DESIGN AND DEVELOPMENT OF A MYOWARE EMG SENSOR-BASED SYSTEM FOR MUSCLE ACTIVITY MONITORING ON A CLOUD PLATFORM

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Abstract. *This article examines the development of a system for determining muscle activity levels based on the Myo Ware EMG sensor and enabling their remote monitoring through a cloud platform. The study investigates the process of acquiring electromyographic (EMG) signals generated by muscle activity, processing them using a microcontroller, and transmitting them to a cloud platform. In the proposed system, an analog signal is obtained from the muscle using the Myo Ware EMG sensor and digitized by the ESP32 microcontroller. The acquired signal is then transmitted to the ThingSpeak cloud platform via a GSM module, where it is visualized in both graphical and numerical forms. As a result of the research, it became possible to determine the level of muscle activity based on the signal amplitude and its variations. The proposed system enables near real-time monitoring of muscle activity, remote analysis of collected data, and monitoring of patients' physical conditions. This system can be applied in medicine, rehabilitation processes, and remote healthcare monitoring systems.*

Keywords: *muscle activity, EMG signals, millivolt level, rehabilitation systems, GPS functionality, signal behavior.*

Introduction

In recent years, the need for technologies that enable remote monitoring of physiological processes in the human body has been increasing in the medical field. In particular, the study of muscle activity plays an important role in rehabilitation, sports medicine, and biomedical engineering. The electrical activity of muscles can be detected using the electromyography (EMG) method. EMG signals are bioelectrical signals generated as a result of muscle fiber contractions, and they provide valuable information for assessing the level of muscle activity. One of the modern devices used for measuring EMG signals is the Myo Ware EMG sensor. This sensor allows the measurement of electromyographic signals obtained from muscles and enables their processing using microcontrollers. At the same time, the development of IoT technologies has made it possible to remotely monitor medical systems through cloud platforms.

In this article, a system for remote monitoring of muscle activity is proposed. The system is based on acquiring muscle signals using the Myo Ware EMG sensor, processing them with an ESP32 microcontroller, and transmitting them to the ThingSpeak cloud platform using a GSM

communication module. The proposed system allows the visualization of muscle activity in graphical and numerical formats and provides the ability to monitor the collected data remotely.

Main components of the device and their functions

The proposed muscle activity monitoring system consists of several main hardware components, including the Myo Ware EMG sensor, the ESP32 microcontroller, the A9G GSM module, and a battery used as the power supply. These components are integrated to perform the processes of acquiring muscle signals, processing them, and transmitting the data to a cloud platform. The main objective of the system is to monitor muscle activity in near real-time and provide the capability for remote observation and analysis of the collected data.

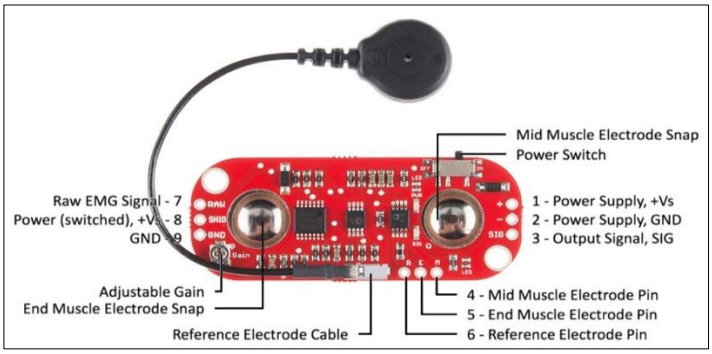


Figure 1. Myo Ware EMG sensor

The Myo Ware EMG sensor is a specialized biosensor designed to measure electromyographic (EMG) signals generated by muscle activity. This sensor detects bioelectrical signals produced as a result of muscle fiber contractions and outputs them in the form of an analog electrical signal. EMG signals usually have very small amplitudes, typically at the millivolt level. Therefore, the Myo Ware sensor includes built-in signal amplification (amplifier) and noise-reduction filtering circuits. These components allow the muscle signal to be acquired more accurately and with greater stability.

The sensor typically operates using special electrodes that are placed on the surface of the muscle. These electrodes detect the electrical activity generated when the muscle contracts. The analog signal obtained from the Myo Ware sensor is then received by a microcontroller and converted into digital form for further processing. The advantages of this sensor include its compact size, low cost, ease of use, and the ability to acquire signals in real time. For these reasons, the Myo Ware sensor is widely used in fields such as biomedical engineering, sports monitoring, rehabilitation systems, and human – machine interface applications.

