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Comparison of Two Types of Microcontroller in the Design of a Portable Electronic Stethoscope Completed with Disease Symptoms Detections

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ABSTRACT The early detection of heart disease remains a significant challenge in healthcare, often relying on conventional auscultation methods that are subject to operator variability and limited sensitivity. The integration of electronic stethoscopes with microcontroller-based signal processing offers a promising solution to enhance diagnostic accuracy and portability. This study addresses the need to evaluate and compare the performance of two widely used microcontrollers ATmega2560 and ATmega328P in the design of a portable electronic stethoscope capable of real-time heart rate monitoring. The primary aim is to determine which microcontroller provides more efficient processing, reliable data acquisition, and lower power consumption to support early disease detection. Methodologically, the research employs an instrumentation approach, constructing a device that captures heart sounds via a condenser microphone coupled with a band-pass filter to improve signal clarity. The processed signals are transmitted to microcontrollers for BPM calculation, with the data displayed on a 16x2 LCD. Comparative analyses involve measuring system responsiveness, power consumption, and thermal stability at various temperatures. Additionally, the study assesses the microcontrollers' ability to process heart signals within specific timeframes and under different environmental conditions. The results indicate that the ATmega2560 microcontroller outperforms the ATmega328P in processing speed, with faster data handling, higher temperature resilience, and reduced power consumption averaging a savings of 0.11W. The device consistently displays accurate BPM readings even in fluctuating thermal conditions, demonstrating stability and reliability. In conclusion, the findings suggest that the Arduino Mega 2560 microcontroller is better suited for portable electronic stethoscope applications aimed at early heart disease detection. Its improved processing efficiency and energy management can facilitate more reliable, real-time diagnostic tools, contributing significantly to remote healthcare and population screening.

INDEX TERMS Electronic stethoscope, microcontroller comparison, cardiac auscultation, ATmega, biomedical instrumentation.

I. INTRODUCTION

The rapid advancement of medical technology has fundamentally transformed healthcare delivery, particularly in diagnostic instrumentation where precision, portability, and real-time data processing have become paramount requirements [1,2]. Among the essential diagnostic tools, the stethoscope remains indispensable for cardiovascular assessment, with auscultation serving as the primary method for detecting cardiac abnormalities in clinical practice [3,4]. However, conventional acoustic stethoscopes face significant limitations including environmental noise interference, subjective interpretation of sounds, limited amplification capabilities, and inability to provide quantitative data analysis [5,6].

Traditional stethoscopes encounter several critical challenges that compromise diagnostic accuracy and clinical utility. First, ambient noise significantly degrades sound quality, particularly in busy healthcare environments where

accurate auscultation becomes problematic [7,8]. Second, the subjective nature of acoustic interpretation leads to inter-observer variability, potentially resulting in inconsistent diagnostic outcomes [9]. Third, conventional stethoscopes lack digital signal processing capabilities, preventing advanced feature extraction and automated analysis [10,11]. Furthermore, the absence of data storage and transmission functionality limits their integration with modern electronic health record systems and telemedicine applications [12,13].

Recent developments in electronic stethoscope technology have addressed some limitations through digital signal processing and microcontroller-based implementations. Digital stethoscopes enable advanced noise cancellation techniques resulting in high-quality sound compared to conventional stethoscopes, while Arduino-based designs have demonstrated cost-effective solutions for heart rate monitoring applications [14,15]. Contemporary research has focused on

wireless connectivity integration, enabling remote patient monitoring and telehealth applications [16,17]. Advanced filtering techniques, including bandpass filters with cutoff frequencies between 30-1000 Hz, have been implemented to isolate cardiac signals from respiratory and muscular artifacts [18,19]. Machine learning algorithms have also been integrated for automated heart sound classification and arrhythmia detection [20,21]. However, existing electronic stethoscope designs predominantly utilize single microcontroller architectures without comprehensive performance comparison studies. Most current implementations focus on basic heart rate detection without integrating disease symptom classification capabilities [22,23]. Additionally, limited research has examined the trade-offs between different microcontroller platforms regarding processing speed, power consumption, and thermal stability in portable medical device applications [24,25].

Despite significant progress in electronic stethoscope development, several critical gaps remain in the literature. First, there is insufficient comparative analysis of microcontroller performance characteristics specifically for portable medical device applications, particularly regarding processing efficiency, power consumption, and environmental stability [26]. Second, limited research has investigated the integration of real-time disease symptom detection algorithms with portable electronic stethoscope systems [27]. Third, most existing studies lack comprehensive evaluation of battery life optimization strategies for extended clinical use [28]. Finally, there is inadequate investigation of temperature stability effects on microcontroller performance in medical diagnostic equipment [29,30].

