# Vita Core: A Low Cost Integrated System for Gastric and Vascular Signal Monitoring

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***Abstract*— Electrogastrography (EGG) is a non-invasive technique used to monitor gastric electrical activity; however, conventional systems are often expensive and complex, limiting their accessibility for continuous monitoring and research applications. This paper presents VITACORE (Vital Integrated Telemetry and Core Organ Evaluation), a low-cost biomedical monitoring system designed using an Arduino Nano and the AD8232 biopotential amplifier. The system captures abdominal bioelectrical signals using surface electrodes and processes them using digital signal processing techniques. A bandpass filter is applied to remove noise and isolate gastric signals within the frequency range of interest. Fast Fourier Transform (FFT) is then utilized to extract the dominant frequency component. Gastric rhythm is computed in Cycles Per Minute (CPM) and classified into bradygastria, normogastria, and tachygastria. In addition, pulse signal monitoring is integrated to provide multi-modal physiological analysis. The system also supports real-time visualization through a webbased dashboard. Experimental result demonstrate that the proposed system can effectively approximate EGG functionality using low-cost components, making it suitable for educational, research, and preliminary diagnostic applications.**

***Index Terms*— Arduino Nano, AD8232, FFT, Gastric Rhythm.***

## I. INTRODUCTION

EGG is a non-invasive biomedical technique used to record and analyze the electrical activity of the stomach. These bioelectrical signals, commonly referred to as gastric slow waves, play a fundamental role in regulating gastrointestinal motility and coordination. Under normal physiological conditions, these slow waves occur at a frequency of approximately 3 CPM and deviations from this range are often associated with disorders such as bradygastria, tachygastria and gastroparesis [1], [10]. The physiological basis and clinical relevance of gastric electrical activity have been extensively discussed in classical medical and biomedical instrumentation literature [3], [4], [9].

The ability to monitor gastric electrical activity has significant clinical importance in the early diagnosis and management of gastrointestinal disorders. However, conventional EGG systems are often expensive, bulky, and require specialized clinical setups, limiting their widespread adoption [1], [10]. Additionally, the acquisition of gastric signals is inherently challenging due to their extremely low amplitude (in the microvolt range) and low-frequency characteristics. These signals are highly susceptible to various forms of interference, including motion artifacts, respiration, and cardiac activity, which complicates accurate signal extraction and analysis [8].

Over the years, significant advancements have been made in biomedical signal processing and instrumentation techniques to improve the acquisition and analysis of such physiological signals. Early works in biomedical instrumentation established fundamental design principles for signal acquisition and noise reduction [3], [9], while later studies focused on advanced signal processing approaches for improving signal quality and interpretability [8]. The development of EGG methodologies and their validation for clinical applications has been further explored in studies such as those by Chen and McCallum [1] and Yin and Chen [10], which highlight both the potential and limitations of EGG in clinical practice.

Recent advancements in embedded systems and Internet of Things (IoT)-based healthcare technologies have opened new possibilities for developing cost-effective and portable biomedical monitoring systems. Microcontroller-based platforms, such as Arduino, have gained significant attention due to their affordability, ease of use, and compatibility with various sensors and modules [2], [7]. Several studies have demonstrated the effectiveness of embedded and wearable systems for real-time health monitoring, incorporating physiological signal acquisition and wireless data transmission [6], [11], [14], [15]. In addition, the integration of multimodal physiological monitoring, such as pulse signal analysis, has been explored for enhanced diagnostic capability in cardiovascular and systemic health assessment [5], [12].

Despite these advancements, there remains a gap between high-cost clinical-grade systems and accessible, low-cost solutions suitable for continuous monitoring and research applications. Many existing systems either lack affordability, portability, or sufficient signal processing capability for reliable real-time analysis. Furthermore, challenges related to signal noise, hardware limitations, and system integration continue to affect the accuracy and usability of such systems.

In this context, the proposed VITACORE system aims to bridge this gap by integrating low-cost hardware components with efficient signal processing techniques to acquire, filter, and analyze gastric electrical signals. The system also incorporates multimodal monitoring through pulse signal acquisition, enhancing its overall diagnostic capability. The primary objective of this work is to design and implement a low-cost, efficient, and reliable system capable of approximating the functionality of conventional EGG systems while maintaining simplicity and accessibility for research and educational applications.

## II. PROPOSED SYSTEM

The proposed system, VITACORE, is a low-cost biomedical monitoring solution designed to analyze gastric electrical activity using non-invasive techniques. The system integrates hardware and software components to acquire, process, and visualize physiological signals in real time.

