Asian Journal of Applied Science and Technology (AJAST)
(Peer Reviewed Quarterly International Journal) Volume 2, Issue 4, Pages 84-89, Oct-Dec 2018

Review on Noise-Power-Area Optimized Biosensing Front End for Wireless Body Sensor Nodes and Medical Implantable Devices

J.M.Arunthathi[1], Mr.R.Prabhakar[2]

[1]PG Scholar, Department of ECE, Vivekanandha college of Engineering for Women, Namakkal, India.
[2]Assistant Professor, Department of ECE, Vivekanandha college of Engineering for Women, Namakkal, India.

Article Received: 25 May 2018 *Article Accepted: 27 September 2018* *Article Published: 06 October 2018*

ABSTRACT

In this paper, we tend to gift a noise, power, and space economical biosensing front-end application fixed microcircuit (ASIC) for the next-generation wireless body detector nodes and implantable devices. We tend to establish the key style parameter tradeoffs within the medical specialty recording systems and do an intensive analysis and optimization to maximize them. Supported our analysis and optimization of the forepart, we tend to propose a style methodology for the recording channel that's applicable to varied medical specialty applications. The ASIC is enforced during a 0.18-µm CMOS method to validate our optimization methodology. The ASIC is reconfigurable to accommodate numerous biopotentials with the high-pass and low-pass cutoff frequencies being 0.5–300 cycle and a hundred and fifty Hz–10 kilocycle per second, severally. The low pass cutoff is provided by associate ultralow power Gm-C low-pass filter that additionally acts as associate technique filter for the switching optimized 10-b sequential approximation register (SAR) analog-to-digital convertor (ADC). The analog forepart (AFE) gain is additionally programmable from thirty eight to seventy two dB. A comprehensive power management unit provides the facility provide multiple reference voltages, and bias currents to the whole chip. The AFE and ADC dissipate solely 5.74 µW and 306 NW from the on-chip regulators, severally. The measured input-referred noise is 2.98 µVrms, leading to the noise potency issue and power potency issue equals 2.6 and 9.46, severally. The active space of the AFE is 0.0228 mm2. We tend to verify the chip practicality during a variety of in vivo and ex vivo biological experiments.

1. INTRODUCTION

Recent advances in Wireless Body Device Nodes (WBSNs) and implantable System-On-Chips (SoCs) enable an enormous paradigm shift in personalised care and effective treatment of assorted sicknesses like neural disorders, cardiac diseases, glaucoma, and polygenic disorder. These nodes utilize the ultralow power CMOS computer circuit design techniques to accumulate and method biopotential signals in a Wireless Body Space Network (WBAN) and transmit the info to the secure mobile devices in real time. The design of a typical device node in an exceedingly WBAN comprising a biosensing analog face (AFE), Associate in Nursing Analog-to Digital Converter (ADC), a digital signal process core, a power management unit (PMU), and a wireless mensuration section. The biopotential signals square measure captured from either implanted or surface electrodes via a biosensing AFE, which is one amongst the foremost vital circuit blocks within the WBSNs and implantable SoCs. Fig:1 shows a pair of illustrates all the planning tradeoffs (i.e., noise, power, area, linearity, Common-Mode Rejection Ratio (CMRR), Power Supply Rejection-Ratio (PSRR), offset rejection, and input impedance) for a biosensing AFE. Thus, an intensive analysis and design improvement of the AFE blocks is important to capture the elaborated data allotted by the biopotential signals. With the ensuing analysis and optimization, the most style challenges of the AFE square measure thanks to the following.

1) System style Constraints of the device Nodes: This includes Associate in nursing optimum range of amplification stages, power consumption, filter specifications, linearity, CMRR, and PSRR. In recent studies, the applying of wireless power transfer in WBSNs demands a really low peak power consumption of the whole SoC. A transformer (linear or switch capacitor) is usually employed as a region of PMU to mitigate the availability voltage fluctuations as a result of unreliable and unpredictable nature of the harvested energy. However, a finite quantity of ripple continues to be gift within the provide voltage thanks to the lack of a bypass off-chip capacitance. Moreover, the post amplification signal process within the digital domain injects switch noise into the AFE that seems as a common-mode provide and substrate noise. The interference from 50/60-Hz power lines additionally appear as a common-mode noise. Therefore, the AFE must have a high PSRR and CMRR, whereas limiting its power consumption to but 10 μW.

