Low-power Data Acquisition for Wearable and Implantable Devices

REU fellow: Ralph Castro[1]
Faculty Mentor: Dr. N. Sertac Artan[2]
Affiliation: [1.] New York City College of Technology, [2.] School of Engineering and Computing Science, NYIT
Emails: ralphmcastror@gmail.com, nartan@nyit.edu

ABSTRACT

Wearable and implantable medical devices ranging from continuous glucose monitors to pacemakers are becoming increasingly vital and ubiquitous. Such devices continuously takes measurements, which consumes battery power. The power consumption is proportional to the amount of information collected and with the frequency of data collection. High power consumption leads to rapid discharging of battery limiting the usage of these devices. These signals are often transmitted over wireless technology for analysis, as well as to keep track of the user's record, which also significantly increases power consumption. In this project, we develop circuit techniques for data acquisition in these devices that reduces the amount of data collected, thus reducing power consumption without any significant change in accuracy.

BACKGROUND

Action Potentials:
- Excitable animal cells such as neurons and muscle cells communicate with other cells by means of rapidly changing electrical signals called action potentials. Action potentials in neurons are also called spikes. The generation patterns, frequency, and morphology of these action potentials vary from cell to cell and for the same cell according to cell's behavior or due to various diseases. Implantable devices have been developed for measuring these action potential parameters to diagnose, monitor, or treat various medical conditions such as spinal cord injuries, and in neuroscience for understanding various brain functions.
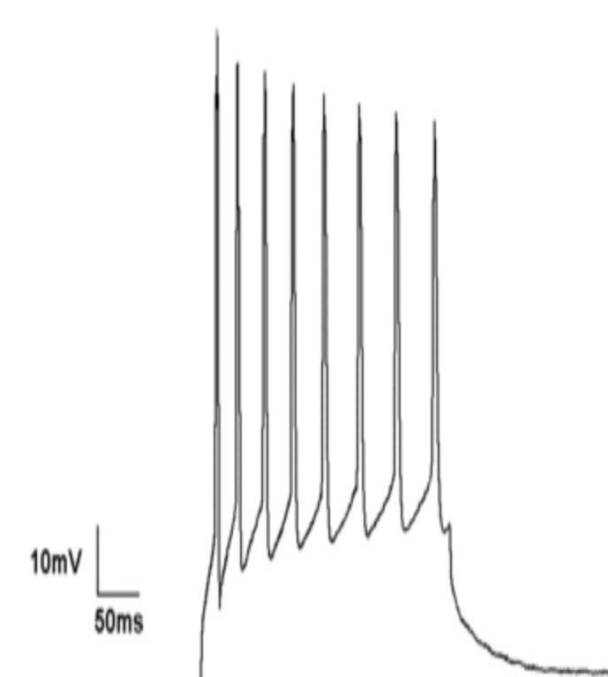
[1]

Data Acquisition:
- Process of sampling real-world signals and transform then into Digital form, for computer manipulation.
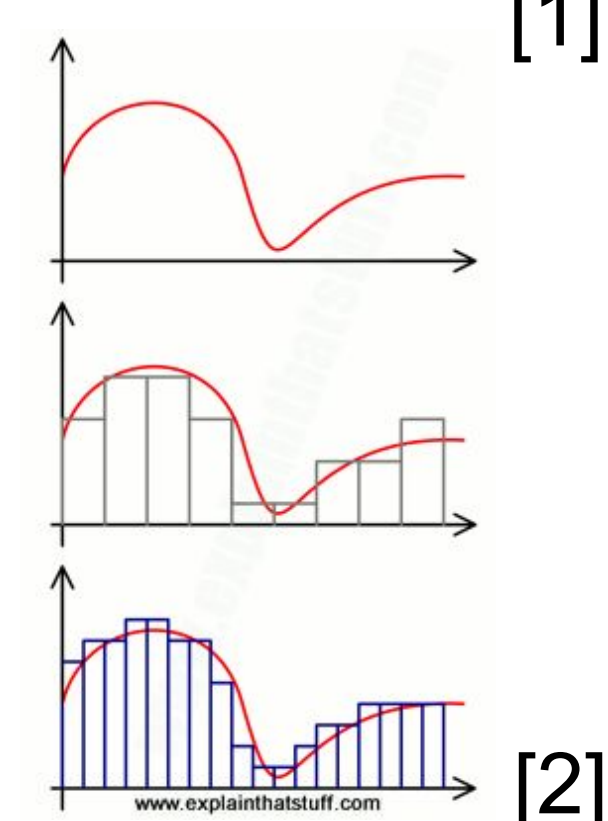
[2]

PROBLEM & OBJECTIVE

Research problem:
- Wearable and implantable devices dissipate power by continuously monitoring, collecting and transmitting biosignals from the user.