The primary objective of the system is to provide an affordable alternative to conventional EGG systems, which are typically expensive and complex. The proposed model utilizes surface electrodes to capture abdominal bioelectrical signals, which are then amplified using a biopotential amplifier and processed using an embedded microcontroller.

### *A. System Architecture*

The system architecture consists of three major modules: signal acquisition, signal processing, and visualization. The signal acquisition module includes surface electrodes and an AD8232 biopotential amplifier. The amplified signal is fed into the Arduino Nano, which performs analog-to-digital conversion. Fig.1 shows the proposed system architectural diagram.

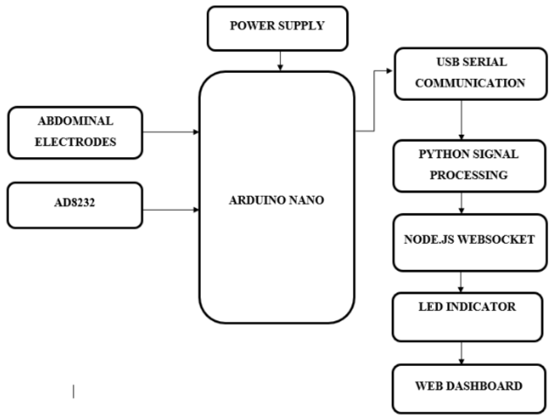


Fig.1. Proposed System Architecture Diagram

The digital data is transmitted to a computer via serial communication, where further processing is carried out using Python. The processed output is displayed through a graphical user interface, enabling real-time monitoring and analysis.

### *B. Working Principle*

The working of the proposed system is based on the acquisition and analysis of low-frequency gastric signals. Initially, electrodes placed on the abdominal region detect electrical activity generated by gastric muscles. These signals are weak and require amplification, which is achieved using the AD8232 module.

The amplified signals are then digitized using the Arduino Nano and transmitted to a computer system. Digital filters are applied to remove noise and interference. FFT is used to convert the signal into the frequency domain, enabling extraction of the dominant frequency.The frequency is converted into CPM and classified into bradygastria, normal, or tachygastria. The results are displayed on a monitoring interface for analysis. The complete system architecture and hardware implementation of the VITA-CORE system are illustrated in Fig. 2.

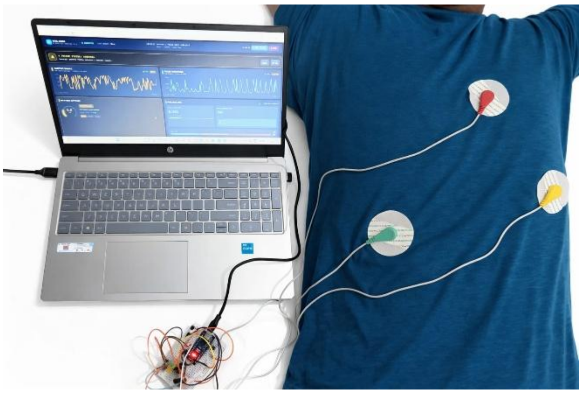

Fig.2. Complete Vita-Core System Setup

As shown in Fig. 2, the system establishes a seamless pipeline from sensor-based signal acquisition to digital processing and real-time visualization, ensuring accurate extraction and interpretation of physiological parameters.

## III. METHODOLOGY

The proposed VITACORE system follows a structured methodology for the acquisition, processing, and analysis of gastric electrical signals. The system integrates both hardware and software components into a unified pipeline for real-time physiological monitoring.

### *A. System Overview*

The overall workflow of the system consists of signal acquisition, signal conditioning, data conversion, digital processing, and visualization. Surface electrodes placed on the abdominal region capture low-amplitude gastric myoelectrical signals, which are then processed to extract clinically relevant parameters.

### *B. Hardware Design and Signal Acquisition*

The hardware module utilizes low-cost biomedical components for acquiring gastric electrical signals. Disposable Ag/AgCl surface electrodes capture low-frequency signals (0.05–0.15 Hz) from the abdominal region.

These signals are amplified and conditioned using the AD8232 biopotential amplifier to reduce noise and motion artifacts. The conditioned output is interfaced with the Arduino Nano (ATmega328P), where the OUT pin is connected to analog pin A6, and lead-off detection pins (LO+ and LO−) are connected to digital pins D10 and D11.

The Arduino performs 10-bit analog-to-digital conversion and transmits the digitized data to the host system. Status indication is provided using LEDs connected to digital pins D8 and D9. Supporting components such as a breadboard, jumper wires, and regulated power supply ensure stable operation. The hardware setup of proposed system is shown as Fig.3.

