Interface Circuits for Wirelessly Powered Bio-Medical Sensor Node

Xiao LIU and Catherine DEHOLLLAIN
École polytechnique fédérale de Lausanne (EPFL) - RFIC, 1015 Lausanne

The Main Objective:
To develop wirelessly powered integrated circuit in nano-scaled CMOS technologies which acquires data from various types of sensors. The circuit should also wirelessly communicate with the base station.

Applications:
- Sensors monitoring vital signals in humans such as ECG, blood pressure and body temperature.
- Implantable sensors in animals in order to study their physiology or behavior.
- Sensors monitoring environment such as pollution and temperature.
- Security applications like cameras, microphone and gas sensors.

Example Applications:

Application:
Currently, the project is focusing on a temperature monitoring application for mouse. The main aim of the system is to monitor the temperature change inside a particular body tissue inside a mouse which exhibits normal activity. Attaching cables or replacing batteries would lead to inflammation, which can influence the temperature. Therefore, it is necessary to develop a wireless powered sensor node.

Sensor Interface:
For medical implants, the sensor interface converts the various physiological signals into digital codes for further processing. For example, the bandwidth and magnitude of bio-electric signals are shown on the right, which are in the order of uV to mV and the frequencies span from DC to a few kHz. The sensor interfaces are composed by the pre-filter/amplifier, analog-digital convertor (ADC) and calibration circuits if necessary.

Considering for different medical applications, the sensor node must be compatible with a variety of sensors, each of which corresponds to particular specifications. As a result, design margins are left in critical parameters, such as the maximum sampling rate and the resolution. An ADC is used in this interface, because its power consumption is directly proportional to various sampling frequency.

The 100K6MC1 thermometer probe from Measurement Specialties Company is used as temperature sensor for its high sensitivity and relatively small volume.

A four-wire measurement topology is used [5], where a multiplexer switches the input signal between the sensor output and reference voltage. The input could also be set to short-circuit to measure the offset voltage of interface circuits.

The sensor is connected to reference resistance $R_{ref}$, which is chosen as 48kΩ, to generate voltage signal and suppress sensor non-linearity. In order to reduce the power-consumption, voltage between $V_{ref1}$ and $V_{ref2}$ equals to 900mV, which leads to 5.4uW power at 24°C. A pre-amplifier is used to match the signal to ADC dynamic range.

Analog-Digital Convertor:

A 10bit SAR ADC is used to convert the signal into digital codes which is transferred through communication blocks. In order to suppress comparator noises, binary-coded compensation is used. And the ADC structure is optimized to adapt the compensation method with minimum DAC sizes, and provides redundant capacitances which could be used to compensate DAC non-linearity due to parasitics. The ADC consumes 15uW power at 100KHz sampling rate. Simulation results shows 9.2bits ENOB.

Publication: