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Shashank Dwivedi, Anup K. Gogoi

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A Novel Adaptive Real-Time Detection Algorithm for an Area-Efficient CMOS Spike Detector Circuit

Shashank Dwivedi[a], Anup K. Gogoi[a]

[a]*Indian Institute of Technology Guwahati, Guwahati, India*

Abstract

For implantable neural detection and recording systems, computationally simple methods are preferred over complex algorithms for power efficiency. Amplitude threshold is the simplest and the most widely employed method for neural spike detection. However, this conventional method for setting the threshold is sensitive to the spike firing rate and spike amplitude. In this work, a novel approach is described for a real-time calculation of the detection threshold in a way that is robust to the change in spike firing rate as well as spike amplitude. An algorithm is proposed that adaptively sets the threshold from background activity by approximating the nonlinear energy operator (NEO). The detection method can distinguish neural spikes accurately with firing rate greater than 100 Hz. The spike detector circuit dissipates 5.1 μW of power per channel and occupies 0.018 mm^2 of layout area when implemented in 0.18 μm CMOS process.

Keywords: Spike detection, nonlinear energy operator, action potential, threshold selection

1. Introduction

Brain-machine interface (BMI) enables communication between the human brain and a machine (e.g., computers) with an ultimate goal of restoring full motor function for people suffering from conditions such as spinal cord injuries or loss of limbs. One of the most important part of brain-machine interface is the development of fully implantable microelectrode arrays (MEAs) for monitoring extracellular neural activities. Nordhausen [1] used high-density microelectrode array featuring a sensing area of 4 × 4 mm^2 that can record up to 100 extracellular neural signals simultaneously. Action potentials (AP), or spikes,

Email address: d.shashank@iitg.ernet.in (Shashank Dwivedi)