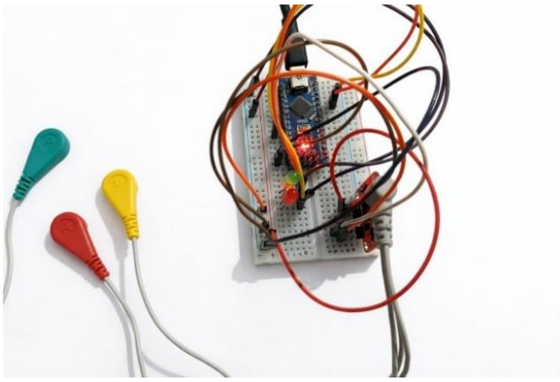

Fig.3. Hardware Setup

### *C. Data Transmission and Firmware*

The firmware for the Arduino Nano is developed using Arduino IDE (C/C++). The microcontroller continuously samples the incoming analog signal at a predefined sampling rate and transmits the digitized data through USB serial communication.

The firmware ensures synchronized sampling and efficient data transfer, enabling real-time signal acquisition without data loss.

### *D. Software Processing and Analysis*

The software module is implemented using *Python,* utilizing libraries such as *NumPy, SciPy,* and *Matplotlib* for signal processing and visualization.

The acquired signal undergoes preprocessing using digital filters (such as low-pass and notch filters) to remove baseline drift and powerline interference. FFT is applied to convert the signal into the frequency domain and extract the dominant frequency component.

The dominant frequency is converted into CPM and used to classify gastric rhythms as:

- Bradygastria (< 2 CPM)
- Normal (2–4 CPM)
- Tachygastria (> 4 CPM)

*E. Visualization and User Interface*

A real-time visualization interface is developed using Python-based tools to display waveform plots and computed parameters. The interface presents both time-domain signals and frequency-domain analysis results, enabling continuous monitoring of gastric activity.

*F. Automated Report Generation*

In addition to real-time visualization, the system incorporates an automated report generation feature. The processed data and extracted parameters, including dominant frequency, CPM values, and classification results, are compiled into a structured diagnostic report.

The report is generated in a digital format and includes patient information, signal analysis results, and graphical representations of the waveform and frequency spectrum. This feature enhances the usability of the system by providing a documented summary that can be stored, reviewed, or shared for further medical evaluation.

## IV. RESULTS AND DISCUSSION

The performance of the proposed VITA-CORE system was evaluated using both real-time and prerecorded physiological signals to assess its accuracy, robustness, and clinical relevance. The system successfully acquired, processed, and visualized gastric and peripheral vascular parameters through an integrated hardware–software framework. The developed dashboard interface provides a comprehensive real-time visualization platform that enables continuous monitoring and rapid interpretation of physiological conditions. The real-time monitoring dashboard is shown in Fig. 4.

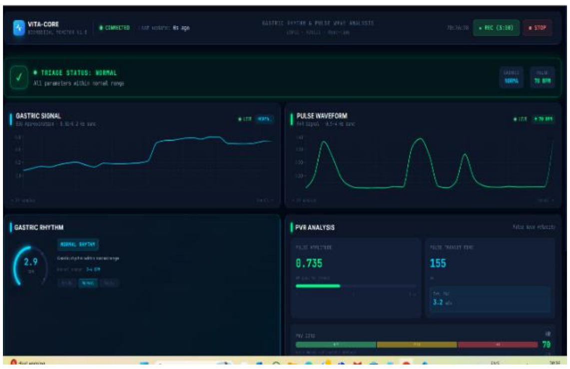


Fig. 4. VITA-CORE Biomedical Monitoring Dashboard

The dashboard interface, as shown in Fig. 4, integrates multiple components, including gastric signal waveform, pulse waveform, gastric rhythm indicator, PVR analysis, and an overall triage status display. The triage status acts as a high-level indicator of system output, where a green signal represents normal physiological conditions, while deviations from normal ranges result in warning or critical alerts indicated by color changes. The gastric signal waveform displayed in the dashboard represents slow-wave activity within the frequency range of 0.01–0.2 Hz. Under normal conditions, the waveform exhibits stable, periodic oscillations corresponding to healthy gastric motility. The observed gastric frequency of 2.93 CPM lies within the normogastria range of 2–4 CPM, confirming normal gastric rhythm.