Objective:
- Develop a battery-driven wearable and implantable system that is capable of biosignal collection and wireless transmission, while being power efficient.

EXPERIMENTAL SET-UP

Wearable system using external ADC and Wireless Module

[3]

[4]
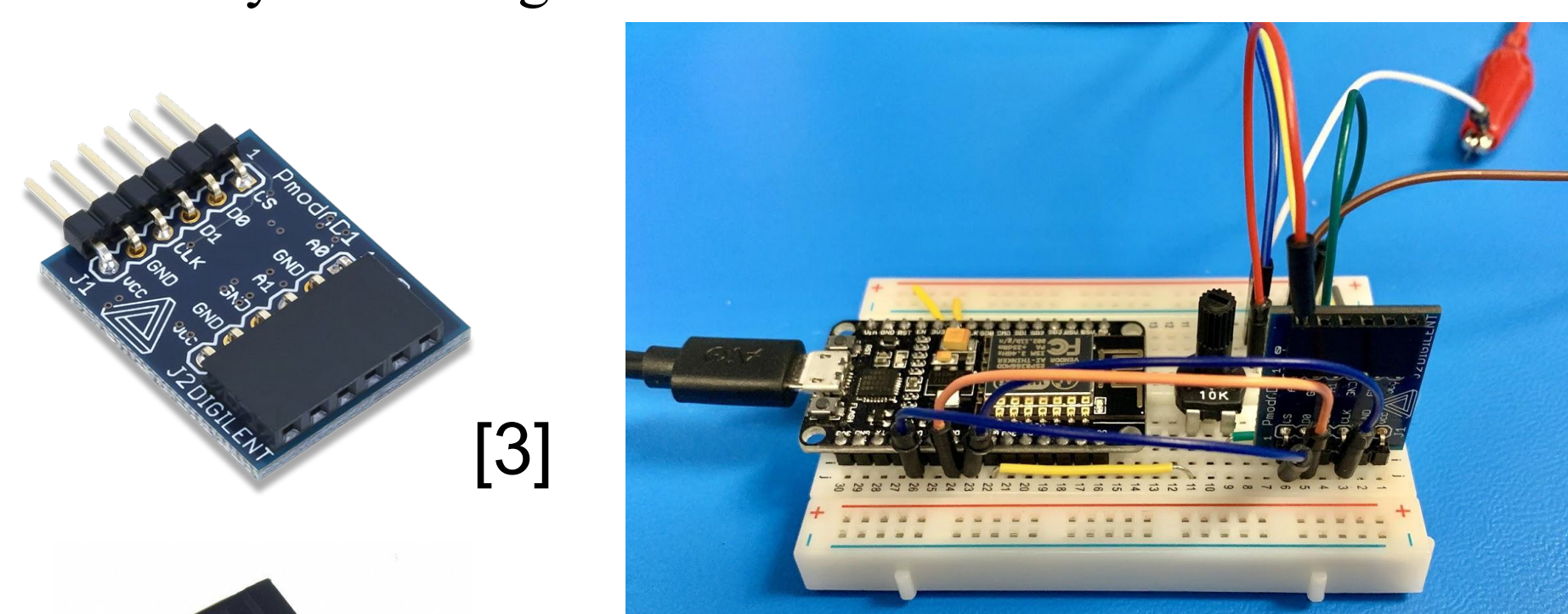
Set-Up Specifications:
- ESP32 Wireless Module with integrated MCU.
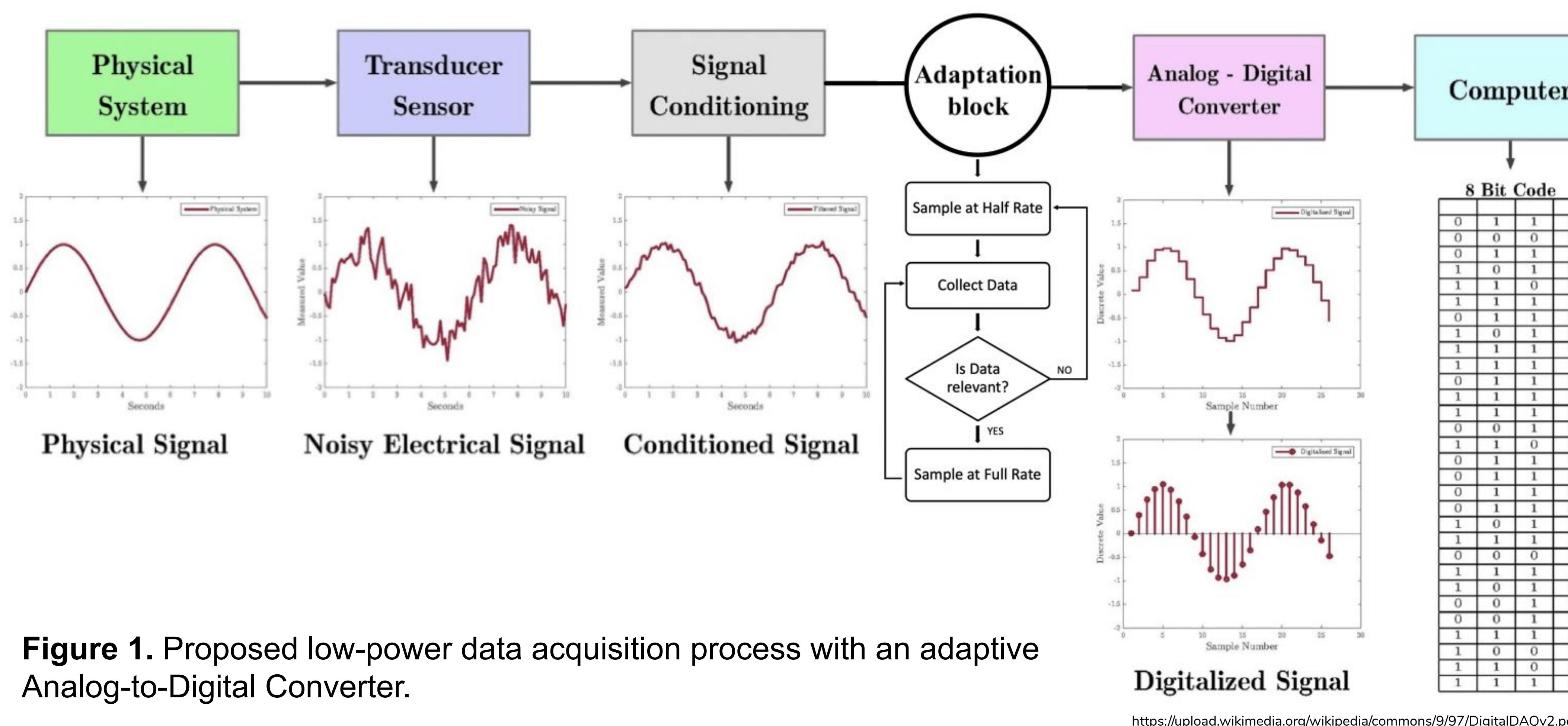- External 12-bit ADC Pmod AD1

