Circuits, Jan 2010.

Cochlear Implants



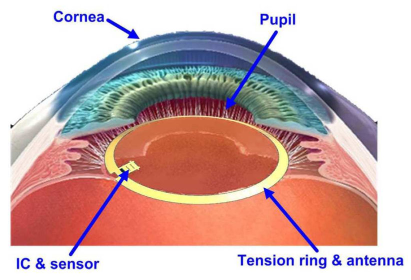
cochlearamericas.com

Cardiac Pacemaker



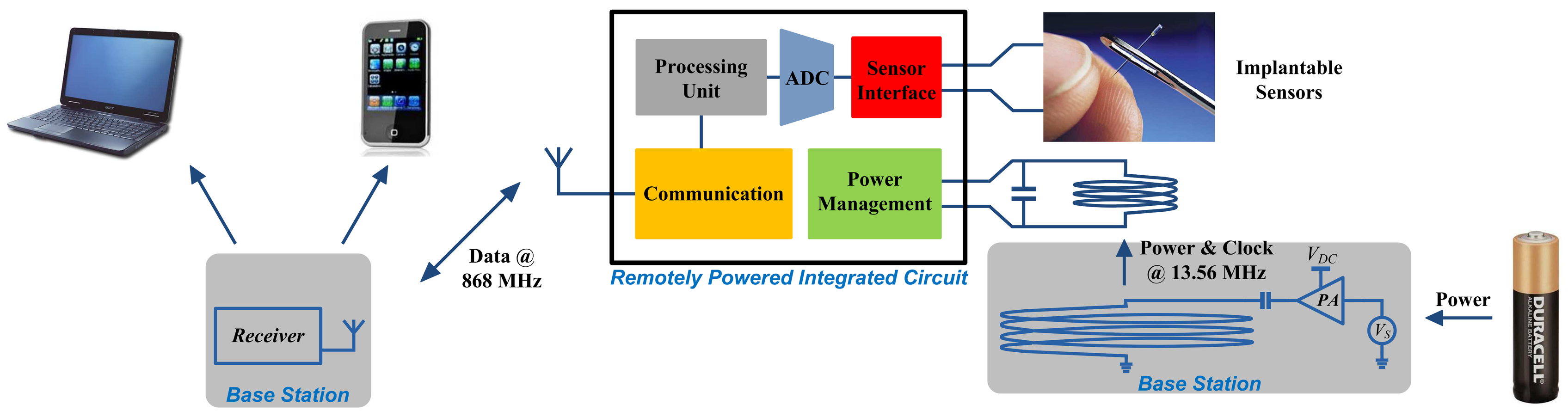
S.Lee, et al., "A Programmable Implantable Micro-Stimulator SoC with Wireless Telemetry: Application in Closed-Loop Endocardial Stimulation for Cardiac Pacemaker," in ISSCC Digest of Technical Papers, Feb. 2011, pp 44-45.

Intraocular Pressure & Temperature Monitor



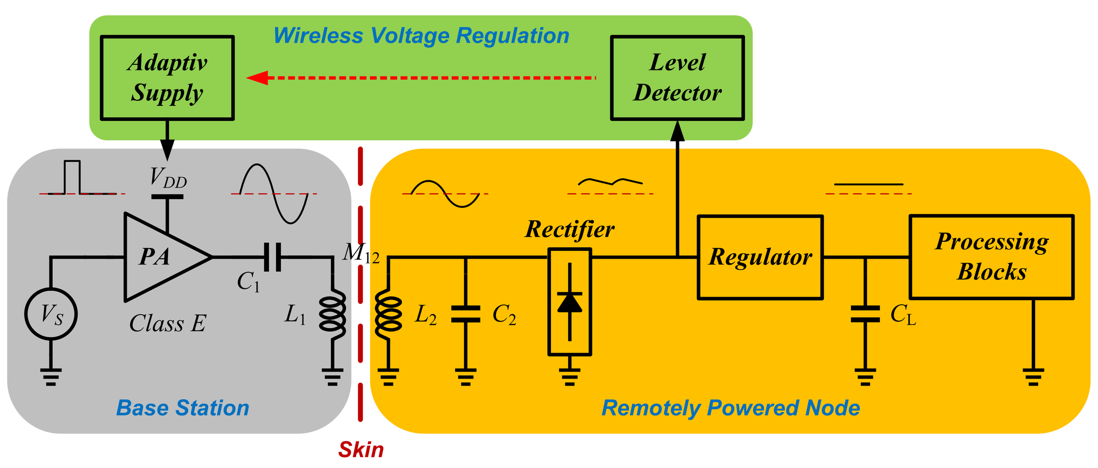
Y. C. Shih, T. Shen, and B. P. Otis, "A 2.3 uW wireless intraocular pressure/temperature monitor," IEEE Journal of Solid State Circuits, vol. 46, no. 11, pp. 2592-2601, Nov. 2011.