Any deviation from this range can indicate abnormalities such as bradygastria, where the frequency falls below 2 CPM, or tachygastria, where it exceeds 4 CPM. Such variations are often associated with gastrointestinal disorders including gastroparesis, delayed gastric emptying, and functional dyspepsia. In abnormal conditions, the waveform may exhibit irregular patterns, reduced amplitude, or loss of periodicity, indicating impaired gastric activity. The pulse waveform component of the dashboard represents peripheral vascular response signals within the range of 0.5–4 Hz. In the observed normal condition, the waveform shows consistent and periodic peaks corresponding to regular cardiac cycles. The measured heart rate of 68 beats per minute (BPM) falls within the normal physiological range of 60–100 BPM, indicating stable cardiovascular activity.

The pulse amplitude and waveform morphology provide insights into blood flow characteristics, where stable amplitude reflects proper perfusion, and any significant reduction or irregularity may indicate circulatory issues. The pulse transit time (PTT), measured as 155 ms in this study, serves as an important indicator of arterial stiffness and vascular health. Lower PTT values may suggest increased arterial stiffness, which is often associated with hypertension or vascular diseases, while higher values may indicate reduced vascular tone. The system also incorporates frequency-domain analysis using Fast Fourier Transform (FFT) to identify dominant frequency components in the gastric signal. The presence of a dominant frequency within the normogastric range confirms the accuracy of signal acquisition and processing.

An important feature of the VITA-CORE system is its ability to provide preliminary disease indications based on observed physiological deviations. Variations in vascular parameters such as pulse waveform irregularities, reduced pulse amplitude, and abnormal pulse transit time can be associated with conditions such as abdominal aortic aneurysm (AAA), where changes in arterial elasticity and blood flow dynamics alter pulse characteristics. Similarly, acute conditions such as renal colic, which involve severe pain and autonomic nervous system activation, may lead to elevated heart rate and transient irregularities in pulse waveform patterns. From a gastrointestinal perspective, abnormalities in gastric frequency and rhythm may indicate disorders such as gastroparesis or functional dyspepsia. While the system does not provide definitive clinical diagnosis, it enables early identification of abnormal physiological patterns and supports preliminary screening.

Following signal processing, the system generates an automated diagnostic report that summarizes key physiological parameters in a structured format. The generated diagnostic report is shown in Fig. 5.


Fig. 5. Generated Clinical Diagnostic Report

The generated report, as shown in Fig. 5, includes gastric frequency, heart rate, pulse transit time, and signal quality metrics along with their interpretations. In the observed case, the gastric frequency was 2.93 CPM, the heart rate was 68 BPM, and the pulse transit time was 155 ms, all of which fall within normal physiological limits. The signal quality was measured at 94%, indicating reliable signal acquisition with minimal noise interference.

In addition to presenting these values, the report provides a clear classification of each parameter based on predefined physiological thresholds, enabling rapid identification of normal and abnormal conditions. This structured representation enhances interpretability by converting complex signal data into clinically meaningful information. Furthermore, the report serves as a decision-support tool by correlating measured parameters with potential physiological states, thereby assisting users in understanding the overall health condition without requiring expertise in signal processing. The consistency between the displayed dashboard values and the generated report also confirms the accuracy of the system's computational algorithms and real-time processing capability.

A summarized representation of the obtained results is presented in Table I.

| CATEGORY | PARAMETER | OBSERVED VALUE | UNIT | RESULT |
|---|---|---|---|---|
| Clinical Status | Triage Level | Green | - | Normal |
| Gastric Analysis (EGG) | Gastric Frequency | 2.93 | CPM | Normal (Normogastria) |
| | Rhythm Status | Normal | - | Stable Gastric Activity |
| Peripheral Vascular | Heart Rate | 68 | BPM | Normal |
| | Pulse Amplitude | 0.758 | V | Stable signal |
| | Pulse Transit Time (PTT) | 155 | ms | Normal |
| | Signal Quality Metric | 94 | % | Good signal quality |

TABLE I. CLINICAL RESULT SUMMARY

Table I provides a comprehensive summary of the physiological parameters measured by the VITA-CORE system along with their observed values, corresponding units, and clinical interpretations. The table is structured to present a clear relationship between raw measurements and their diagnostic significance, thereby enabling quick assessment of the subject's physiological condition. The first parameter, the triage level, represents the overall system classification derived from the combined analysis of gastric and vascular signals. In the observed case, the triage level is indicated as "Green," which corresponds to a normal physiological state, suggesting that all monitored parameters fall within acceptable limits. Any deviation from this condition would result in a change in triage level to "Yellow" or "Red," indicating moderate or severe abnormality, respectively.

