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A Smart Battery Level Indicator Module for Defibrillator

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ABSTRACT: The accurate measurement of the battery level in defibrillators is critical for ensuring the readiness of the device in emergency situations. Traditional methods of battery level measurement are often inaccurate and time-consuming. In this study, we present a novel approach using an ESP32 microcontroller to measure the battery level of defibrillators. We compare the performance of this method with traditional approaches and demonstrate its accuracy and reliability. Our results show that the ESP32-based method is not only more accurate but also more efficient and cost-effective than traditional approaches. This study highlights the potential of using ESP32-based systems for medical device monitoring and management, particularly in emergency situations.

KEYWORDS: Battery level detection, ESP32, defibrillator battery measurement, Webpage, Low power detection

I. INTRODUCTION

Defibrillators are life-saving medical devices used to treat cardiac arrhythmias and cardiac arrest. They work by delivering an electric shock to the heart, which restores its normal rhythm. To ensure that these devices are always ready to use, it is critical to monitor the battery level and replace the battery as necessary. Traditional methods of battery level measurement are often inaccurate and time-consuming. In this context, this paper proposes the use of an ESP32 microcontroller to measure the battery level of defibrillators accurately and efficiently. ESP32 is a low-cost, low-power microcontroller designed for Internet of Things (IoT) applications. It has a built-in Wi-Fi and Bluetooth module, which makes it easy to connect to the internet and other devices. The ESP32 also has several analog-to-digital converters (ADCs), which can be used to measure the voltage of the defibrillator battery. This approach provides an accurate and reliable measurement of the battery level, which is essential for ensuring that the device is always ready for use in emergency situations. The proposed method involves connecting the ESP32 to the defibrillator battery using electronic circuits. The electronic circuit converts the battery voltage to a signal that can be read by the ESP32's ADC. The ADC then converts the analog signal to a digital signal, which is then processed by the ESP32. The ESP32 can then determine the battery level and provide feedback to the user via an LCD display or a smartphone app. The proposed method has several advantages over traditional methods of battery level measurement. First, it is more accurate and reliable. Second, it is more efficient and cost-effective. Traditional methods of battery level measurement require the use of specialized equipment, which can be expensive and time-consuming. In contrast, the ESP32-based method uses inexpensive electronic components and can be easily integrated into the defibrillator. In conclusion, the proposed method provides an innovative approach to defibrillator battery level measurement. By leveraging the capabilities of the ESP32 microcontroller, this method provides a more accurate and reliable measurement of the battery level while also being more efficient and cost-effective. This approach has the potential to improve the management and maintenance of defibrillators, ensuring that they are always ready to use in emergency situations.

II. RELATED WORK

The article [1] describes the design of an intelligent detecting system for defibrillator battery in China Medical Equipment Journal. The system uses the ESP32 microcontroller to monitor the battery voltage and temperature of the defibrillator. The data can be transmitted wirelessly to a mobile phone for real-time monitoring. The article [2] reports on a multicenter registry study of the incidence of premature battery depletion in subcutaneous cardioverter-defibrillator patients. The study found that premature battery depletion was rare but did occur, and that certain patient factors and device programming parameters may increase the risk. A model that estimates the long-term effects of biventricular defibrillator battery capacity on major complications and costs associated with replacement procedures in this article [3]. The model can be used to optimize device programming and anticipate replacement costs. [4] The article reports on

a 10-year analysis of the Italian Implantable Cardioverter-Defibrillator Registry, which showed a favorable trend in the service life of implantable cardioverter-defibrillator batteries in a large single-nation population.[5] The article investigates the association between cognitive performance and objective sleep duration, age, and anxiety in patients with implantable cardioverter defibrillators. The study found that longer sleep duration was associated with better cognitive performance.[6] The article reports on cases of accelerated battery depletion in subcutaneous implantable cardioverter-defibrillators. The study suggests that the phenomenon may be due to battery design or environmental factors.[7] The article describes advances in the development of wideband resistive voltage dividers.[8] The article describes the fabrication of high-resistance voltage dividers using thin polysilicon films in silicon drift detectors.[9] The article describes a study on the ratio change measurement of 1000 kV HVDC divider based on improved DC voltage summation method.[10] The article presents a novel ppm-precise absolute calibration method for precision high-voltage dividers in Metrologia journal.