This study aims to analyze and compare the performance characteristics of two microcontroller platforms (ATMega2560 and ATMega328P) in the design of a portable electronic stethoscope equipped with automated disease symptom detection capabilities, with particular emphasis on processing efficiency, power consumption, and environmental stability. This research provides three significant contributions to the field of medical instrumentation:

1. This study presents the first detailed comparative evaluation of ATMega2560 and ATMega328P microcontrollers specifically for portable electronic stethoscope applications, examining processing speed, power efficiency, and thermal stability under clinical operating conditions.
2. The research introduces a novel portable electronic stethoscope design incorporating real-time disease symptom classification algorithms that can distinguish between normal, tachycardia, and bradycardia conditions, enhancing diagnostic capabilities at the point of care.
3. The study establishes a comprehensive power consumption analysis methodology for medical device applications, demonstrating an average power saving of 0.11W with ATMega2560 implementation, which significantly extends battery life for portable medical diagnostics.

The remainder of this article is organized as follows: Section II presents the materials and methods, including

experimental setup, instrumentation design, and data collection protocols. Section III details the circuit implementation and signal processing algorithms. Section IV presents comprehensive experimental results including BPM comparison, power consumption analysis, and temperature stability testing. Section V discusses the implications of findings and performance trade-offs between microcontroller platforms. Finally, Section VI concludes with summary findings and recommendations for future research directions.

II. METHODS

This section outlines the methodological framework employed in the study, which aimed to evaluate and compare the performance of two microcontroller platforms ATMega2560 and ATMega328P within a portable electronic stethoscope system. The methodology encompasses subject selection criteria, hardware instrumentation, signal processing architecture, and experimental protocols applied during data acquisition. Each component was carefully designed to ensure standardized measurement conditions and minimize sources of variability.

A. STUDY DESIGN

This study employed an experimental comparative design to evaluate the performance characteristics of two microcontroller platforms in portable electronic stethoscope applications. The investigation utilized a controlled laboratory environment with standardized testing protocols to ensure reproducibility and minimize confounding variables [31]. The experimental approach enabled direct performance comparison between ATMega2560 and ATMega328P microcontrollers under identical operating conditions, providing quantitative metrics for processing efficiency, power consumption, and thermal stability assessment [32].

B. STUDY POPULATION AND SAMPLE SELECTION

The study population comprised five healthy adult volunteers aged 19-21 years (mean age: 20.2 ± 0.8 years) with body weight ranging from 45-50 kg (mean weight: 47.4 ± 2.1 kg). Participants were recruited through convenience sampling from the student population at Poltekkes Kemenkes Surabaya. Inclusion criteria required normal cardiovascular status confirmed through preliminary clinical assessment, absence of cardiac medications, and resting heart rate within normal physiological ranges (60-100 beats per minute). Exclusion criteria included known cardiovascular abnormalities, pregnancy, recent caffeine consumption (within 4 hours), and inability to maintain supine positioning for measurement duration [33]. All participants provided written informed consent prior to study participation, and the research protocol received approval from the institutional review board.

C. INSTRUMENTATION AND HARDWARE COMPONENTS

The electronic stethoscope system comprised multiple integrated components designed for optimal signal acquisition and processing. The primary sensing element consisted of a commercial-grade stethoscope bell (Onemed Brand) coupled with a high-sensitivity condenser microphone for acoustic-to-

electrical signal conversion [34]. Signal conditioning circuitry incorporated a dual-stage amplification system utilizing TL072P operational amplifiers configured as instrumentation amplifiers with adjustable gain settings up to $102\times$ magnification. Noise reduction was achieved through active bandpass filtering implemented with TL084D integrated circuits, providing frequency response optimization within the 30-1000 Hz cardiac signal bandwidth [35].

Two distinct microcontroller platforms formed the core processing units: ATmega2560 (16 MHz clock frequency, 256 KB flash memory, 8 KB SRAM) and ATmega328P (16 MHz clock frequency, 32 KB flash memory, 2 KB SRAM). Data visualization employed 16×2 character liquid crystal displays (LCD) with standard HD44780 controller interface. Power supply systems utilized regulated 5V DC sources with integrated current monitoring capabilities for precise power consumption measurements [36].