The gastric analysis section includes gastric frequency and rhythm status, which are critical indicators of gastric motility. The observed gastric frequency of 2.93 CPM lies within the normal normogastria range of 2–4 CPM, confirming stable gastric activity. Values below 2 CPM correspond to bradygastria, which may indicate conditions such as gastroparesis or delayed gastric emptying, whereas values above 4 CPM indicate tachygastria, often associated with gastric dysrhythmias and functional digestive disorders. The rhythm status further supports this observation by confirming whether the waveform exhibits regular periodic activity. A normal rhythm indicates consistent slow-wave propagation, while irregular rhythm may suggest impaired gastric coordination or underlying gastrointestinal dysfunction.

The peripheral vascular section of the table includes heart rate, pulse amplitude, pulse transit time, and signal quality metrics, each contributing to cardiovascular assessment. The measured heart rate of 68 BPM falls within the standard normal range of 60–100 BPM, indicating stable cardiac activity. Deviations from this range may indicate bradycardia or tachycardia, which could be associated with arrhythmias or stress-related conditions. The pulse amplitude value of 0.758 V reflects the strength of the peripheral blood flow signal; consistent amplitude indicates proper vascular perfusion, while reduced amplitude may suggest weak circulation, hypotension, or vascular obstruction.

Pulse transit time (PTT), observed as 155 ms, is an important parameter used to evaluate arterial stiffness and vascular elasticity. Normal PTT values typically range between 150–200 ms, and the observed value indicates healthy vascular conditions. A decrease in PTT may indicate increased arterial stiffness, which is commonly associated with hypertension or vascular diseases such as atherosclerosis, while increased PTT may reflect reduced vascular tone. In certain pathological conditions, such as AAA, alterations in arterial wall structure can lead to detectable variations in pulse propagation characteristics, which may be reflected in abnormal PTT values.

The signal quality metric, measured at 94%, indicates the reliability and integrity of the acquired physiological signals. High signal quality ensures that the measurements are minimally affected by noise, motion artifacts, or improper electrode placement. Lower signal quality values may compromise the accuracy of analysis and can lead to misinterpretation of physiological conditions. Therefore, this parameter plays a crucial role in validating the credibility of the system output.

Overall, Table I serves as a consolidated representation of both gastric and vascular parameters, linking measured values with their physiological and clinical significance. The consistency of all observed values within normal ranges confirms the proper functioning of the system under test conditions. Additionally, the inclusion of interpretation alongside each parameter enhances usability by enabling users to quickly identify potential abnormalities and relate them to possible underlying conditions. This structured representation supports the system's objective of providing a reliable, user-friendly, and clinically relevant monitoring solution.

## V. CONCLUSION

This paper presents VITA-CORE, a low-cost integrated system for simultaneous gastric and vascular signal monitoring. The system successfully combines Arduino-based hardware with efficient digital signal processing techniques to acquire, filter, and analyze physiological signals in real time. The implementation demonstrates that reliable biomedical signal monitoring can be achieved using affordable and accessible components without relying on complex clinical infrastructure.

The use of appropriate filtering techniques and Fast Fourier Transform (FFT) enables accurate extraction of gastric slow-wave activity, ensuring that the dominant frequency components are preserved while minimizing noise and interference. The CPM-based classification approach provides a simple yet effective method for interpreting gastric rhythms, allowing differentiation between normal and abnormal conditions. In addition, the integration of pulse signal monitoring enhances the system's capability by providing complementary cardiovascular information, resulting in a more comprehensive physiological assessment.

Experimental results confirm that the system is capable of stable signal acquisition, real-time visualization, and automated parameter extraction. The graphical interface and diagnostic output improve usability and make the system suitable for both technical and non-technical users. Although the system does not aim to replace clinical-grade EGG devices, it serves as a practical and cost-effective alternative for research, academic learning, and preliminary health monitoring applications.

Further improvements may include the integration of wireless communication modules and cloud-based data storage to enable remote monitoring and telemedicine applications. The incorporation of mobile or web-based interfaces can also improve accessibility and user interaction. Future work can focus on enhancing system reliability and accuracy by integrating dedicated hardware components such as wearable abdominal belts for stable electrode placement and PPG or pressure-based sensors for improved cardiovascular signal acquisition. With extensive validation and optimization, the proposed system can be extended toward clinically supportive applications, contributing to the development of affordable and scalable healthcare monitoring solutions.

In conclusion, the VITA-CORE system demonstrates a balanced approach between cost, performance, and functionality, highlighting its potential as an innovative solution in the field of biomedical instrumentation and real-time health monitoring.

## APPENDIX

### SOURCE CODE AND REPOSITORY

The complete firmware for the Arduino Nano and ESP32, as well as the Python scripts for real-time visualization, are hosted on GitHub for open-access replication.
Link: https://github.com/Thasleema-Biomedical/VITA-CORE.git

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