METHODOLOGY

Figure 1. Proposed low-power data acquisition process with an adaptive Analog-to-Digital Converter.

https://upload.wikimedia.org/wikipedia/commons/9/97/DigitalDAQv2.pdf

RESULTS

With our proposed data acquisition acquisition system with Adaptive ADC, we obtained a decrease in power consumption for up to 19% and a reduction of 63% data samples without losing spikes detection accuracy.
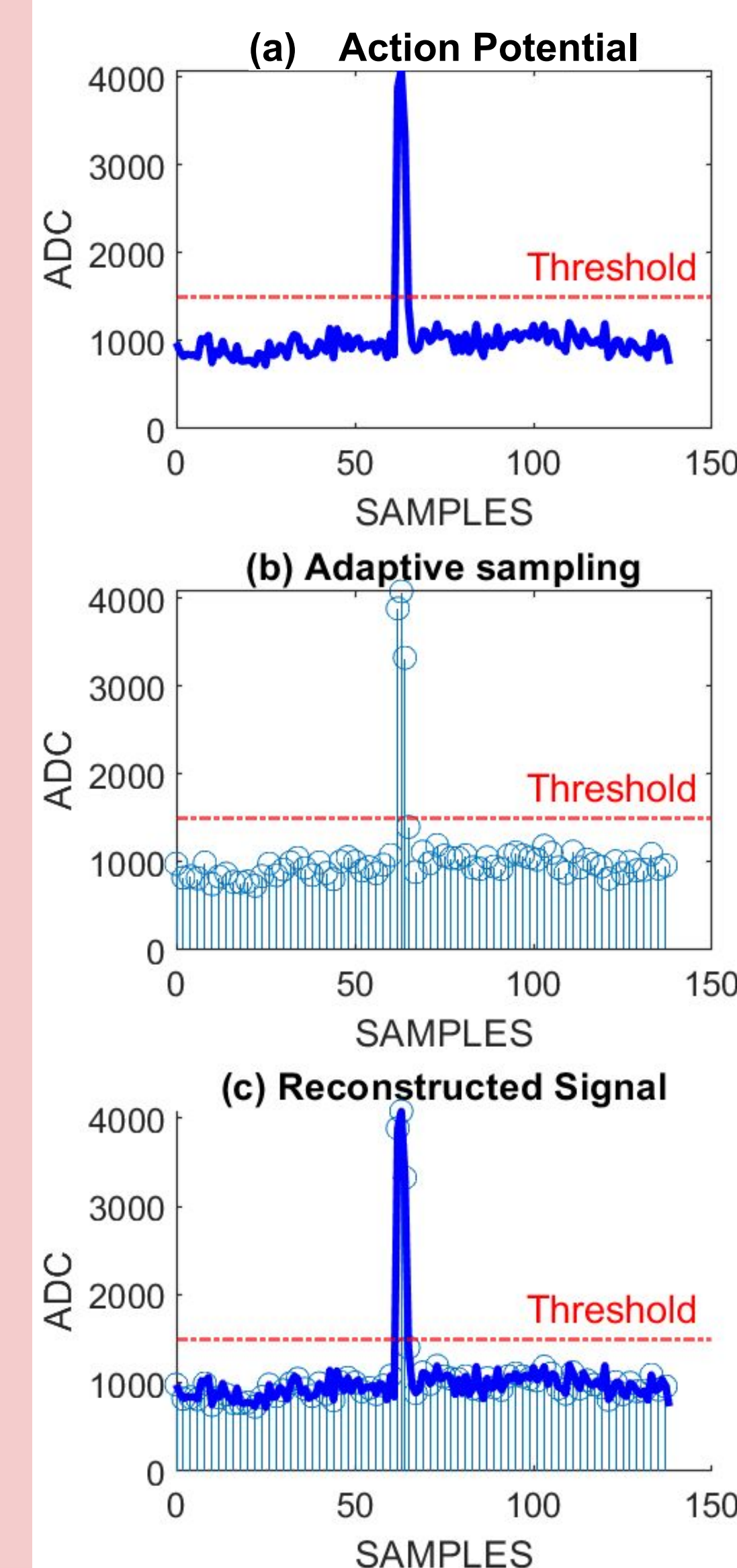