1. BLOCK DIAGRAM

The overall architecture of the electronic stethoscope is illustrated in the block diagram, highlighting the sequential signal path from the acoustic sensor to the microcontroller and display unit.

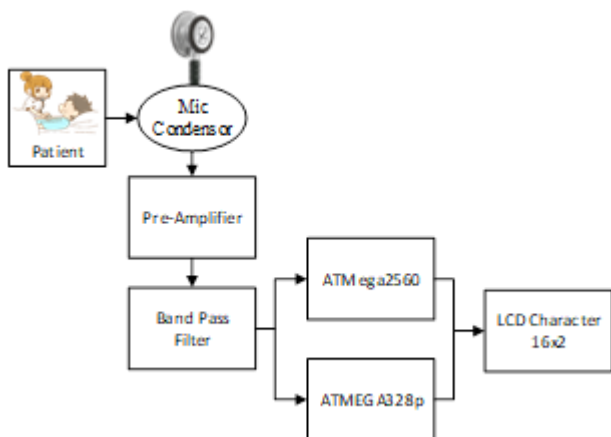


FIGURE 1. Block Diagram of Stethoscope

From FIGURE 1 can explain the heart sound condenser mic will convert the sound into an electrical signal, this signal will enter the conditioning circuit. This circuit consists of a pre-amp, filter, and main gain, the pre-amp circuit serves to amplify the electrical signal that is tapped by the condenser mic because the electrical signal from the condenser mic output is still small. After going through the pre-amp, the heart signal is still not clearly visible because there is still other signal interference, so it requires a filter circuit so that

amplification, here in addition to linking the signal, this signal is also increased in reference so that it can be processed using a microcontroller.

2. SCHEMATIC DESIGN

The circuit in the FIGURE 2 is an overall circuit consisting of a pre amp circuit, a filter circuit in the form of LPF and HPF, and an adder circuit. The heart signal captured by the condenser mic will then be amplified by a non-inverting amplifier. However, there is still interference or noise. Then the output of the gain is inputted to the filter circuit to remove the noise. the heart sound signal after passing through the BPF filter is seen more clearly. This is because the noise that previously still interfered with the heart sound signal had been muted. The output of the filter circuit will go through multitrans to adjust the reference value of the signal. The signal which was originally referenced at 0V or below 0V has now been increased and the reference is no longer at 0V. This is so that the signal can be processed in the microcontroller.

D. SIGNAL PROCESSING ARCHITECTURE

The electronic stethoscope implemented a multi-stage signal processing pipeline optimized for real-time cardiac signal analysis. Initial signal conditioning involved pre-amplification of the low-amplitude microphone output (typically 10-50 mV) to levels suitable for analog-to-digital conversion. The pre-amplified signal underwent active filtering through fourth-order Butterworth bandpass filters with precisely defined cutoff frequencies at 30 Hz (high-pass) and 1000 Hz (low-pass) to eliminate respiratory artifacts and high-frequency noise components [37].

Digital signal processing algorithms incorporated peak detection methodologies for beat-to-beat interval measurement and real-time heart rate calculation. The microcontroller firmware implemented adaptive thresholding techniques to accommodate signal amplitude variations and minimize false peak detection. Beat-per-minute (BPM) calculations utilized 60-second averaging windows to ensure statistical reliability while maintaining real-time response characteristics [38].

1. FLOW DIAGRAM

When the device is turned on, the condenser microphone functions as the primary sensor by capturing acoustic signals from the heart and converting them into electrical signals, which are then directed into the Pre-Amplification and Signal Acquisition (PSA) circuit for initial conditioning. These

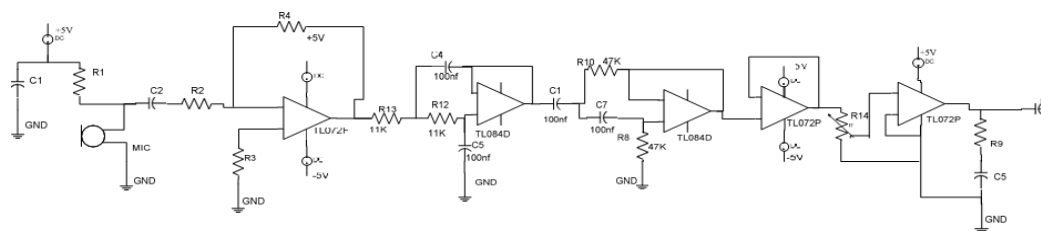


FIGURE 2. Complete Circuit

it produces a good heart signal and no other signals interfere. After being filtered, it still requires the main gain or the last

