Abstract

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Development of a multichannel CMOS integrated circuit for recording neuronal activity and its application in functional brain research

Multi-electrode recording of neural signals is a crucial experimental method in modern neuroscience research and the development of electronic nervous system prostheses. One of the intensively developed research directions is brain research. Using integrated circuits, it is possible to record brain activity with the resolution of single neurons simultaneously from hundreds of cells. Amplifiers of neural signals based on CMOS technology allow the construction of compact systems with hundreds of recording channels.

This study aimed to develop a preamplifier belonging to a reading path dedicated to a neuronal probe that enables the recording of brain signals. In particular, an in-depth analysis of the nonlinearity of the input coupling circuit was presented, along with a novel pseudo-resistor linearization method present in this circuit. Finally, the design of a prototype integrated circuit *HiFiNeuroPre* developed with SOI-CMOS 180 nm technology is presented, in which all critical requirements for this type of electronic circuit are addressed.

The thesis shows that the highest distortion occurs for signal frequencies near the lower cutoff frequency. In contrast, for designs described in the literature, the harmonic distortion is usually reported for the frequency of 1 kHz, which is very far from the lower cutoff frequency of 1 Hz used in field potential measurements. Based on the data available in the literature, it seems that the problem of harmonic distortion in the low-frequency range is widely ignored.

The developed circuit was optimized for the relevant parameters, i.e. noise and power consumption. Tests of the prototype circuit confirmed, the proposed solution's effectiveness and reduced nonlinear distortion significantly to less than 1% over the full frequency range from 0,1 kHz to 10 kHz, and for signals with amplitudes up to 10 mV_{pp}. Based on the developed chip and a multi-electrode probe recording system was built and successfully applied in a pilot neuroscience experiment.

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