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Cmos Rf Transceiver For Wireless Sensor Networks In Medical Field

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Abstract:

Wireless sensor network cost reduction has become a critical necessity for expanding their use in fields where a large number of sensors are needed. For analog sensors, the traditional method of using multichannel analog-to-digital converters and/or analog multiplexers would not result in a price reduction. Furthermore, the analog multiplexer adds to the measurement error. The developed advanced, stable, yet cost-effective sensor nodes architectures are described in detail in this paper and are suitable for further integration in a node on chip. These sensor nodes can operate with a wide range of analog and quasi-digital sensors and transducers, and their sensing subsystem allows for the best metrological results. A comprehensive comparative study of sensor node's architectures and sensing sub-systems are presented.

Keywords: Wireless Sensor Network, Low power RF, CMOS, Healthcare monitoring; medical information systems.

1. INTRODUCTION :

"Wireless sensor networks (WSN) field is a very active research topic with many applications in area monitoring, industrial monitoring, biomedical systems and agriculture. It is a group of small sensing nodes (sensors) that collect physical information from the surroundings and communicate wirelessly to send the collected data to a base station. WSN nodes can be powered internally using a battery attached to the node or wirelessly by harvesting the power of the transmitted RF signal as in passive WSN"[1]. Either way, the transceiver circuit of each node should be designed to meet the minimal power requirements.

The nodes that make up the network play a key role in wireless communication since wireless sensor networking is designed around low-power radios. The deployment of nodes can take many different physical forms, depending on the sensor application and the desired communication pattern. Deployment may also be a one-time event, with the installation and use of a sensor network taking place at different times. It can also be a continuous mechanism in which more nodes are added to the network over time. A single sensor node to multiple sensor nodes can be used in the application.

Background

"There is a long history of using sensors in medicine and public health" [2], [3]. Sensors, which are embedded in a variety of medical instruments for use in hospitals, clinics, and homes, provide insight into physiological and physical health states that are critical to the detection, diagnosis, treatment, and management of ailments. Many aspects of modern medicine would be impossible or prohibitively expensive without sensors such as thermometers and blood pressure monitors. Pressure monitors, glucose monitors, electrocardiography (ECG), photoplethysmography (PPG), electroencephalography (EEG), and various imaging sensors are all examples of medical devices. Interventional devices such as pacemakers and insulin pumps require the ability to calculate physiological condition.

Recent years have witnessed the emergence of various embedded computing platforms that integrate processing, storage, wireless networking, and sensors. These embedded computing platforms offer the ability to sense physical phenomena at temporal and spatial fidelities that were previously impractical. Embedded computing platforms used in healthcare range from smartphones to specialized wireless sensing platforms known as motes, which have much stricter resource constraints in terms of available computing power, memory, network bandwidth, and available energy.

Transceiver Design

WSNs are inherently low-power network with short range communication capability. Most of WSNs are very dense networks and hence low cost of its nodes is an important requirement. RF transceivers are the most power consuming and high cost part of a sensor node in WSNS. Consequently its low power and low cost requirements, demands new design strategies. Prior to define a design strategy it is necessary to define some parts of the networks communication protocol. Communication protocol and the radio link specifications insert limitations or offers freedoms on the transceiver characteristics. The most important characteristics of a receiver are :

- Dynamic range
- Sensitivity
- Linearity
- Noise figure
- Phase noise
- Working frequency and band width
- Channel selectivity
- Power consumption
- Spurious frequencies effect
- Leakage effects
- Image band rejection

The transceiver architecture and its configuration is selected or designed based on the specific application and the designer's experience. Among various specifications of the radio link,
modulation scheme greatly influence the transceiver architecture. Simple modulations make possible to use very simple transceiver architectures, in expense of lower data rate, lower signal quality and lower spectral efficiency. After selecting the transceiver architecture and configuration, the required circuits and sub-blocks will be presented and finally the performance of the transceiver will be analyzed and optimized.

Heterodyne Architecture

. Heterodyne architecture has been used in more than 98% of radio frequency applications until 1995. Block diagram of heterodyne receiver has been shown in Fig. 1. Image-reject filter is placed after LNA and attenuates the image signal in the mixer input. Image signal has at fIF distance from the local oscillator frequency, in counter side of the massage signal. Today this architecture is widely used in optical and electro-optical systems, astronomy and space science , high frequency imaging and accurate and standard frequency measurement and spectral analysis, medical analysis and in mm-wave wireless communications. This architecture has been noticed in modern CMOS technologies for WSN applications.