System Building Blocks



Remote Powering

Main Blocks for Wireless Power Transfer:



Total Link Efficiency: $\eta_T = \eta_{PA} \times \eta_{Coupling} \times \eta_{Rectifier} \times \eta_{Regulator}$

Functions of Different Blocks:

PA is converting the DC power from the battery to AC power for coupling.

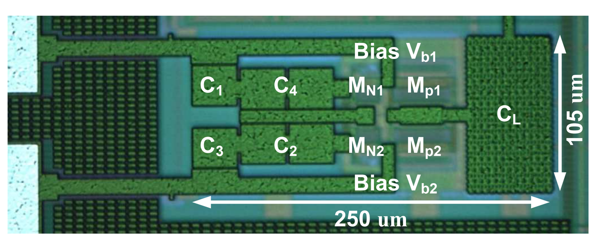
L1 & L2 are coupling energy from base station to remotely powered side.

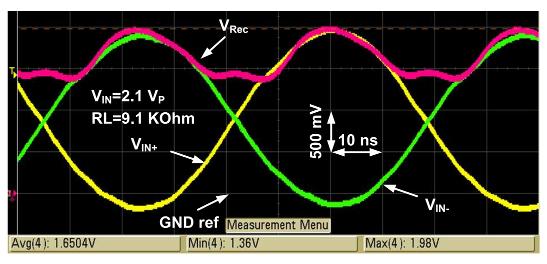
Rectifier is converting coupled AC voltage to DC voltage.

Regulator is stabilizing the voltage for processing blocks.

Wireless Voltage Regulation can be used to compensate the variation of the coupling between the inductors.

Performance of the Fabricated Rectifier:

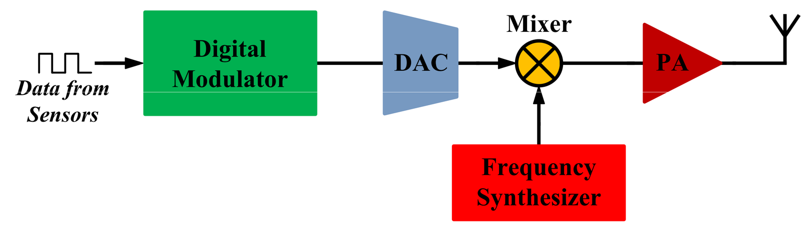




Rectifier Performance	
Technology	0.18 um
Frequency	13.56 MHz
Output Power	300 uW
Output Voltage	1.65 V
Peak Input Voltage	2.1 V
PCE (Simulated)	85 %

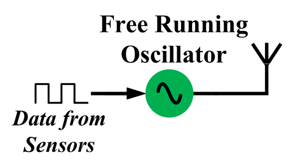
Low Power Communication

Standard Transmitter:



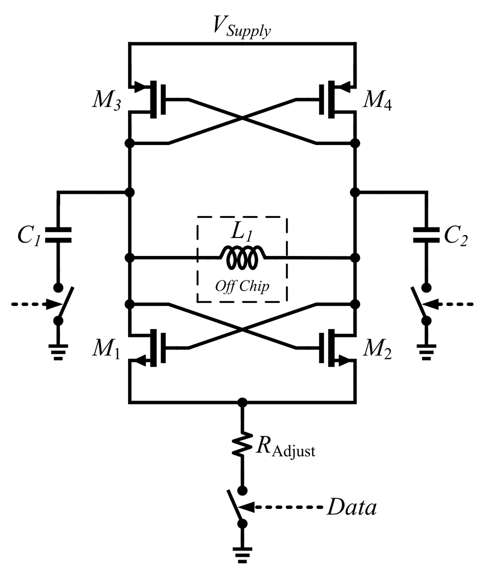
Standards transmitters are sutiable for high data rates and require power hungry blocks like frequency synthesizers and power amplifiers.

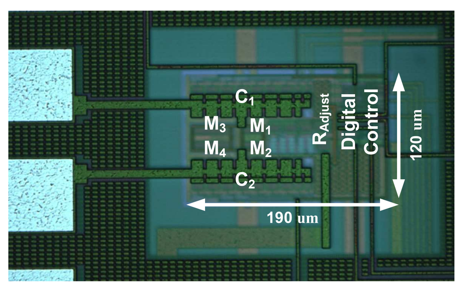
Low Power Transmitter:



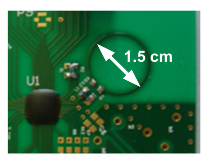
Low data rate of biomedical signals and short communication range make it possible to use low precision transmitter by directly modulating the free running oscillator.

