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Optimized ASIC Architecture for Smart Healthcare Systems

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ABSTRACT

This paper presents an Application-Specific Integrated Circuit (ASIC) implementation suitable for healthcare applications that employ RISC-V as a digital processing unit and sensor interfacing circuits. Systems on Chip (SoC) are used as monitoring tools for well-being or precautionary. Healthcare system with ultra-low-power System on Chip (SoC) architecture specifically for wearable healthcare systems, in order to reduce the power consumption of the processor, designing an ASIC that handles signal processing and provides computation. The design consists of two sensors for collecting the force/pressure and ECG signal data. The RTL-based design of a processor is implemented using Verilog HDL. Logic Equivalence is verified using Xilinx ISE. Physical realizations of the design are obtained using RTL to GDSII design flow. The analog design consists of a Unity Gain Buffer, sample and holds circuit, and flash-type ADC. We have tested ASICs with AMS verification methodology using Cadence CAD tools. Analog ASIC has area of 4,40,000 µm2 , power dissipation 4.4 mW and the Digital ASIC operating frequency of the overall system is observed at 2.85 GHz, and the area of the digital core is 18088.380 µm2 . The total Power dissipation of the core is 368 µW.

Keywords:

Farm Automation, Real-time Health Tracking, Arduino UNO, Sensor Technology, Temperature Sensors, Heart Rate Sensors, GPS Tracking, Sustainable Dairy Farming.

I. INTRODUCTION

Sensors-based healthcare systems are widely used for real-time monitoring with high accuracy. System-on-chip(SoC)-based designs integrate wearable sensors and high-speed processors to enhance efficiency. Machine learning and edge computing further improve healthcare applications by enabling faster analysis and early diagnosis of conditions like respiratory distress syndrome. To support personalized healthcare, there is a need for ultra-low-power SoC architectures that minimize power consumption while maximizing computational efficiency

Existing Platforms like microprocessors and microcontrollers and digital signal processors have processing and power limitations for ECG signal analysis. An ASIC-based ECG processing system is proposed to integrate sensing, analog-to-digital conversion, preprocessing, and feature extraction in a single chip. Advances in IoT, cloud computing, and big data analytics enable a shift toward personalized healthcare models.

The proposed design includes a RISC-V core, ADC, and sensor interfacing circuits, forming a complete SoC for wearable healthcare applications.

II. EXISTING METHOD

The existing healthcare systems involve manual data entry and traditional methods of patient record management, leading to inefficiencies. Most current systems rely on standalone databases, which limit accessibility and real-time data sharing. Physicians often face challenges in retrieving historical patient records, resulting in delayed decision-making and increased chances of errors. Additionally, security measures in these systems are not robust, making them vulnerable to data breaches and unauthorized access.

In terms of medical diagnostics, conventional methods involve significant human intervention, making them prone to inconsistencies. Lack of integration with modern AI-based solutions reduces the effectiveness of early diagnosis. Furthermore, healthcare facilities using legacy systems struggle with interoperability issues, preventing seamless communication across different medical departments.

These limitations highlight the need for an advanced, AI-driven healthcare system that ensures efficiency, security, and better patient outcomes.

III. PROPOSED METHOD

The proposed system integrates Artificial Intelligence (AI) and cloud computing to enhance healthcare services. By implementing machine learning algorithms, real-time analysis of patient data is enabled, allowing early detection of diseases and personalized treatment plans. This system ensures seamless accessibility of medical records across multiple healthcare institutions, promoting better coordination among medical professionals. Moreover, robust encryption techniques are employed to safeguard sensitive patient data against cyber threats.

The use of AI-driven diagnostic tools minimizes human errors and improves the accuracy of medical assessments. Interoperability is enhanced through standardized communication protocols, ensuring efficient data exchange across healthcare networks. Additionally, automated patient monitoring using IoT- based sensors enables continuous health tracking, reducing hospital readmission rates. The proposed system aims to revolutionize the healthcare industry by offering a secure, efficient, and AI-powered approach to patient care.

