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Development of the Application Specific ROIC for SpO_2 Signal Acquisition in Wearable Devices

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Summary:

This paper presents the design of the ASCEPLIUS1 - low-power ASIC developed for photoplethysmographic (PPG) signal acquisition in wearable SpO_2 monitoring systems. The work focuses on system requirements, architecture definition and implementation of a dedicated analog front-end for photodiode signals by dedicated IC module. The proposed ASIC implements a dedicated analog circuit integrating signal conditioning functions close to the optical sensor, supporting near-sensor processing while reducing system complexity, power consumption and the number of external components. The particular attention is given to low-power operation, signal integrity, dynamic range and compatibility with external data-conversion and processing circuitry. The fabricated ASIC is intended for integration within a wearable SpO_2 project demonstrator.

Key words: IC's / ASIC Design. ROIC, SpO_2 Signal Acquisition, Wearables

1. MOTIVATION AND DESCRIPTION OF WORK

The rapid development of wearable health-monitoring devices creates a growing demand for customer-oriented compact, energy-efficient and highly integrated solutions for continuous physiological parameter monitoring. Oxygen saturation (SpO_2) is one of vital parameters that may be derived from photoplethysmography (PPG) method in wearable applications. Conventional implementations often rely on multiple discrete components for photodetector signal conditioning, amplification and analog-to-digital conversion. Such architectures increase system complexity, power consumption and physical dimensions, which are critical constraints for battery-powered wearable applications. Dedicated application-specific integrated circuits (ASICs) offer an attractive approach by integrating the sensor interface and signal-conditioning functions into a compact and energy-efficient solution.

This paper presents the development of ASCEPLIUS1, the low-power ASIC developed by Lukasiewicz-IMiF for SpO_2 parameter extraction in wearable health-monitoring applications. The device was developed within the H2TRAIN European project (*Enabling digital technologies for Holistic Health-lifestyle motivational and assisTed supeRvision supported by Artificial Intelligence Networks*) [1] with the objective of implementing a dedicated analog front-end readout module optimized for photoplethysmography (PPG). The developed IC chip integrates analog front-end blocks necessary for reflective PPG signal processing.

The ASCEPLIUS1 IC includes two configurable drivers for LED emitters (LD1-3), transimpedance amplifier (TIA) for PPG signal forming and amplification along with ambient light cancellation (ALC) block for DC signal cancellation. Digital control unit (DCU) is used for chip configuration with SPI-compatible interface. This chip also includes integrated low dropout regulator (LDO) with 1.2V core voltage enabling the single supply voltage operation. ASCEPLUS1 is equipped also with integrated

oscillator (OSC) for internal clocking, with additional possibility to provide external clock source with CLKE pin.

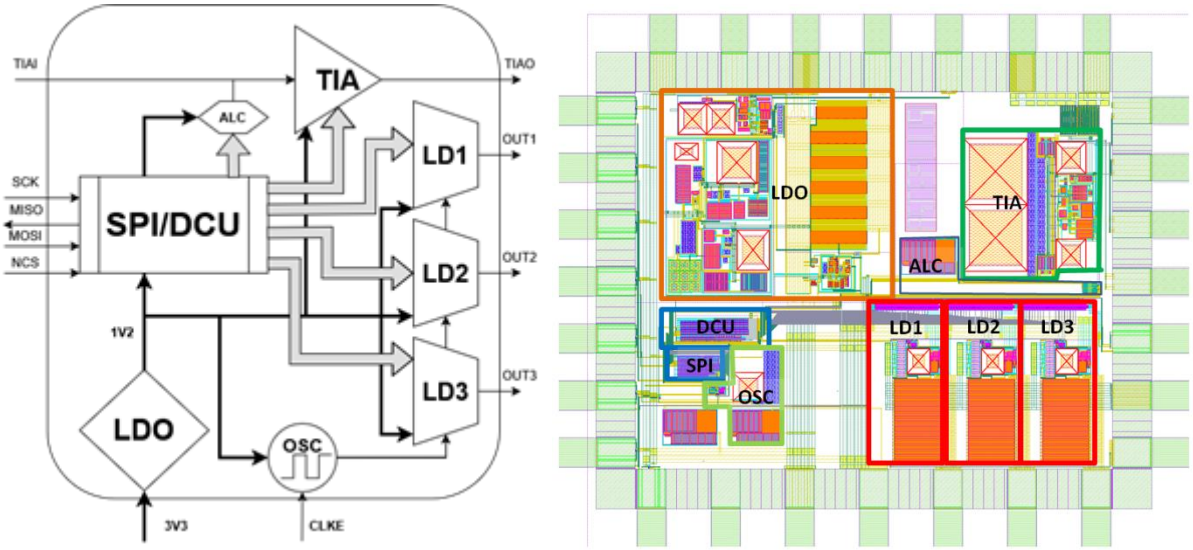

Fig. 1. ASCEPLIUS1 idea diagram (left) and 1.2 x 1.0 mm layout

The designed ASCEPLIUS1 circuit is fabricated using one of 65 nm CMOS processes made available by Europractice MPW service. The custom PCB testbench is developed with chip-on-board (COB) assembled ASCEPLIUS1 for chip testing purposes. Initial electrical verification of the fabricated devices is used to assess the operation of the designed functional blocks and to validate the main design assumptions. The current stage with the primary focus on the design methodology, system requirements and implementation of the ASIC architecture will be presented in this paper.

2. SUMMARY

The presented ASIC demonstrates the feasibility of implementing a dedicated ultra-low-power signal-acquisition interface for wearable SpO_2 monitoring. The proposed architecture provides a basis for further integration of sensing, analog signal conditioning and processing functions closer to the sensor, supporting the development of compact and energy-efficient next-generation wearable health-monitoring devices.

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3. REFERENCES

[1] https://www.h2train-project.eu/