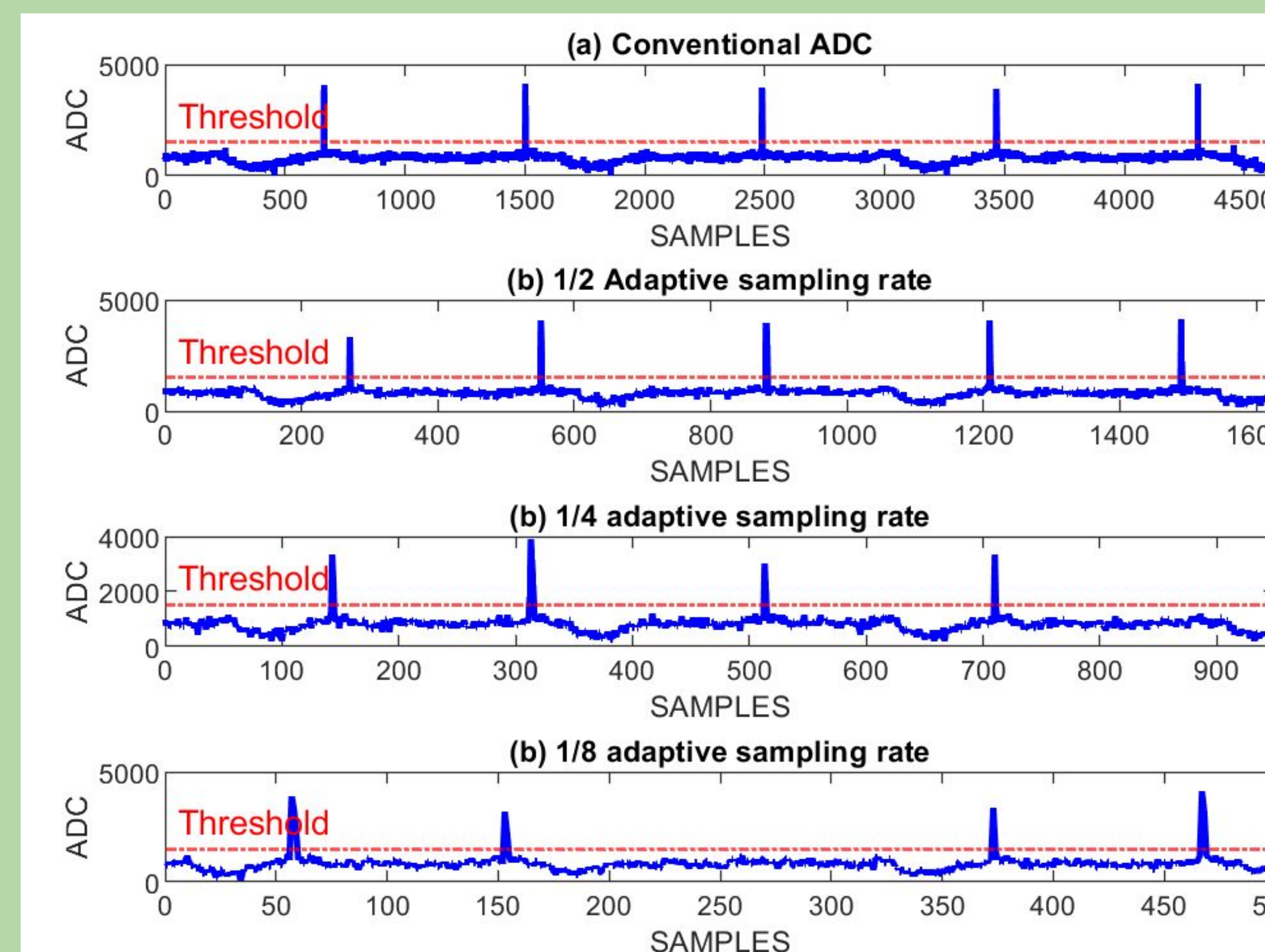**Figure 2.** Adaptive sampling and recreation of signal.

Figure 3. Comparison between conventional ADC and different adaptive sampling rates.

	Conventional ADC	1/2 Rate	1/4 Rate	1/8 Rate
No transmission	~95mA	~93mA	~91mA	~88mA
Transmission	~221mA	~203mA	~193mA	~182mA
% transmission savings		9%	14%	19%

Table 1. Power consumption comparison

DISCUSSIONS

- A simulated action potentials database was used to simulate, test and develop this work.
- Threshold is set above noise level.
- Lost of packets with collected data may occur when transmitting over WIFI. as it is a normal behavior when using UDP transport layer at a fast transmission rate.
- In order to have a consistent transmission of data, a high quality wireless router is needed

FUTURE WORK

- Real Action Potential detection
- Improve transmission performance
- Deeper reduction of the sampling rate.
- Faster transmission rate
- Adaptive noise level threshold

CONCLUSIONS

In this work, a battery-driven, power-efficient wearable and implantable device was developed, with the purpose of action potential acquisition and wireless data transmission. We have implemented an adaptive Analog-to-Digital Converter that reduces the sampling rate when it detects that the input biosignal is not of relevance according to its application. With this approach, we were able to reduce the amount of data transmitted for up to 63%, and decrease the overall power consumption of the system by 19%, without losing action potentials detection accuracy.

REFERENCES

[1] LHestrin, Shaul & Armstrong, William. (1996). Morphology and Physiology of Cortical Neurons in Layer I. The Journal of neuroscience : the official journal of the Society for Neuroscience. 16. 5290-300.
[2] Nawab, S. Hamid et al. "High-yield decomposition of surface EMG signals." Clinical neurophysiology : official journal of the International Federation of Clinical Neurophysiology 121 10 (2010): 1602-15 .
[3] Digilent Inc. https://store.digilentinc.com/pmod-ad1-two-12-bit-a-d-inputs/. Accessed July 29th 2019.
[4] Espressif Copyright © 1995-2019, Digi-Key Electronics. /. Accessed July 29th 2019. https://www.digikey.ca/product-detail/en/espressif-systems/ESP32

ACKNOWLEDGEMENT