2) The character of Biopotential Signals: These signals square measure characterized as a low-frequency and low-amplitude signals. The amplitude of such signals varies from tens of micro volts to a number of millivolts and their frequency spectrum spans from sub-1 cycle per second to a number of kc. To ensure a clean signal acquisition, the AFE electronic equipment must have a sufficiently low Input-Referred Noise (IRN) per unit information measure. Since the low frequencies square measure of interest, the sparkle or 1/f noise of MOS transistors is a direct concern. So as to accommodate the higher finish of the amplitude vary, a spare dynamic vary of the electronic equipment is also needed.

3) Reconfigurable AFE: In future, the device nodes in an exceedingly WBAN can capture the varied biopotential signals, with totally different amplitudes and bandwidths, at the same time from the various elements of a personality's body. Consequently, a single AFE with reconfigurable parameters settings, like gain, bandwidth, bias current, and sampling rate, is very fascinating. Also, the dependence of peak signal amplitude on the sort of conductor used and interface setting necessitates a reconfigurable gain stage. The electronic equipment dimensionally at terribly low bias current is another vital style parameter for the ultralow power AFE.

4) Device Interface between the AFE and Electrodes: The electrode–tissue interface creates a dc offset voltage (up to 200–300 mV), that should be filtered out by the AFE so as to avoid the saturation of the first-stage amplifier. Also, so as to scale back the sensitivity to conductor electrical phenomenon imbalance, the AFE ought to present a really high input electrical phenomenon to the preceding electrodes.

5) Chip Area: It should be as tiny as doable for the body worn and implantable devices. It's popularly known that the 1/f noise of the MOS transistors is inversely proportional to the occupied space that makes it very difficult to satisfy the realm and noise specifications at the same time. In order to handle the above-named challenges, we gift a completely integrated AFE for the WBSNs and implantable SoCs, that follows a style methodology improvement to meet the wants expose by a number of style parameters. The remainder of this paper describes the performance analysis of the recording electronic equipment channel and prior work. The chip mensuration results and biological knowledge from the in vivo animal and ex vivo human studies square measure are given.

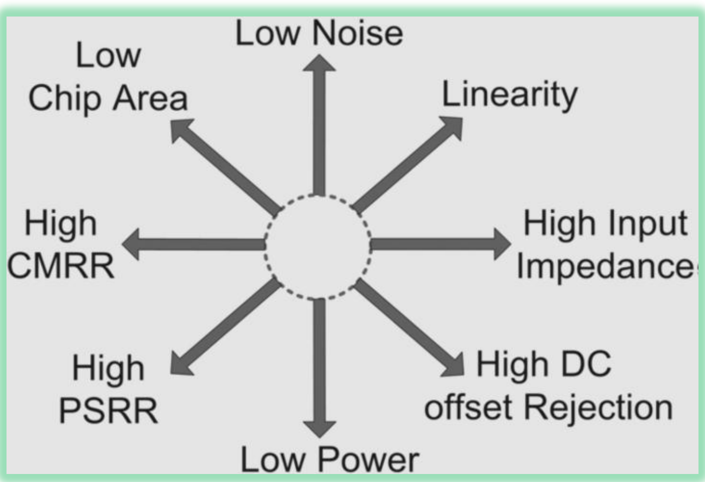

Fig: 1 Design parameter tradeoffs in a biosensing AFE

II. SURVEY ON METHODOLOGIES USED

1. RFID Technology

Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically-stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source (such as a battery) and may operate hundreds of meters from the RFID reader. Unlike a barcode, the tag need not be within the line of sight of the reader, so it may be embedded in the tracked object. RFID is one method for Automatic Identification and Data Capture (AIDC).

RFID tags are used in many industries, for example, an RFID tag attached to an automobile during production can be used to track its progress through the assembly line; RFID-tagged pharmaceuticals can be tracked through warehouses; and implanting RFID microchips in livestock and pets allows for positive identification of animals.

Since RFID tags can be attached to cash, clothing, and possessions, or implanted in animals and people, the possibility of reading personally-linked information without consent has raised serious privacy concerns. These concerns resulted in standard specifications development addressing privacy and security issues. ISO/IEC 18000 and ISO/IEC 29167 use on-chip cryptography methods for intractability, tag and reader authentication, and over-the-air privacy. ISO/IEC 20248 specifies a digital signature data structure for RFID and barcodes providing data, source and read method authenticity. This work is done within ISO/IEC JTC 1/SC 31 Automatic identification and data capture techniques. Tags can also be used in shops to expedite checkout, and to prevent theft by customers and employees.