The image signal problem is the bottleneck of heterodyne receiver, in sense of fully integrated design. Special techniques have been proposed this problem. Image signal will be described in the next section. In general the image signal power can be even very higher than the massage signal. So image rejection is the most problem of heterodyne receiver in radio communication applications. Choosing higher IF frequency eases the image rejection, however the IF signal processing and adjacent channel rejection will be more difficult. New architecture has been proposed for heterodyne receiver and claimed that the new architecture has many advantages over direct-conversion receivers and relaxes the performance of the receiver building blocks and eases the overall system floor planning.

Heterodyne receiver can be designed as single or double IF stage. In classic heterodyne receiver channel selection is done by the RF local oscillator and hence the IF filter bandwidth is equal to the channel band width. In some other types the IF filter is wide and covers all the receiver operation band and channel selection is done in IF band. This configuration, named Wide IF heterodyne, has the benefit of more accurate channel selection, in expense of increased noise band width of the receiver. Main advantages of heterodyne receiver are :

- High selectivity (good channel selecting in communication application and high spectral resolution in spectroscopy and spectral measurements)
- High sensitivity
- High dynamic range (AGC1 easily be added to the IF amplifier)
- Less sensitive to DC offset of the mixer, spurious frequencies, high frequency leakages and even-order inter-modulation terms
- Less sensitivity to flicker noise

Main drawbacks of heterodyne architectures are :

- Image reject filter problem in fully integrated design. In many applications, this filter should be implemented using SAW filters or other technologies that can not be integrated in bulk CMOS technology.
- Inherently complicated (needs two VCO and some mixers)
- High DC power consumption
- IF filter problem in fully integrated design
- The LNA must drive 50Ω load (the off-chip image reject filter) and this adds to the power dissipation, gain and noise problems.

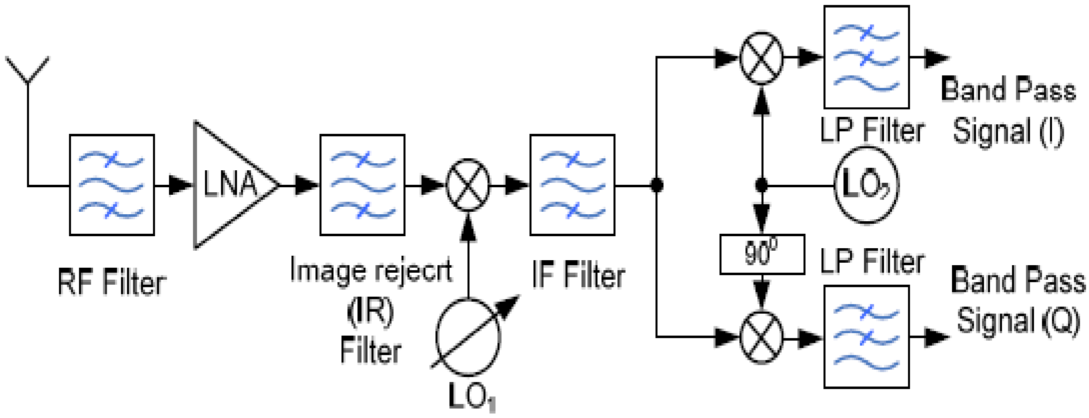

Fig. 1: Block Diagram of Heterodyne Architecture

CMOS Sensors in Medical Applications

- **Biometric personal identification**

Biometric personal identification is strongly related to security and it refers to "identifying an individual based on his or her distinguishing physiological and/or behavioral characteristics (biometric identifiers)". Usually, conventional image sensors with external hardware or software image processing are used. The difficulty for on-chip integration is caused by the complexity of the required image processing algorithms. However, there are some developments that successfully achieve the required goals by parallel processing utilization. To give some more detailed examples in the field, we concentrate on fingerprint sensors. Generally these sensors can be classified by the physical phenomena used for sensing: optical, capacitance, pressure and temperature. The first two classes are the most popular and both mainly employ CMOS technology.

