Autonomous Thermoelectric Energy-Harvesting Platform for Biomedical Sensors

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SUMMARY

UCLA researchers in the Department of Electrical Engineering have a developed miniature implantable thermoelectric energy-harvester with true energy autonomy.

BACKGROUND

The size of existing batteries presents a major limitation in the design of size-constrained wireless sensors, including wearable and implantable biosensors. A commonly sought-after solution to this limitation is to develop thermo-electric energy harvesters (TEH) that can function as autonomous energy sources for implantable and wearable sensing systems. However, TEH technologies have not previously achieved adequate energy density and conversion efficiency to enable their use as autonomous energy sources in such applications. Specifically, previous TEH technologies have been limited by the inefficiency of power management electronics, and by their inability to harvest energy in natural environments due to limited thermal gradient (<2K).

INNOVATION

Dr. Dejan Markovic and colleagues have developed a miniature implantable TEH that offers superior power density and form factor, which can eliminate the need for conventional batteries in size-constrained biosensor applications. The system features an integrated power-efficient start-up module, a fast, fully analog maximum power-point tracking controller, and a compact TEH source that can achieve true energy autonomy in real environments. The system measures < 1cm^3 in volume and weighs <3g, which makes it suitable for wearable biosensor applications, particularly in size-constrained settings. The harvesting platform has a 7.9X times improved regulated power density compared to the existing technologies.

APPLICATIONS

The technology may be leveraged and adapted for a variety of wearable and implantable sensors, including:

- Wearable & implantable brain-computer interfaces, including electro-encephalogram (EEG), electro-corticography (ECoG), and penetrating brain electrodes
- Skin temperature sensors
- Continuous blood glucose monitoring sensors
- Wearable heart monitors and electrocardiogram (ECG) sensors
- Electromyogram (EMG) sensors
- Wearable sensors for detecting chemical biomarkers in sweat
- Wearable activity monitors

ADVANTAGES

- Miniature design (0.83 cm^2) that meets the biophysical and anatomical constraints of small animal models such as rats
- True energy autonomy in a real environment
- Optimal power output with minimal source impedance

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INVENTORS

- Markovic, Dejan

OTHER INFORMATION

KEYWORDS

thermoelectric energy harvesting, neural recording, wearable computing, implantable medical devices, power management, low power electronic devices

CATEGORIZED AS

- **Energy**
  - Other
- **Medical**
  - Devices
  - Research Tools
  - Software
- **Sensors & Instrumentation**
  - Biosensors
  - Medical
- **Engineering**
  - Other

RELATED CASES

2015-245-0

- Start-up voltage as low as 65mV
- 68% peak end-to-end efficiency at 4K
- <20ms tracking time
- 7.9X improvement in regulated power density
- Low cost of fabrication

STATE OF DEVELOPMENT

The technology has been prototyped, tested, and performance-characterized, both in a laboratory test fixture and with in vivo rat tests. Preliminary studies have demonstrated 645μW regulated power output when implanted within the head of a rat (effective 3.5K).

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,355,192	07/16/2019	2015-245

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- Scalable Parameterized VLSI Architecture for Compressive Sensing Sparse Approximation
- 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
- Load Adaptive, Reconfigurable Active Rectifier for Multiple Input Multple Output (MIMO) Implant Power Management
- A High Dynamic-Range Sensing Front-End For Neural Signal Recording Systems
- A Distance-Immune Low-Power Inductively-Coupled Bidirectional Data Link

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