2. Capacitive Feedback Chopper Stabilized Instrumental Amplifier

The instrumentation amplifier (IA) is one of the crucial blocks in an electrocardiogram recording system. It is the first block in the analog front-end chain that processes the ECG signal from the human body and thus it defines some of the most important specifications of the ECG system like the noise and common mode rejection ratio (CMRR). The extremely low ECG signal bandwidth also makes it difficult to achieve a fully ECG recording integrated system. In this thesis, a fully integrated IA topology is presented that achieves low noise levels and low power dissipation. The chopper stabilized technique is implemented together with an AC coupled amplifier to reduce the effect of flicker noise while eliminating the effect of the differential electrode offset (DEO). An ultralow power operational transconductance amplifier (OTA) is the only active power consuming block in the IA and so overall low power consumption is achieved. A new implementation of a large resistor using the T-network is presented which makes it easy to achieve a fully integrated solution. The proposed IA operates on a 2V supply and consumes a total iv current of 1.4µA while achieving an integrated noise of 1.2µVrms within the bandwidth. The proposed IA will relax the power and noise requirements of the analog-to-digital converter (ADC) that immediately follows it in the signal chain and thus reduce the cost and increase the lifetime of the recording device.

3. TDMA Protocol

Time-Division Multiple Access (TDMA) is a channel access method for shared-medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using its own time slot. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity. TDMA is used in the digital 2G cellular systems such as Global System for Mobile Communications (GSM), IS-136, Personal Digital Cellular (PDC) and in the Digital Enhanced Cordless Telecommunications (DECT) standard for portable phones. It is also used extensively in satellite systems, combat-net radio systems, and passive optical network (PON) networks for upstream traffic from premises to the operator.

TDMA is a type of time-division multiplexing (TDM), with the special point that instead of having one transmitter connected to one receiver, there are multiple transmitters. In the case of the *uplink* from a mobile phone to a base station this becomes particularly difficult because the mobile phone can move around and vary the *timing advance* required to make its transmission match the gap in transmission from its peers.

4. Magnetic Resonant Coupling Method

From the beginning of inductive power transmission, resonant circuits are used to enhance the inductive power transmission. Already Nicola Tesla used resonances in his first experiments about inductive power transmission more than hundred years ago. Especially for systems with a low coupling factor, a resonant receiver can improve the power transfer. Resonant power transmission is a special, but widely used method of inductive power transmission and is limited by the same constraints of magnetic fields emissions and efficiency. To understand the effect, it can be compared to mechanical resonances. Consider a string tuned to a certain tone as mechanical resonator. Even a far away and low level sound generator can excite the string to vibration, if the tone pitch is matched. Here, the resonator in the receiver consists of the receiver inductance and a capacitor. Also the transmitter can have a resonator. The transmitter and receiver coils LTx and LRx can be considered as weakly coupled transformer. For this, an equivalent circuit diagram consisting of magnetizing and stray inductance can be derived. Now, the only remaining limit for the power transmission is the winding resistances of the coils, which impedance is one or two orders of magnitude lower than that of the inductances.

5. Neural Probe Technologies

NeuroNexus **neural probes** are fabricated using state-of-the-art micro fabrication and packaging technologies, and are designed to minimize tissue damage for superior signal quality. Each probe's mechanical, geometric, and electrical characteristics are precise and highly reproducible for consistent, high-quality results.

We offer a diverse line of high quality, high-density microelectrode arrays for neural interfaces. Because so many options are available, you may wish to learn more about configuring probes for an order by studying our Configuration Guide.

6. Packaging Technique

In electronics manufacturing, integrated circuit packaging is the final stage of semiconductor device fabrication, in which the tiny block of semiconducting material is encapsulated in a supporting case that prevents physical damage and corrosion. The case, known as a "package", supports the electrical contacts which connect the device to a circuit board. In the integrated circuit industry, the process is often referred to as packaging. Other names include semiconductor device assembly, assembly, encapsulation or sealing. The packaging stage is followed by testing of the integrated circuit. The term is sometimes confused with electronic packaging, which is the mounting and interconnecting of integrated circuits (and other components) onto printed-circuit boards.

7. Microsystem Integration

MEMS devices open up new possibilities for miniaturized system solutions. The Fraunhofer IPMS offers appropriate development services to help their customers creating innovative products. The system design with the use of MEMS, optics and other photonic components and the assembly techniques for systems with the smallest volumes presuppose each other. Hence, the Fraunhofer IPMS has the required know-how and the equipment necessary for micro assembly and offers the fabrication of small series as a service.

8. Digital Signal Processing (DSP) module

A digital signal processor (DSP) is a specialized microprocessor, with its architecture optimized for the operational needs of digital signal processing. The goal of digital DSP signal processors is usually to measure, filter or compress continuous real-world analog signals. Most general-purpose microprocessors can also execute digital signal processing algorithms successfully, but dedicated DSPs usually have better power efficiency thus they are more suitable in portable devices such as mobile phones because of power consumption constraints. DSPs often use special memory architectures that are able to fetch multiple data or instructions at the same time.