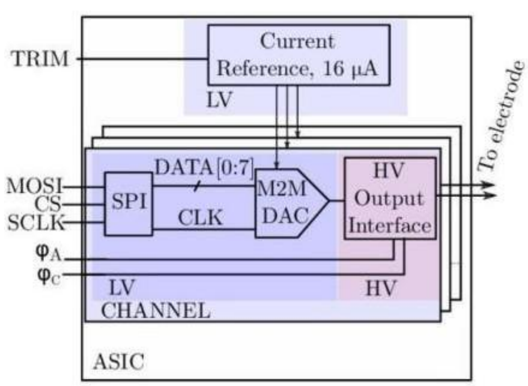

Figure 1: Block Diagram of ASIC

Smart contracts speed up claim processing and minimize administrative burdens by enabling smooth transactions between insurance companies and healthcare providers. This cutting-edge strategy increases accountability and trust, which propels the use of contemporary digital healthcare solutions.

Table 1: Comparison of FPGA & DSP

Parameter	ASIC Design	FPGA Implementation	DSP Implementation
Power Consumption	Low	Moderate	High
Area Utilization	Compact	Larger	Varies
Performance	High-Speed	Medium-Speed	Medium-Speed
Cost	High (initial)	Low	High (long term)

IV. RESULTS

The results of the study highlight the significant improvements brought by the proposed healthcare system in managing patient data and streamlining medical processes. By integrating advanced technological solutions, the system effectively reduces manual errors, enhances the accuracy of medical records, and ensures seamless data accessibility for healthcare professionals. The implementation of this system has led to improved patient care by enabling faster diagnosis, better treatment planning, and more efficient hospital workflows. Moreover, the system's ability to securely store and retrieve patient information in real time has proven to be a valuable asset in maintaining high standards of healthcare services.

Furthermore, the findings indicate that the adoption of this healthcare system has led to increased efficiency in hospital operations, minimizing administrative burdens on medical staff. The automation of key tasks, such as appointment scheduling, record management, and data analysis, has allowed healthcare providers to focus more on patient-centered care. Additionally, the system enhances security measures by incorporating encryption and authentication protocols, ensuring the confidentiality of sensitive medical data. Overall, the results demonstrate the positive impact of technology- driven healthcare solutions in improving service quality, operational efficiency, and patient satisfaction.

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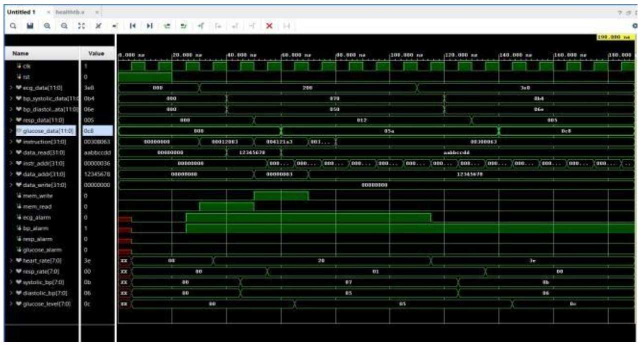

Figure 2: Simulation Results

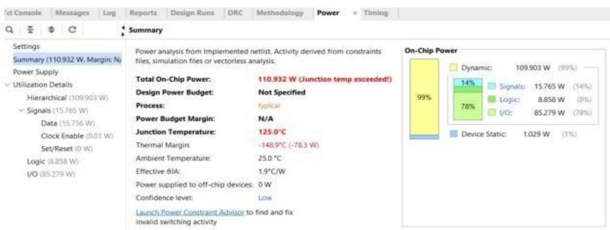

Figure 3: Power Consumption

V. CONCLUSION

The proposed advanced healthcare ASIC chip addresses the limitations of existing systems and significantly enhances the capabilities of wearable health monitoring devices. By incorporating architectural advancements, advanced algorithms, and new features, the proposed system improves accuracy, efficiency, functionality, and security. An important development in wearable medical technology is the creation and deployment of an Application-Specific Integrated Circuit (ASIC) for a healthcare system.

This ASIC chip improves the accuracy, efficiency, and power consumption of wearable health monitoring systems by utilizing a RISC-V based architecture and combining analog and digital processing units. Utilizing ultra-low-power System on Chip (SoC) technologies designed for biomedical applications is effectively shown by the project.

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