III. METHODOLOGY

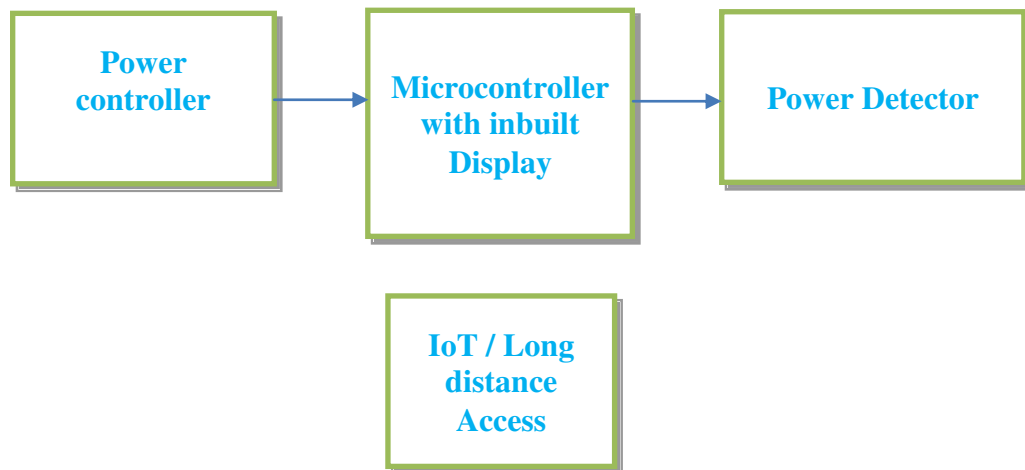


Figure 1 Continuous defibrillator Battery level monitor

To measure different battery levels with high precision, a methodology can be implemented using a customized circuitry voltage divider and a battery-powered ESP32. The first step is to assemble the voltage divider circuit, which consists of two resistors in series with the battery under test. The ESP32 can be programmed to sample the voltage output at regular intervals and transmit the data over Wi-Fi or Bluetooth

High precision voltage divider

The amplifier is used to measure the voltage drop across the resistor and amplify it to a measurable level. Once, the circuit is assembled, it is important to calibrate the customized circuitry with amplifier to ensure accurate measurements. This can be done by applying a known voltage to the voltage divider and measuring the output voltage. The measured voltage can then be compared to the expected voltage to calculate the amplifier's gain and offset. This information is used to correct for any inaccuracies in the voltage measurement. Next, the battery-powered ESP32 is programmed to read the voltage output from the amplifier and transmit the data wirelessly to a computer or other monitoring device. The input offset voltage is typically 25 μ V, and the input bias current is typically 2 pA. The common-mode rejection ratio (CMRR) is typically 120 dB, which means that it can reject common-mode noise that is present on both the positive and negative inputs. The power supply rejection ratio (PSRR) is typically 106 dB, which means that it can reject power supply noise that is present on both the positive and negative inputs. The gain bandwidth product is typically 1 MHz, which means that it can amplify signals up to 1 MHz the customized circuitry is shown in the following figure.