PERFORMANCE COMPARISONWITH CAPACITIVELY COUPLED BIOSENSING FRONT ENDS

Types of methods used	Supply Voltage (V)	Sensing Modality	Gain	High-Pass Cutoff (Hz)	Low-Pass Cutoff (Hz)	CMOS Technology	Active Area
Existing	**1.4**	**Multiple**	**32-72 dB**	**0.5-300**	**150-10K**	**0.18μm**	**0.0228mm^2**
Wireless Prosthesis Control	1.8	EMG	43-58 dB	0.65-3	1K	0.18μm	N/A
Active Electrodes	1.8	Neural	30-4000 V/V	0.5/200/300/500	200/6000	0.18μm	N/A
Neural Recording Amplifier	1.8	Neural	39.4 dB	10	7.2K	0.18μm	0.25mm^2
Wireless Biosignal Interface	1.2	Multiple	43-80 dB	0-1.5K	N/A	0.13μm	N/A
Digital	1	Neural	45-65 dB	10-1K	3K-8K	65nm	0.0258mm^2

Compression							
Lossless Data Compressor	2.4	ECG	47-66 dB	0.0075	35-175	0.35µm	N/A

III. CONCLUSION

Next-generation battery-less WBSNs and implantable devices in a WBAN require a reconfigurable AFE that can be used in multiple biosensing applications. In this paper, we proposed a design and optimization methodology for the capacitively coupled AFE, based on the mathematical analysis of a number of design parameter tradeoffs. Each individual block of the AFE is analyzed separately and then optimized in the system to maximize these design tradeoffs. The design methodology of our reconfigurable AFE is verified by implementing a chip in a 0.18-μm CMOS process that also includes a 10-b SAR ADC, a PMU, and a clock oscillator. Finally, the chip functionality is verified in a number of *invivo* rodent and *ex vivo* human biological experiments**.**

REFERENCES

1. P. Harpe, H. Gao, R. van Dommele, E. Cantatore, and A. H. M. van Roermund, “A 0.20 mm^2 3 nW signal acquisitionic for miniature sensor nodes in 65 nm CMOS,” IEEE J. Solid-State Circuits, vol. 51, no. 1, pp. 240–248, Jan. 2016.

2. H. Bhamraet al., “A 24 µW, battery less, crystal-free, multinode synchronized SoC ‘bionode’ for wireless prosthesis control,” IEEE J. Solid-State Circuits, vol. 50, no. 11, pp. 2714–2727, Nov. 2015.

3. Y.-J. Kim, H. S. Bhamra, J. Joseph, and P. P. Irazoqui, “An ultralow-power RF energy-harvesting transceiver for multiple-node sensor application,” IEEE Trans. Circuits Syst. II, Exp. Briefs, vol. 62, no. 11, pp. 1028–1032, Nov. 2015.

4. Y.-P. Chen et al., “An injectable 64 nW ECG mixed-signal SoC in 65 nm for arrhythmia monitoring,” IEEE J. Solid-State Circuits, vol. 50, no. 1,pp. 375–390, Jan. 2015.

5. C. J. Deepuet al., “An ECG-on-chip with 535 nW/channel integrated lossless data compressor for wireless sensors,” IEEE J. Solid-State Circuits, vol. 49, no. 11, pp. 2435–2448, Nov. 2014.

6. L. Xia, J. Cheng, N. E. Glover, and P. Chiang, “0.56 V, –20 dBm RF-powered, multi-node wireless body area network system-on-a-chip with harvesting-efficiency tracking loop,” IEEE J. Solid-State Circuits, vol. 49, no. 6, pp. 1345–1355, Jun. 2014.

7. K. E. Koh, T. C. Beh, T. Imura, and Y. Hori, "Impedance matching and power division using impedance inverter for wireless power transfer via magnetic resonant coupling," Industry Applications, IEEE Transactions on, vol. 50, pp. 2061-2070, 2014.

8. H. Kim et al., “A configurable and low-power mixed signal SoC for portable ECG monitoring applications,” IEEE Trans. Biomed. Circuits Syst., vol. 8, no. 2, pp. 257–267, Apr. 2014.

9. C. M. Lopez et al, “An implantable 455-active electrode 52-channel CMOS neural probe,” IEEE J. Solid-State Circuits, vol. 49, no. 1, pp. 248–261, Jan. 2014.

10. G. E. Perlin and K. D. Wise, “An ultra-compact integrated front end for wireless neural recording microsystems,” J. Micro electro mech. Syst., vol. 19, no. 6, pp. 1409–1421, Dec. 2010.