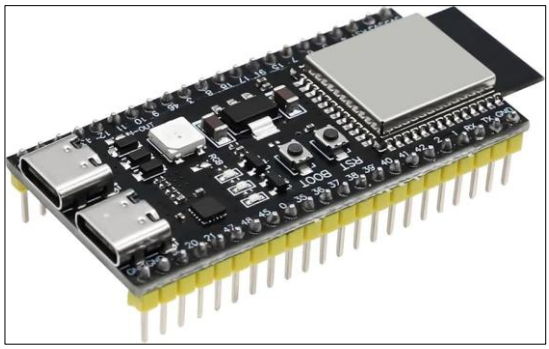


Figure 2. ESP32 microcontroller

The ESP32 microcontroller serves as the main control and computing unit of the system. This microcontroller receives the analog signal coming from the Myo Ware EMG sensor and converts it into digital form using its built-in analog-to-digital converter (ADC). The digitized

signal is then processed using software algorithms and used to determine the level of muscle activity. The ESP32 microcontroller is distinguished by its high processing speed, low power consumption, and support for multiple peripheral interfaces. Due to its integrated Wi-Fi and Bluetooth modules, it is widely used in IoT-based systems. In this study, the ESP32 microcontroller is responsible for collecting data from the sensors, performing preliminary signal processing, calculating the level of muscle activity, and transmitting the processed data to the cloud platform via the GSM module.

In addition, the ESP32 microcontroller enables signal analysis, monitoring of signal variations over time, and calculation of various mathematical indicators. For this reason, it is considered one of the modern microcontrollers widely used in medical monitoring systems and IoT devices.

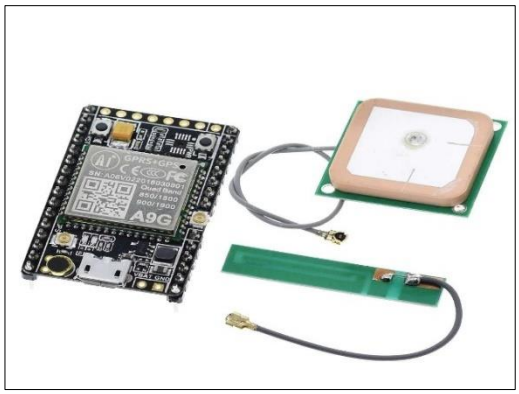


Figure 3. A9G GSM moduli

The A9G GSM module is a communication module designed to transmit data through wireless communication networks. This module uses GSM and GPRS technologies to send data obtained from the device to the internet via a mobile communication network. The A9G module communicates with the ESP32 microcontroller through a serial communication interface (UART) and transmits the data received from the microcontroller to the cloud platform. In the proposed system, muscle activity data obtained from EMG signals are transmitted to the ThingSpeak cloud platform through the A9G module. On the cloud platform, these data are stored and visualized in both graphical and numerical forms, allowing users to monitor them remotely. The use of the GSM module enables the system to operate independently of Wi-Fi networks, which provides significant advantages for remote monitoring systems. In addition, the A9G module also supports GPS functionality, which makes it possible to determine the geographical location of the device when necessary. For this reason, it is widely used in various IoT systems, especially in remote monitoring and tracking applications.



Figure 4. Battery for the device

The battery serves as the main power source that provides energy for the operation of the device. It supplies the electrical power required for the Myo Ware EMG sensor, ESP32 microcontroller, and A9G GSM module. The use of a battery ensures that the device remains portable and allows it to operate in various environments. As a power source, rechargeable lithium-ion or lithium-polymer batteries are typically used. These batteries are compact in size and capable of supporting the device's operation for extended periods. By using a battery, the device can operate wirelessly and independently, enabling the monitoring of a patient's muscle activity even during movement.

The use of a portable power supply allows the monitoring system to function in a mobile mode. As a result, muscle activity can be monitored not only in laboratory conditions but also in real-life scenarios such as during rehabilitation processes or everyday activities.

