A 4.78 mm 2 Fully-Integrated Neuromodulation SoC Combining 64 Acquisition Channels With Digital Compression and Simultaneous Dual Stimulation

2019年12月26日

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Compared to the state of the art, this represents the lowest area and power for the highest integration complexity achieved to date.

To provide viable treatment options for patients, a BMI must achieve long-term actionpotentials recordings from a large population of neurons (thousands) in multiple regions of the brain.

However, standard rack mount electronics and large cables typically used for experimentation prohibit this scaling. Furthermore, a

wired interface through the skull introduces a persistent infection risk for patients, and space constraints prohibit significant

energy storage beneath the skull.

Consequently, next generation neural interfaces must be powered and communicate wirelessly, with the ability to scale to thousands of channels.

This requires a System-on-Chip (SoC) solution capable of closed loop BMI, which achieves significant improvements in area, power and signal compression over current state of the art.

The system architecture, subdivided into the primary circuit functions:Amplification, Stimuation, Digital Compression and Power Train.

屏幕剪辑的捕获时间: 2019/12/27 19:56

The low system power and area,and high level of integration,are achieved using a highly optimized recording channel, adiabatic charge recycling stimulator, novel spike detection algorithm, and configurable compression back end.

The LNA utilizes MIM capacitors for AC-coupling and feed back, which enables placement of the capacitors over the active circuits in order to minimize die area.

This area efficiency enables a substantial increase in number of recording channels per chip, as well as integration of on-chip compression and stimulation. Note that this design consumes 2.3 the area of our previous open loop design[13],which is the smallest neural recording channel reported to date. However, that design required per channel gain calibration that weconsidered unsuitable for deployment in complex systems with hundreds to thousands of channels.

屏幕剪辑的捕获时间: 2019/12/27 21:02

Compressionblockdiagramandthepowerconsumption,datarates,and compression ratio for different output modes.

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Spike detection block diagram showing programmable delay, NEO, and moving average filter

In a BMI system, neural stimulation is used to provide feedback to the patient. Charge is deposited onto an electrode until the resulting electric field becomes strong enough to trigger a response from neighboring neurons.

屏幕剪辑的捕获时间: 2019/12/27 21:33

The in vivo neuromodulation test system is composed of a microwire implanted array, a compact headstage containing the SoC, a base tation, and a GUI.