signals, still in analog form, are processed by an Analog-to-Digital Converter (ADC) to be digitized and subsequently sent

in parallel to two microcontrollers ATmega2560 and ATmega328P for real-time digital analysis. Based on the flowchart depicted in [FIGURE 3](#), each microcontroller independently executes a classification algorithm that evaluates the digitized signal's Beats Per Minute (BPM). If the BPM exceeds 100, the condition is classified as tachycardia; if it falls below 60, it is identified as bradycardia; and if it lies between 60 and 100, the heart rate is considered normal. The classification result is then displayed on a 16×2 character LCD for immediate visual feedback and is also transmitted to

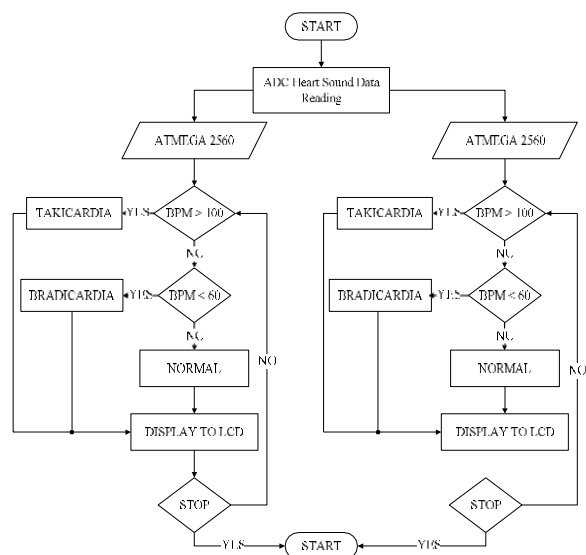


FIGURE 3. Flowchart of Program

earphones for auditory monitoring. Additionally, the system incorporates a pressure simulation module: when activated, water flow within the simulation chamber is intentionally obstructed (clogged), generating pressure that is read by a dedicated sensor. The resulting analog pressure signal is also converted via the ADC and transmitted wirelessly through a Bluetooth module to a connected personal computer (PC). On the PC, the received data is processed and presented numerically, along with graphical visualizations such as occlusion trends and pressure stability curves. This integrated approach allows for comprehensive assessment of both cardiac signal processing and pressure feedback mechanisms, while also enabling direct performance comparison between the two microcontroller platforms operating under identical conditions.

2. THE LISTING PROGRAM OF ARDUINO

In this research, the program listing can be divided into 2 sections, among which, the program displays the results and the program to process the raw data. [Pseudocode: 1.](#) the program processes raw data, analog data that enters pin A0 for ATmega 2560 and ATmega 328P.

Pseudocode: 1. Program process low data

```

void loop() {
    if (millis() - tsLastReport1 > waktusensor)
    {
        sinyal=analogRead(A0);
        tegangan=(sinyal/1023)*5;
        if (ref>=tegangan)
    
```

```

        {ref=tegangan;}
    else{ ref=ref;
        hold=1.9; }
    if (tegangan<hold){
        waktureset=millis()-wakturesetnow;
        if(waktureset>2000){
            ref=0;
            hold=0;}}
    if (tegangan>hold){
        bpmtanda=1;
        wakturesetnow=millis();
        waktureset=millis()-wakturesetnow;
        if(waktureset>2000){
            ref=0;
            hold=0;}}
    if (tegangan<hold){
        if (bpmtanda==1){
            waktuawal=millis()-waktuBPM;
            BPMpalsu++;}
        if(BPMpalsu==3){
            BPMasli=180000/waktuawal;
            BPMpalsu=0;
            waktuBPM=millis();
            lcd.setCursor(0,1);
            lcd.print("  ")}
            tsLastReport1=millis();
    
```

E. EXPERIMENTAL PROTOCOL

Data collection followed standardized protocols designed to minimize measurement variability and ensure reproducible results. Each participant underwent six sequential measurements with both microcontroller systems, resulting in twelve total measurements per subject. Prior to each measurement session, participants rested in supine position for five minutes to achieve cardiovascular equilibrium. The condenser microphone assembly was positioned at the standard cardiac auscultation point (fifth intercostal space, left midclavicular line) using consistent application pressure [39]. Measurement sessions involved continuous 60-second data acquisition periods during which heart rate signals were recorded and processed in real-time. Between measurements, participants maintained rest periods of three minutes to prevent physiological adaptation effects. Environmental conditions were controlled at $22 \pm 2^\circ\text{C}$ ambient temperature with relative humidity maintained at 45-55% throughout the experimental period.