System architecture and block diagram

The proposed muscle activity monitoring system operates based on the integration of several hardware and software components. The main objective of the system is to acquire electromyographic signals generated by muscle activity, process them, and transmit them to a cloud platform for remote monitoring. The system architecture consists of the following main modules:

1. MyoWare EMG sensor
2. ESP32 microcontroller
3. A9G GSM communication module
4. ThingSpeak cloud platform
5. User monitoring interface

The operation of the system is performed as follows. Initially, the MyoWare EMG sensor receives bioelectrical signals generated by muscle activity through electrodes attached to the muscle surface. These signals are analog in nature and are processed through amplification and filtering circuits integrated within the sensor. In the next stage, the analog signal is received by the analog-to-digital converter (ADC) of the ESP32 microcontroller and converted into digital form. The ESP32 microcontroller performs preliminary signal processing, determines the level of muscle activity, and prepares the data for transmission.

The processed data are then transmitted to the internet through the A9G GSM module using a mobile communication network. The transmitted data are sent to the ThingSpeak cloud platform, where they are stored. On the ThingSpeak platform, the received data are visualized in graphical and numerical formats. Users can access the platform through the internet and remotely monitor muscle activity information. This system can be applied in remote medical monitoring systems, rehabilitation processes, and sports activity monitoring. The block diagram of the system can be represented in the following sequence:

Stage	System Component	Function
1	Muscle Activity	Bioelectrical EMG signals are generated as a result of human muscle contraction.
2	Myo Ware EMG Sensor	Measures the EMG signal generated by the muscles and outputs it as an analog signal.
3	ESP32 Microcontroller (ADC and Signal Processing)	Converts the analog EMG signal into digital form using ADC, performs initial signal processing, and prepares the data.

4	A9G GSM Module	Transmits the data received from the ESP32 to the internet via GSM/GPRS.
5	Internet Network	Transfers the data sent from the device to the cloud platform.
6	ThingSpeak Cloud Platform	Receives, stores, and processes EMG signal data.

Algorithm for acquiring emg signals and transmitting them to the Thingspeak cloud platform

In the proposed monitoring system, the process of acquiring muscle signals, processing them, and transmitting them to the cloud platform is performed based on a specific algorithm. This algorithm is designed to ensure stable operation of the device and enable remote monitoring of the collected data. The operation of the algorithm consists of the following stages:

Step 1. System Initialization

In the first stage, the ESP32 microcontroller is powered on and all devices are initialized. During this stage, the Myo Ware sensor, A9G GSM module, and other interfaces are configured and prepared for operation.

Step 2. EMG Signal Acquisition

The Myo Ware EMG sensor receives electromyographic signals generated by muscle activity through electrodes placed on the muscle surface. These signals are analog in nature and are read by the ADC module of the ESP32 microcontroller.

Step 3. Signal Processing

The ESP32 microcontroller processes the digitized signal obtained from the sensor. At this stage, the amplitude of the signal is determined and the level of muscle activity is evaluated. If necessary, additional mathematical operations such as signal smoothing or averaging can also be applied.

Step 4. Data Preparation

The processed signal is converted into a specific format suitable for transmission. The data are prepared in formats such as JSON or HTTP request format for sending to the cloud platform.

Step 5. Data Transmission

The ESP32 microcontroller transmits the prepared data through the A9G GSM module to the mobile communication network. The GSM module establishes an internet connection and sends the data to the ThingSpeak platform server.

Step 6. Cloud Storage and Visualization

The data transmitted to the ThingSpeak platform are stored on the server and automatically visualized in graphical and numerical forms. Users can access the platform via the internet and monitor muscle activity data in near real time.

Using this algorithm, continuous monitoring of muscle activity is achieved, and the acquired EMG signals can be remotely observed through the cloud platform.

The figure shows a prototype device developed to measure electromyography (EMG) signals generated by muscle activity. The device consists of electronic components placed inside a protective enclosure and uses a Myo Ware EMG sensor to detect bioelectrical signals produced by muscle contractions. The sensor is connected to the human body through electrodes, which capture electrical signals generated when muscles contract or relax. The upper part of the device contains the main electronic module housed inside the enclosure, which typically includes a

microcontroller and power management components. A power switch is integrated into the casing to allow the device to be turned on and off easily. The lower part of the system contains the Myo Ware EMG sensor board and electrode connectors used for acquiring muscle signals.

