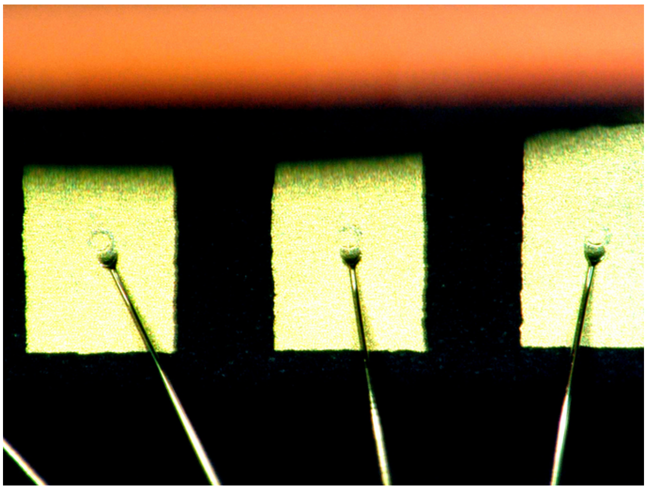
Area-Energy Efficient Analog Front-End Architecture for Multi-Channel Neural Recording System

TECHNOLOGY NUMBER: 6743



OVERVIEW

Modular 128-channel AFE with spectrum equalization for large-scale neural recording

- Reduces area and energy consumption using spectrum equalization and Δ-modulation
- Utilized in neuroscience research, brain-machine interfaces, and neural prosthetics

BACKGROUND

The advancements in neural recording have surged significantly, paralleled to Moore's Law, yet the demand for higher channel counts persists to thoroughly explore neuronal activity. Historically, multi-electrode arrays enabled large-scale monitoring, integrated either monolithically or hybridly, but often faced tethering, bulkiness, and thermal constraints due to high energy consumption. While recent innovations raise channel numbers, energy and area efficiency remain problematic, limiting simultaneous recordings of over a thousand neurons. In small animal brains, where neuron numbers can far exceed a few hundred, the complexity of inter-neuronal connectivity demands more sophisticated and extensive capabilities. Existing systems achieve hundreds of channels with significant power usage, presenting a gap for a scalable, less power-intensive solution to achieve comprehensive neural insight, critical for both basic neuroscience and clinical applications like prosthetics or brain-machine interfaces.

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Category
Hardware
Engineering & Physical Sciences
Semiconductor, MEMS, and Electronics

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INNOVATION

Researchers at the University of Michigan have developed a 128-channel analog front-end (AFE) architecture utilizing spectrum equalization in conjunction with Δ-modulation, optimized for extensive neural recording. The modularity ensures scalability to over 1024 channels. By exploiting the inherent low-frequency dominance in neural signals, the design reduces dynamic range requirements, consequently lowering power consumption without losing signal fidelity. This compact and energy-efficient approach achieves an energy-area product of 6.34 $fJ/C \cdot s \cdot mm^2$ while maintaining over 10-bit resolution and sub-μW energy usage per channel. Real-world applications include high-density neural signal acquisitions for neuroscience, enabling advanced brain-machine interfacing, and development of neural prosthetics. This system aligns with evolving demands to decipher complex neural networks through expansive channel capacity while maintaining small physical and thermal footprints, thereby facilitating long-term, minimally invasive monitoring.

ADDITIONAL INFORMATION

REFERENCES

S. -Y. Park, J. Cho, K. Na and E. Yoon, "Modular 128-Channel Δ - ΔΣ Analog Front-End Architecture Using Spectrum Equalization Scheme for 1024-Channel 3-D Neural Recording Microsystems," in IEEE Journal of Solid-State Circuits, vol. 53, no. 2, pp. 501-514, Feb. 2018, doi: 10.1109/JSSC.2017.2764053

INTELLECTUAL PROPERTY

US10321835 "Biological recording device and method for recording biological electrical activity"