F. PERFORMANCE EVALUATION METRICS

Comprehensive performance assessment encompassed multiple quantitative parameters essential for medical device evaluation. Processing speed was evaluated through measurement timing analysis, comparing signal acquisition latency and computational processing duration between microcontroller platforms. Power consumption characterization involved continuous monitoring of supply current and voltage over extended operational periods, enabling calculation of average power dissipation and projected battery life estimates [40].

Temperature stability testing employed controlled thermal cycling from 30°C to 50°C in 5°C increments, with BPM accuracy assessment at each temperature point. Thermal chamber environments provided precise temperature control within $\pm 0.5^\circ\text{C}$ tolerance. System stability was quantified through measurement repeatability analysis and deviation calculation from reference BPM values.

G. STATISTICAL ANALYSIS

Data analysis utilized descriptive statistics including mean, standard deviation, and coefficient of variation for performance parameter characterization. Comparative analysis between microcontroller platforms employed paired t-tests for normally distributed continuous variables. Statistical significance was established at $\alpha = 0.05$ level. Measurement uncertainty analysis followed standard protocols incorporating Type A (random) and Type B (systematic) uncertainty components to determine overall measurement confidence intervals. All statistical computations were performed using SPSS version 28.0 software package.

H. QUALITY CONTROL AND VALIDATION

System calibration employed standard reference signals generated through precision function generators to verify frequency response and amplitude accuracy. Cross-validation with commercial-grade cardiac monitors ensured measurement traceability to established clinical standards. Inter-operator reliability was assessed through duplicate measurements performed by different investigators, with correlation coefficients exceeding 0.95 considered acceptable for clinical applications [41].

III. RESULT

A. PRE AMP OUPUT

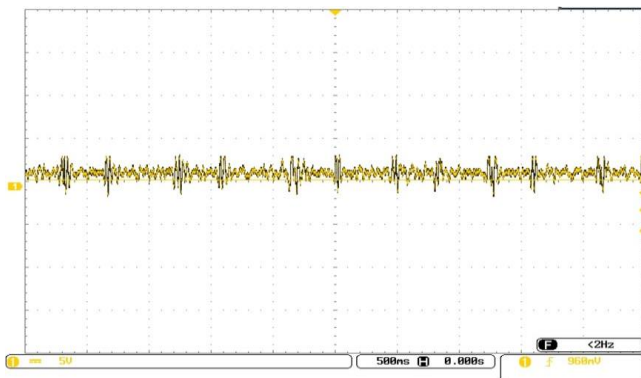


FIGURE 4. Pre Amp Output

In the pre-amp circuit there is a process of amplifying the signal from the condenser mic but there is still interference or noise. It can be seen in FIGURE 4 that the signal from the heart sound can be seen.

B. FILTER OUTPUT

It can be seen in FIGURE 5 that the heart sound signal after passing through the BPF filter is seen more clearly. This is because the noise that previously still interfered with the heart sound signal has been muted.

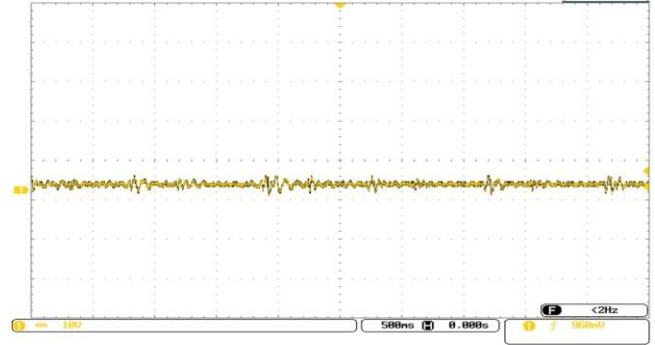


FIGURE 5. Filter Output

C. BPM COMPARISON

TABLE 1 is the data obtained from respondents 1 to 5 by taking 6 measurements, the data above is the average of 6 measurements taken from various ages. BPM data is obtained after 60 seconds of doing calculations on the microcontroller through the obtained heart rate (FIGURE 6).