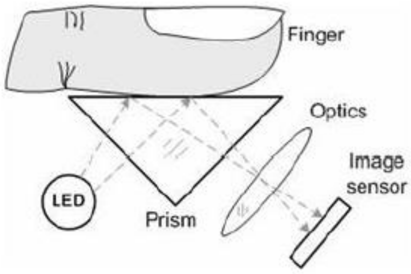

Fig. 2: Reflection Based Sensor

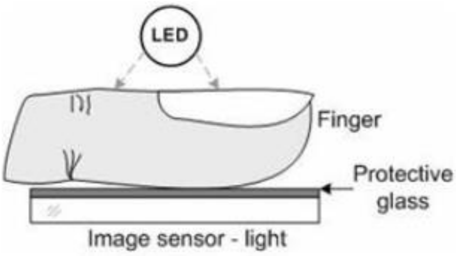

Fig. 3: Transmission Based Sensor

- **Wireless Capsule Endoscopy**

  Conventional medical instrumentation for gastrointestinal tract observation and surgery uses an endoscope that is externally penetrated. These systems are well developed and provide a good solution for inter-body observation and surgery. However, the small intestine (bowel) was almost not reachable using this conventional equipment, leaving it for observation only through surgery through inconvenient and sometimes painful push endoscopy procedures. Few years ago the sphere was revolutionized by the invention of the wireless image sensor capsule, which after swallowing, constantly transmits a video signal during its travel inside the body. The capsule movement is insured by the natural peristalsis. According to Gavriel Iddan , the founder of Given Imaging that commercializes this technology, “The design of the video capsule was made possible by progress in the performance of three technologies: complementary metal oxide silicon (CMOS) image sensors, application-specific integrated circuit (ASIC) devices, and white-light emitting diode (LED) illumination”.

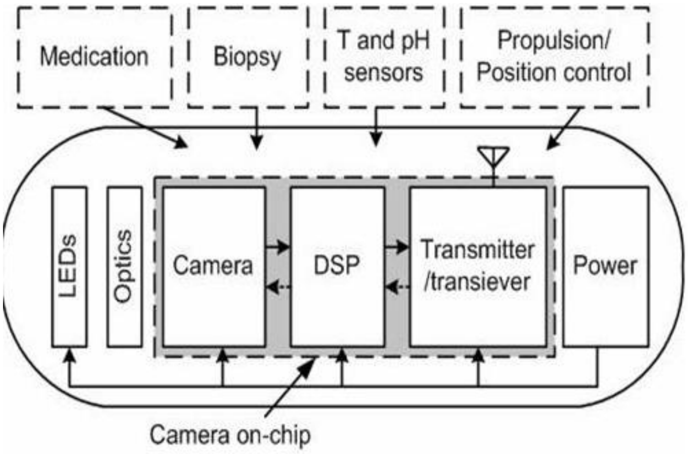

Fig. 4: The swallow capsule architecture

- **Artificial Retina**

  Artificial vision is another example of CMOS image sensors implementation in medical applications. Today millions of people are suffering from full or partial blindness that was caused by various retinal deceases. In the early eighties it was shown that electrical stimulation of the retinal nerves can simulate visual sensation even in the patients with fully degraded receptors. Recently, researchers in a number of research institutes have developed miniature devices that can be implanted into the eye and stimulate the remaining retinal neural cells, returning partial vision ability for the blind patients. Such implants are called artificial retinas. Usually they are implanted in the macula area that normally is densely populated by the receptors and enables high-resolution vision. This break-through was enabled by the progress in electronics, surgical instrumentation, and biocompatible materials.

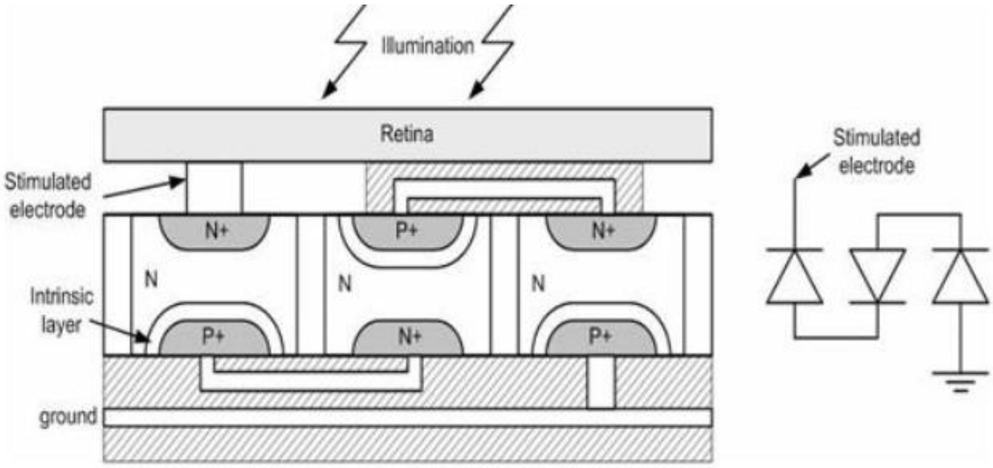

Fig. 5: Basic Architecture of Silicon Retina

2. CONCLUSION

In this paper, we discussed about the WSN and RF Transceiver. The motivation for research and development in CMOS was presented. A general architecture of a CMOS imager was shown. An approach for CMOS sensors in various applications at different design levels was presented. Although we couldn't provide more detailed explanations on existing low-power design techniques due to the limited space available, we hope we have succeeded in presenting general concepts that can be useful to beginners in the area of image sensors design.

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