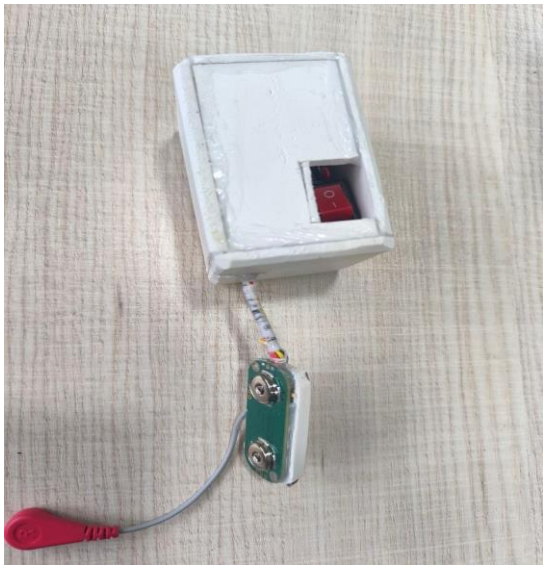


Figure 5. Prototype of a muscle signal measurement device based on the Myo ware EMG sensor.

The device can be integrated with IoT technologies to transmit collected EMG signals wirelessly to a remote server or cloud platform. This enables real-time monitoring, storage, and analysis of muscle activity data. Such systems are widely used in biomedical engineering, healthcare monitoring, rehabilitation systems, sports science, and physiological signal research.

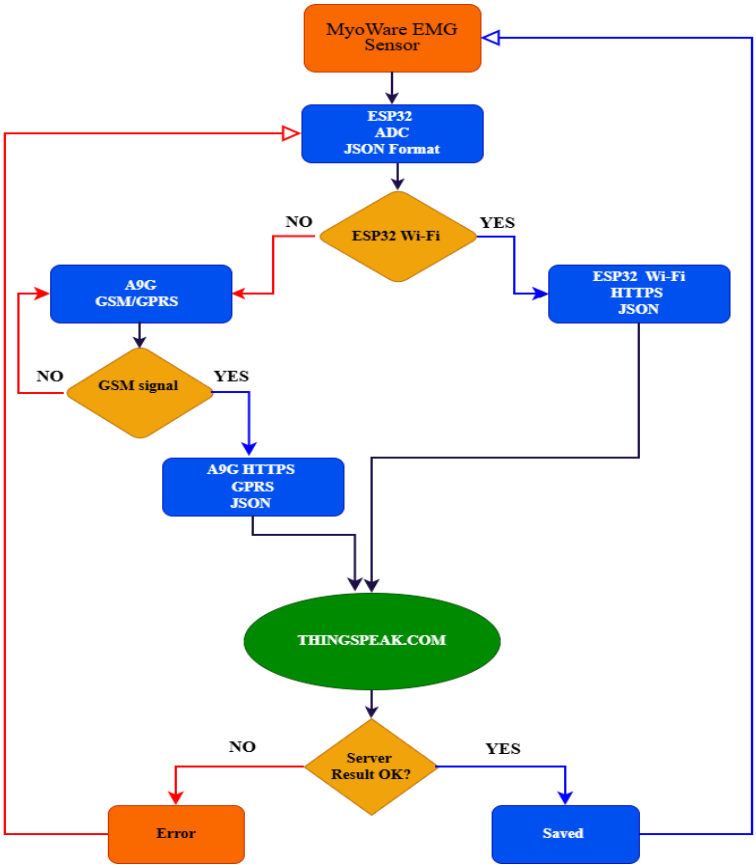


Figure 6. Algorithm for transmitting EMG signals to the Thingspeak cloud platform using Myo ware EMG sensor, ESP32, and A9G GSm module

This algorithm illustrates the process of remote muscle activity monitoring using EMG (Electromyography) signals through IoT technology and cloud platforms. The process begins with the Myo Ware EMG sensor, which captures bioelectrical signals generated by muscle activity. The analog EMG signal is then processed by the ESP32 microcontroller, where it is converted into digital data using an ADC (Analog-to-Digital Converter) and formatted into JSON. In the next stage, the data can be transmitted to the internet using two communication methods. The first method uses the ESP32 Wi-Fi module, which sends the data directly to the cloud platform via the HTTPS protocol in JSON format. The second method uses the A9G GSM/GPRS module, which transmits the data through the mobile cellular network. If a GSM signal is available, the A9G module sends the data to the cloud server using HTTPS in JSON format.

Once the data reaches the ThingSpeak.com cloud platform, the server receives and processes it. If the server successfully receives the data, it is stored in the system and marked as Saved, allowing it to be used later for graphical and numerical monitoring. If an error occurs during transmission, the system returns an Error status, indicating that the data transmission failed and may need to be resent.