Performance of the Fabricated Transmitter:



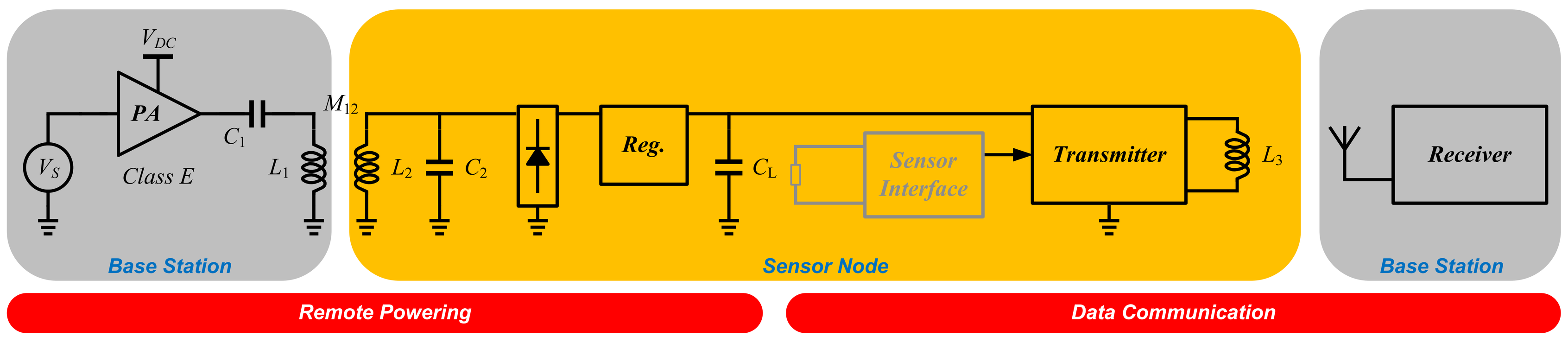


External Inductor as Transmitter Antenna

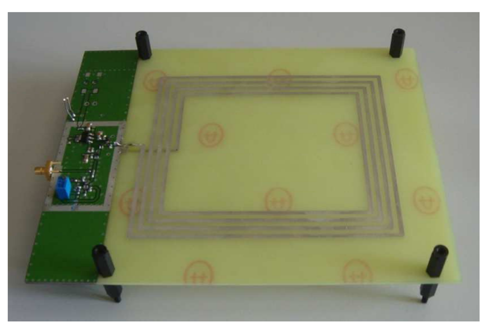


Oscillator Performance	
Technology	0.18 um
External Inductor	27 nH
Frequency	700 – 802 MHz (5 Bit)
Supply Voltage	1 V
Supply Current	65 – 176 uA (4 Bit)

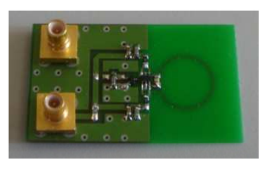
Demonstration of the Concept



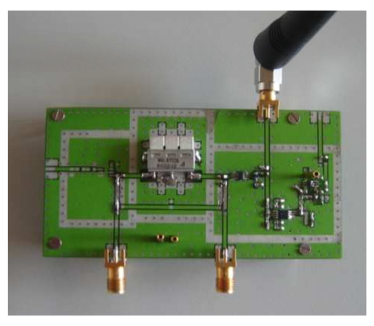
Performance of Different Blocks:



Class E PA	
Operation Frequency	13.56 MHz
Power Consumption	370 mW

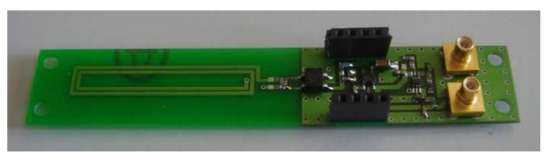


Data Transmitter	
Operation Frequency	868 MHz
Power Consumption	840 uW
Data Rate	12 Kbps



Data Receiver	
Operation Frequency	868 MHz
Data Rate	12 Kbps
Sensitivity	-85 dBm
Power Consumption	152 mW

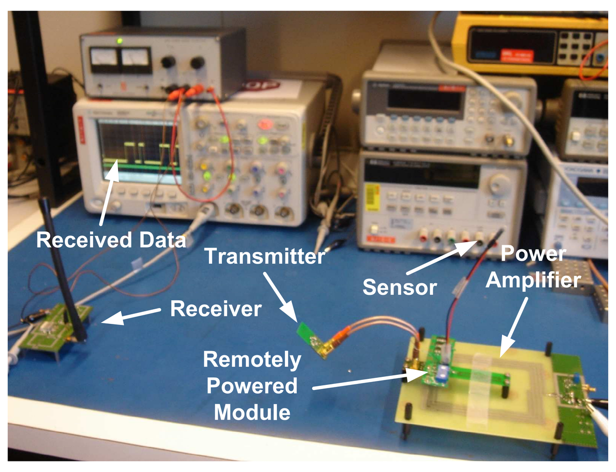
Data Link Operation Distance	40 cm



Rectifier & Clock generation	
Rectified Voltage	4 V
Regulated Voltage	3 & 1.8 V
Clock Frequency	192 KHz

Power Link Operation Distance	1.5 cm
Link Efficiency: PA+ Coupling+Rectifier	4.3 %

System Setup:



Expected Contributions

This research aims to improve the already existing platforms with:

- *Intelligent usage of the harvested power by modifying the system level design.*
- *Extending the system operation to multiple implants.*