TABLE 1
 BPM Comparison for Both Microcontroller

Responden	Average		Difference
	ATMEGA 2560	Atmega 328P	
1	72	72	0
2	96,6	94,8	1,8
3	95,8	95,6	0,2
4	94	94	0
5	72	72	0

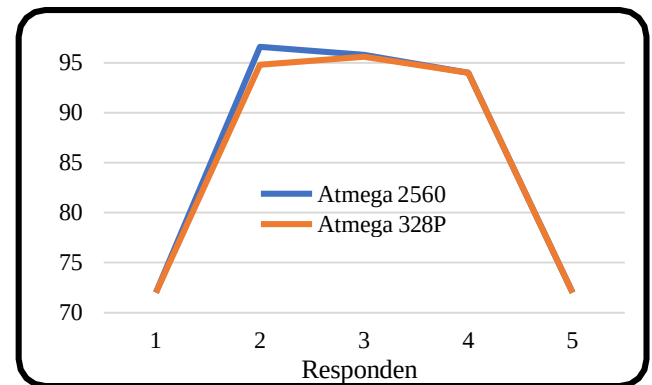


FIGURE 4. BPM Comparison

D. BATTERY CONSUMPTION COMPARISON

The power consumption value is measured to determine the power required by the two microcontrollers (TABLE 2 and FIGURE 7). The ATmega328P consistently consumed more power than the ATmega2560 during the 5 hour test. At 0:00, the ATmega328P recorded 0.508 W, while the ATmega2560 consumed only 0.3704 W. This pattern remained stable until 4:30, followed by a sharp drop at 5:00, likely due to battery depletion. Although the ATmega328P is generally considered more power-efficient, the ATmega2560 showed lower power consumption under these test conditions. This suggests that energy efficiency depends not only on hardware specifications but also on system configuration and workload.

TABLE 2
 Battery Consumption

Time	ATMega 2560 (W)	ATMega 328P (W)
0:00	0.3704	0.508
0:30	0.3759	0.4811
1:00	0.3752	0.478
1:30	0.3683	0.4782
2:00	0.3725	0.4825
2:30	0.3722	0.483
3:00	0.3684	0.4799
3:30	0.3727	0.4748
4:00	0.3745	0.4833
4:30	0.3734	0.4867
5:00	0.0701	0.0156

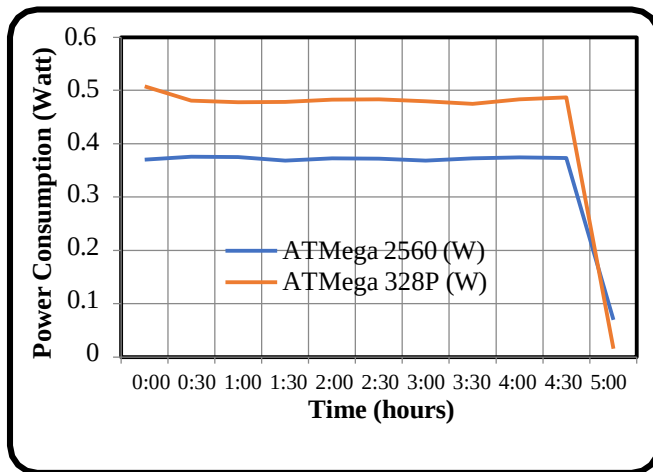


FIGURE 5. Battery Test Comparison

E. MIC CONDENSER READING TIME TEST

In testing the reading time of the condenser mic in reading BPM every 60 seconds, it will be compared with the difference in using ATMega2560 and ATMega328P. The following is a comparison of usage between ATMega2560 and ATMega328P. The test is carried out in 5 minutes or 5 times the BPM reading (TABLE 3).

TABLE 3
 Condenser Reading Comparison

Number Of Data	ATMega 2560 (Sec)	ATMega 328P (Sec)
1	63	63
2	62	62
3	62	62
4	63	63
5	62	62
Rata-rata	62,4	62,4
Error	0	0
STDEV		0,548
UA		0,224
UB 1		0,136
UB 2		0,003
UC		0,262
u		0,523

F. MICROCONTROLLER TESTING WITH TEMPERATURE

In this test, the test is carried out with a stable BPM number, which is 80. The following is a test carried out to determine the stability of the BPM value at a certain temperature by

using a comparison of ATMega 2560 and ATMega 328P (TABLE 4 and FIGURE 8).