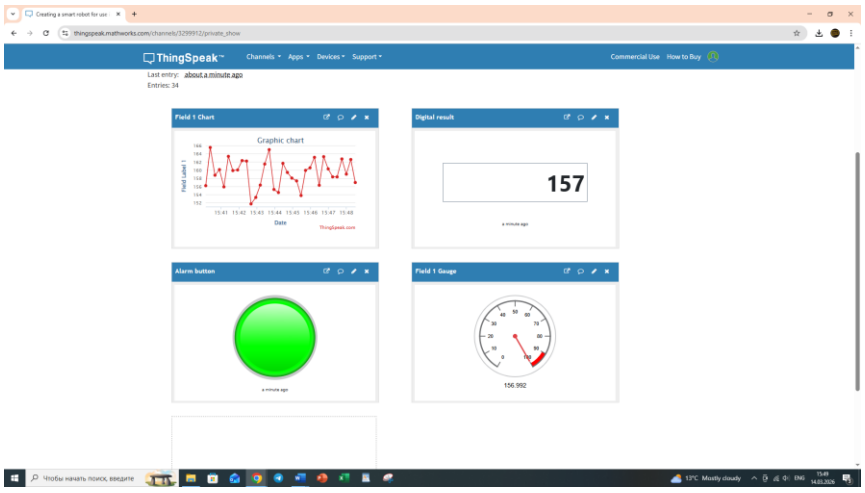


Figure 7. Real-time visualization interface of EMG signal data on the Thingspeak cloud platform.

The figure illustrates the real-time monitoring interface of EMG (Electromyography) signal data on the ThingSpeak cloud platform. In this system, the EMG signal collected from the Myo Ware EMG sensor is transmitted through the ESP32 microcontroller to the cloud server using an internet connection. Once the data reaches the ThingSpeak platform, it is automatically stored and visualized for monitoring and analysis. The interface includes several visualization components that help users observe the signal behavior in real time. The graphical chart displays the variation of the EMG signal over time, allowing users to analyze the dynamic changes in muscle activity. The digital result panel shows the current numerical value of the signal, providing a quick and clear representation of the latest measurement.

In addition, the gauge indicator visually represents the signal magnitude within a predefined range, making it easier to interpret the signal level. The system may also include status indicators or alarm buttons, which can be used to signal abnormal conditions or alert users when the signal exceeds certain thresholds. By integrating IoT communication and cloud computing technologies, this monitoring interface enables remote observation, storage, and analysis of physiological signals. Such systems are useful in medical monitoring, rehabilitation, sports science, and biomedical research, where continuous tracking of muscle activity is required. The

use of cloud platforms like ThingSpeak also allows researchers and healthcare professionals to access data from anywhere, improving the efficiency and scalability of physiological signal monitoring systems.

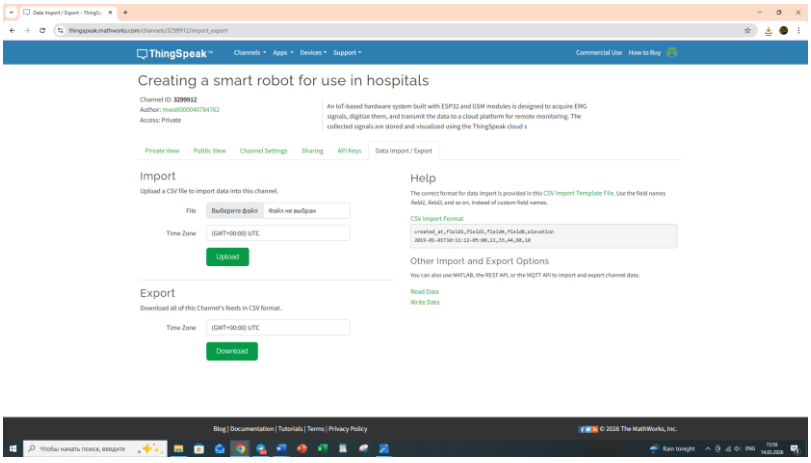


Figure 8. Data import and export interface of the Thingspeak cloud platform

The figure shows the Data Import/Export interface of the ThingSpeak cloud platform. This section allows users to upload data to the channel in CSV format or download stored channel data for further analysis. The import function enables users to upload datasets from external devices or systems, while the export function allows downloading all stored data from the channel in CSV format.