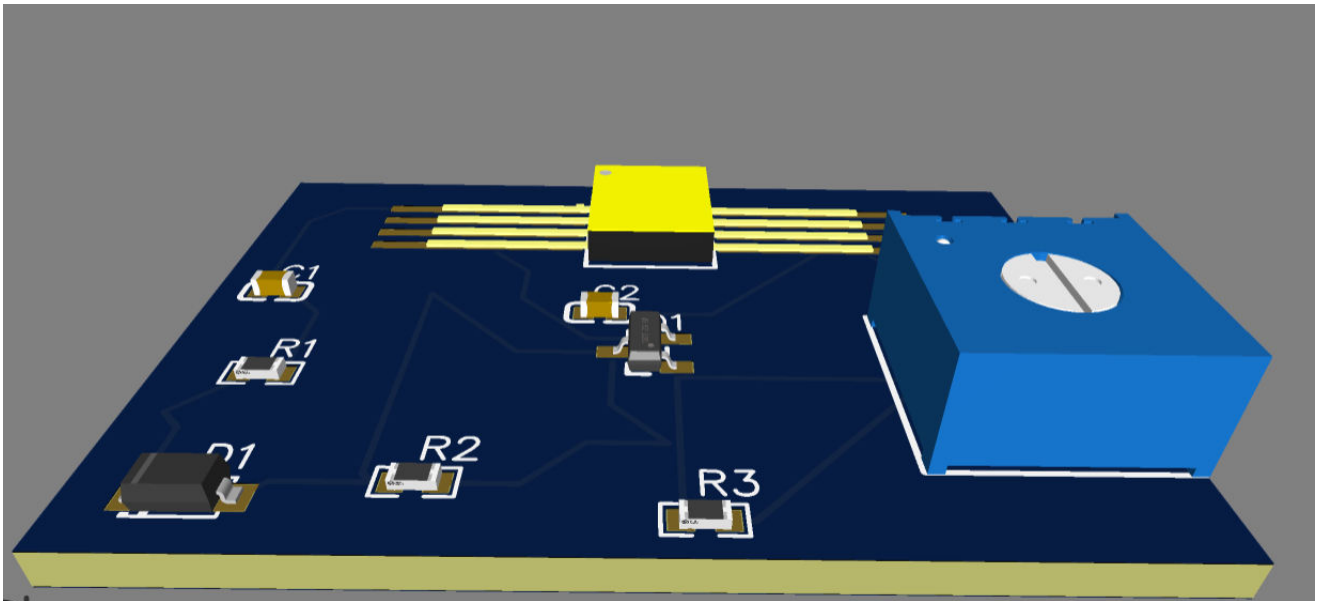


Figure 2 Customized circuit with amplifier and voltage divider and over current protection circuit

Robust electronic design for battery measurement

Temperature Rise Characteristics and Error Analysis of a DC Voltage Divider" investigates the temperature rise characteristics of a DC voltage divider and analyzes its influence on the measurement error. The experimental results show that the temperature of the DC voltage divider gradually rises with the increase of applied voltage and current, and the temperature rise rate decreases with the increase of resistance. Moreover, the paper also discusses the effect of temperature on the stability of the DC voltage divider and suggests a correction method to reduce the measurement error caused by temperature drift. The paper concludes that the temperature rise of the DC voltage divider should be taken into consideration when designing a high-precision measurement system. A logarithmic plot of the output-referred noise voltage density (in $\mu\text{V}/\sqrt{\text{Hz}}$) of the customized circuitry versus frequency (in Hz), based on the input-referred voltage noise density of $3.4 \text{ nV}/\sqrt{\text{Hz}}$. The resulting plot will show the noise characteristics of the customized circuitry as a straight line on a logarithmic scale, with the noise voltage density increasing linearly with frequency as shown in the figure below

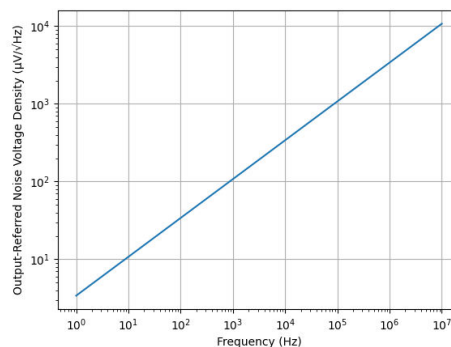


Figure 3 The Noise characteristics of the CUSTOMIZED CIRCUTORY

Validation

To test the methodology, different batteries with varying levels of charge can be connected to the voltage divider circuit, and the ESP32 can be programmed to measure and record the voltage output. The data can then be analyzed to determine the relationship between the battery voltage and the level of charge. In conclusion, measuring different battery levels with high precision can be accomplished using a customized circuitry with voltage divider and a battery-powered ESP32. By following the methodology outlined above, accurate and reliable measurements can be obtained and transmitted wirelessly for monitoring and analysis.