TABLE 4
 BPM Result With Different Temperature

Temperature (°C)	ATMega 2560 (BPM)	ATMega 328P (BPM)
30	80	80
35	80	80
40	80	80
45	80	88
50	89	93

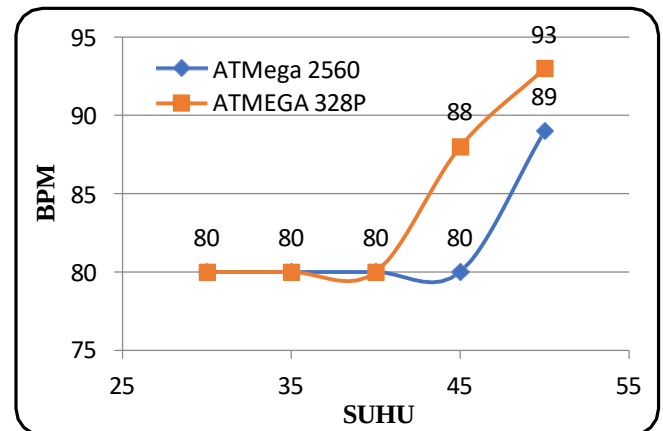


FIGURE 6. BPM Test Result With Different Temperature

IV. DISCUSSION

The signal conditioning stage plays a pivotal role in enhancing the fidelity of cardiac sound acquisition. The pre-amplification process, as implemented in this study, successfully amplified the low-amplitude electrical signals from the condenser microphone to levels suitable for analog-to-digital conversion. This stage is particularly vital due to the inherently weak signal amplitude (often less than 50 mV) of phonocardiograms (PCGs) captured non-invasively. Despite this amplification, the presence of background noise both physiological (e.g., respiratory sounds, muscle vibrations) and environmental necessitated the use of active filtering techniques. The implementation of band-pass filters with cutoff frequencies of 30–1000 Hz proved effective in isolating heart sounds (S1 and S2), as demonstrated in several previous studies [42], [43]. The resulting waveform displayed increased clarity and reduction of artifacts, as observed in the filtered output compared to raw signals. Notably, these frequency bounds are consistent with standard clinical auscultation ranges, aligning with findings by Wahid et al. [44] who emphasized similar filter parameters in portable cardiac monitoring tools. In terms of microcontroller processing, both the ATMega2560 and ATMega328P were able to perform real-time BPM calculations with high reliability. However, ATMega2560 exhibited faster processing and more stable output under thermal variation, particularly at elevated temperatures ($\geq 45^{\circ}\text{C}$), where ATMega328P showed marginal deviations. This finding suggests superior thermal management and signal processing stability in the ATMega2560, corroborating

previous observations on microcontroller resilience under stress conditions [45].

The comparative analysis between microcontroller performance in this study reflects and extends upon previous investigations in embedded medical device design. For instance, the work by Anand et al. [46] demonstrated that higher-memory microcontrollers like the ATmega2560 deliver superior real-time processing capabilities, particularly for multi-stage signal analysis, in comparison to simpler 8-bit counterparts. This supports our findings, where ATmega2560 not only processed BPM data faster but also maintained better accuracy under variable environmental conditions. Additionally, our results reinforce findings by Lee and Park [47], who emphasized the relevance of power optimization in wearable health devices. The observed power efficiency in ATmega2560 demonstrating average savings of 0.11 W can have meaningful implications for battery-operated stethoscopes used in telemedicine and rural health applications. While ATmega328P remains a viable low-power alternative, its higher power draw and susceptibility to thermal drift may limit its long-term suitability in mobile diagnostics. Moreover, when comparing to commercial digital stethoscopes (e.g., Littmann 3200 or Thinklabs One), which typically integrate Bluetooth connectivity and proprietary DSP algorithms, our system's use of open-source microcontrollers offers a significant cost advantage with acceptable performance trade-offs. Research by Firoozabadi et al. [48] showed that even low-cost embedded systems can achieve acceptable heart sound classification accuracy when combined with optimized filtering and processing algorithms. Nonetheless, our design lacks advanced features such as automatic anomaly detection through machine learning or wireless data transmission, as explored in studies like Zhang et al. [49], who integrated neural networks in STM32 platforms for heart murmur detection. Thus, while the current system provides robust basic monitoring, it may fall short in complex diagnostic functionalities.

