A High Dynamic-Range Sensing Front-End For Neural Signal Recording Systems

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INVENTORS

- Markovic, Dejan

OTHER INFORMATION

KEYWORDS

Chopper amplifier, closed loop, front-end, low noise, low power, neuromodulation, closed-loop neuromodulation, neural signal recording, dynamic range, common-mode artifacts, differential-mode artifacts, neural stimulation therapy, drug-resistant neurological conditions, epileptic seizures, neuroprosthetics, brain-machine interfaces, neurological investigative tool

CATEGORIZED AS

- **Biotechnology**
  - Other
- **Engineering**
  - Engineering
  - Other
- **Medical**
  - Devices
  - Other
  - Research Tools
  - Therapeutics
- **Sensors & Instrumentation**
  - Biosensors
  - Medical

SUMMARY

UCLA researchers in the Department of Electrical Engineering have invented a novel neural recording chopper amplifier for neuromodulation systems that can simultaneously record and stimulate.

BACKGROUND

Closed-loop neuromodulation with simultaneous stimulation and sensing is needed to administer therapy in patients suffering from drug-resistant neurological ailments. However, stimulation generates large artifacts at the recording sites, which saturate traditional front-ends with common-mode (CM) artifacts around 500 mV and differential-mode (DM) artifacts between 50 mV – 100 mV. Although power and noise limitations have been improved in prior work, these methods still suffer from low Z_{in} and limited input signal range, making them incapable of performing true closed-loop operation.

INNOVATION

Researchers led by Professor Dejan Markovic have developed an innovative front-end technology that enables implantable neuromodulation systems to record and stimulate simultaneously. This neural recording chopper amplifier can tolerate 80 mV_{pp} DM and 650 mV_{pp} CM artifacts in a signal band of 1 Hz – 5 kHz, with a dynamic range of 74 dB in the spike band and 81 dB in the LFP band. This implantable system overcomes the limitations of wall-plugged systems, such as limited duration of recordings (hours vs. weeks), risk of infection (does not require an open wound), and patient discomfort. Moreover, this system will enable neuroscientists to probe and investigate the brain in ways that current technologies do not support.

APPLICATIONS

- Closed-loop neuromodulation
- Neural stimulation therapy for drug-resistant neurological conditions
- Diagnosis/treatment of neurological disorders, such as epileptic seizures
- Neuroprosthetic technologies to aid in paralyzed patients
- Brain-machine interfaces
- Neurological investigative tool

ADVANTAGES

- Tolerates 650 mV_{pp} CM and 80 mV_{pp} DM artifacts
- Fabricated in 40 nm CMOS technology
- Significantly improves Z_{in} (5.3x) and the linear input range (2x)
- Increases the maximum resistance of duty-cycled resistors (32x)
- Does not require off-chip caps
- Achieves comparable power and noise performance

STATE OF DEVELOPMENT

Prototype chopper amplifiers have been fabricated in 40 nm CMOS technology with an area of 0.069 mm^2/ch, using a total power of 2.8 µW from a 1.2 V core supply.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,025,215	06/01/2021	2017-229

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Scalable Parameterized VLSI Architecture for Compressive Sensing Sparse Approximation
- Autonomous Thermoelectric Energy-Harvesting Platform for Biomedical Sensors
- Electrode Agnostic, Supply Variant Stimulation Engine For Implantable Neural Stimulation
- A Simple, Area-Efficient Ripple-Rejection Technique for Chopped Bio-Signal Amplifiers
- Saturation-Tolerant Electrophysiological Recording Interface

RELATED CASES

2017-229-0

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