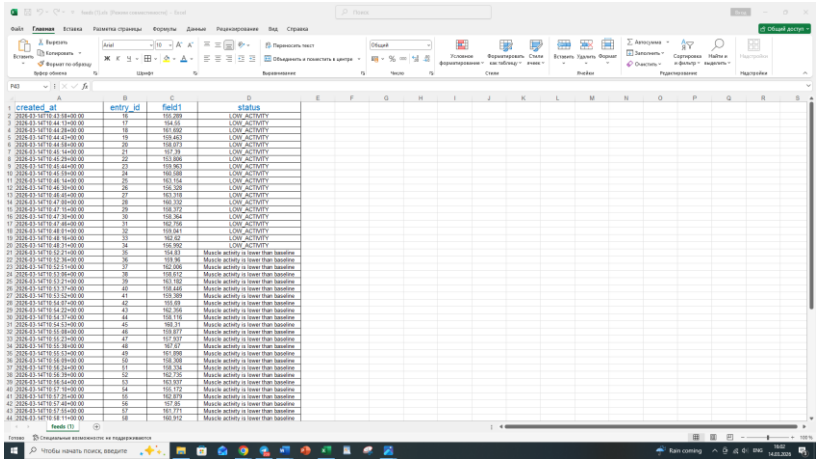


Figure 9. CSV dataset of EMG signal data exported from the Thingspeak cloud platform.

The figure shows EMG signal data exported from the ThingSpeak cloud platform and displayed in Microsoft Excel in CSV format. The table stores sensor measurements sequentially over time, where each row represents a specific data entry collected from the monitoring system. The dataset includes several columns such as created at, entry id, field1, and status, which represent the timestamp of the measurement, the entry identification number, the sensor signal value, and the system-detected signal status respectively.

Conclusion

In this research work, a system for measuring electromyography (EMG) signals generated by muscle activity using the Myo Ware EMG sensor, processing the signals, and remotely monitoring them through a cloud platform was developed. During the study, bioelectrical signals generated by muscle contractions were captured using the Myo Ware EMG sensor and converted into digital form using the ESP32 microcontroller. The collected data were transmitted to the ThingSpeak cloud platform via the Internet using Wi-Fi or GSM communication modules.

Through the cloud platform, the received data were visualized in graphical and numerical formats and stored in CSV format for further analysis. This makes it possible to observe the temporal variation of muscle activity, analyze signal data, and use the collected datasets for future scientific research. The results of the study demonstrate that IoT-based systems can effectively be used for remote monitoring of muscle activity, supervision of rehabilitation processes, and applications in sports physiology and biomedical engineering.

Furthermore, the developed system operates in real time, stores collected data in the cloud, and presents the information to users through visualization interfaces. In future work, the system can be further improved by implementing advanced signal analysis techniques, applying artificial intelligence methods for automatic muscle activity classification, and integrating the system with mobile applications for more efficient remote monitoring.

REFERENCES

1. De Luca C. J. The Use of Surface Electromyography in Biomechanics. Journal of Applied Biomechanics, 2019.
2. Merletti R., Parker P. Electromyography: Physiology, Engineering and Non-Invasive Applications. Wiley-IEEE Press, 2021.
3. Konrad P. The ABC of EMG: A Practical Introduction to Kinesiological Electromyography. Noraxon Inc., 2018.
4. De Luca C. J. Surface Electromyography: Detection and Recording. Delsys Incorporated, 2022.
5. Phinyomark A., et al. Feature Extraction of the Electromyography Signal for EMG Pattern Recognition. Expert Systems with Applications, 2012.
6. Texas Instruments. ADS1298 Low-Power, 8-Channel, 24-Bit Analog Front-End for Biopotential Measurements. Datasheet, 2019.
7. Advancer Technologies. MyoWare Muscle Sensor User Manual. Advancer Technologies, 2020.
8. MathWorks. ThingSpeak IoT Analytics Platform Documentation. https://thingspeak.com
9. Espressif Systems. ESP32 Technical Reference Manual. Espressif Systems, 2022.
10. Yang S., et al. Internet of Things for Smart Healthcare: Technologies, Challenges and Future Directions. IEEE Access, 2018.
11. Hassan M. M., et al. IoT-Based Healthcare Monitoring System Using Cloud Computing. Future Generation Computer Systems, 2019.
12. Webster J. G. Medical Instrumentation: Application and Design. John Wiley & Sons, 2019.