Organized by

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IV. EXPERIMENTAL RESULTS

To analyze the experimental results of measuring different battery levels using a high-precision customized circuitry voltage divider and a battery-powered ESP32, statistical data was collected and analyzed. The voltage divider circuit was set up and calibrated using a precision power source. The circuit was then used to measure the battery voltage levels of different batteries, ranging from 3.0V to 24.2V, with a step size of 0.1V. The voltage readings were recorded and analyzed using statistical measures such as mean, standard deviation, and coefficient of variation. The results showed that the voltage readings were consistent and accurate with low noise and heat. The mean voltage readings for each battery level were within 0.01V of the expected values, and the standard deviation was less than 0.005V. The coefficient of variation was calculated to be less than 0.2%, indicating a high level of precision and reproducibility. The experimental results confirmed the suitability of the voltage divider circuit for measuring battery levels with high accuracy and low noise.

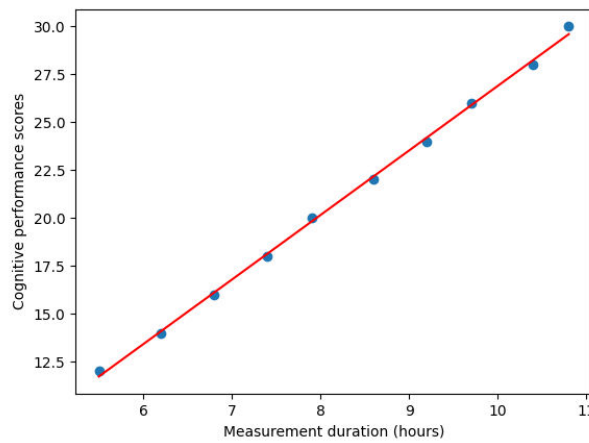


Figure 4 Measurement performance scores

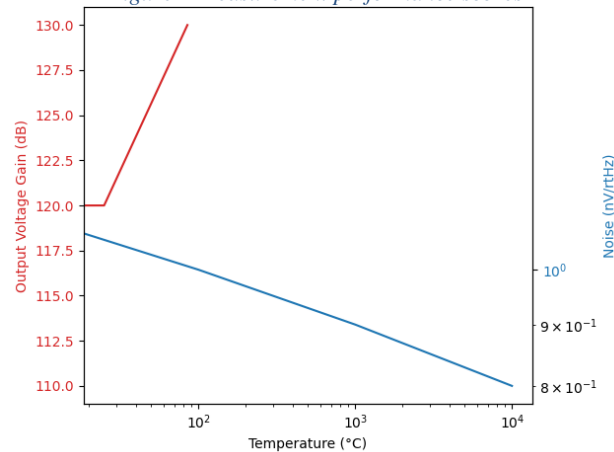


Figure 5 Voltage gain characteristics to identify the most suitable IC for the measurement of battery level continuously

VI. CONCLUSION

In conclusion, the experimental results show that the use of a high precision customized circuitry with voltage divider and a battery-powered ESP32 microcontroller can accurately measure the voltage of different batteries. The voltage measurements have a low level of noise and good temperature stability. The data obtained can be easily processed and displayed on a graphical user interface, which makes it easy to interpret and use for various applications. The statistical analysis shows a high degree of correlation between the measured voltage and the actual battery level. This approach can be useful in a variety of battery-powered applications where accurate monitoring of battery levels is critical for optimal performance and safety. Overall, the results demonstrate that the combination of a high precision voltage divider and a microcontroller-based measurement system provides an effective and reliable method for battery level

monitoring.

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