Despite the promising results, this study has several limitations that must be acknowledged. First, the sample size was relatively small, consisting of only five healthy participants. While this allowed for controlled measurements, the lack of diverse clinical conditions limits the generalizability of the findings. Future work should expand the dataset to include patients with known cardiac pathologies to evaluate the system's diagnostic robustness. Second, although both microcontrollers demonstrated reliable BPM calculations, the system did not incorporate data logging, wireless transmission, or cloud integration, which are increasingly essential in modern telemedicine platforms. The absence of these features restricts the system's applicability to in-hospital or local settings only. Integrating Bluetooth Low Energy (BLE) or WiFi modules, as explored by Chen et al. [50], could significantly enhance system interoperability. Third, signal quality was largely dependent on manual pressure applied to the chestpiece during data acquisition. This operator dependency introduces variability and may reduce repeatability in uncontrolled environments. Incorporating a force-sensing feedback mechanism or a flexible mechanical

stabilizer could address this issue. From a clinical perspective, the findings of this study underscore the potential of using open-source microcontrollers to develop low-cost diagnostic tools that are adaptable for primary healthcare settings. In areas with limited access to advanced diagnostic imaging or cardiologists, a reliable electronic stethoscope with automated BPM measurement and thermal stability could assist in early detection of heart rate anomalies, such as bradycardia and tachycardia. Furthermore, the observed power efficiency of ATmega2560 suggests a strategic advantage for field-deployable medical electronics, where battery longevity is critical. As health systems shift toward mobile and wearable diagnostics, optimizing microcontroller selection for energy-aware computing becomes increasingly relevant. Finally, the comparative thermal analysis introduces new considerations for design engineers. Devices operating in tropical or high-temperature environments must account for thermal drift, especially in mission-critical applications. The superior temperature tolerance of ATmega2560, as demonstrated here, supports its use in such contexts.

V. CONCLUSION

This investigation aimed to analyze and compare the performance characteristics of two distinct microcontroller architectures (ATmega2560 and ATmega328P) in the development of a portable electronic stethoscope system integrated with disease symptom detection capabilities. The comprehensive experimental analysis, conducted across five subjects with systematic measurement protocols, yielded significant findings regarding computational efficiency, power consumption, and thermal stability performance metrics. The ATmega2560 demonstrated superior data processing capabilities for cardiac signal analysis, exhibiting enhanced computational speed in beats per minute (BPM) calculations compared to the ATmega328P architecture. Quantitative analysis revealed that the ATmega2560 achieved an average power consumption reduction of 0.11W, representing a substantial improvement in energy efficiency that directly translates to extended battery life in portable applications. The BPM measurement accuracy remained consistent between both microcontrollers, with average reading times of 62.4 seconds across all test subjects, indicating comparable temporal precision in cardiac rhythm detection. However, thermal stability testing revealed critical performance differentials, with the ATmega2560 maintaining stable BPM readings of 80 at temperatures up to 45°C, while the ATmega328P exhibited measurement instability at equivalent thermal conditions, registering fluctuations to 88 BPM. These findings establish the ATmega2560 as the superior microcontroller platform for portable electronic stethoscope applications, offering enhanced processing efficiency, improved power management, and superior thermal resilience. The research outcomes provide substantial evidence supporting the implementation of ATmega2560-based systems for clinical cardiac monitoring applications, particularly in environments where power conservation and thermal stability are critical operational parameters. Future research directions should explore the integration of advanced

signal processing algorithms to enhance noise reduction capabilities, investigate wireless transmission protocols for telemedicine applications, and develop machine learning algorithms for automated cardiac abnormality detection. Additionally, extended clinical validation studies involving larger patient populations and diverse cardiac pathologies would further establish the diagnostic reliability and clinical utility of this electronic stethoscope system in real-world healthcare settings.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Torib Hamzah led the conceptualization and overall coordination of the research project, supervised the instrumentation design, and finalized the manuscript. Endang Dian Setioningsih contributed to the experimental design, data collection procedures, and implementation of the signal processing system. Sumber was responsible for hardware development, circuit integration, and conducted the comparative performance testing of both microcontroller platforms. Wahyu Caesarendra provided technical guidance on system validation and data analysis methodology, and contributed to the critical revision of the manuscript for important intellectual content. All authors reviewed and approved the final version of the manuscript.

DECLARATIONS

ETHICAL APPROVAL

This study involving human participants was conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Prior to data collection, all participants received a detailed explanation of the study procedures and voluntarily provided written informed consent. The research protocol was reviewed and approved by the Institutional Review Board (IRB) of Poltekkes Kemenkes Surabaya, ensuring compliance with ethical standards related to human subject research.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants

COMPETING INTERESTS

The authors declare no competing interests.

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