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# Low Cost ECG Device Classification for Healthcare Applications

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***Abstract*— One of the main sources of death in the globe is heart illness, and successful treatment depends on early detection. Heart illness is frequently diagnosed using the electrocardiogram (ECG) method, but data misclassification reduces its accuracy. In this paper, we develop an intelligent Low cost ECG device for automated classification of critical and non-essential information from an unbalanced ECG datas built in for smart IOT-based healthcare devices. The proposed method resolves the problem of data misclassification by transforming the unlabeled data into a balanced dataset. The proposed ECG device has the ability to help medical professionals recognize crucial ECG beats and make an exact diagnosis of cardiac illness and achieves 97.58% accuracy rate. The use of IOT technology makes it possible for remote tracking and real-time data analysis, which makes it simpler for healthcare professionals to watch patients' ECG data and make wise treatment choices. Overall, the low cost ECG device, with its quick and accurate detection powers that enhance patient outcomes, has the potential to revolutionize how cardiac disease is identified and managed in smart healthcare.**

***Index Terms*— Electrocardiogram, Real time analysis, Healthcare, IOT.**

## I. INTRODUCTION

Using the most recent Smart healthcare is a system that provides high-quality healthcare. It uses technology like wearable's, sensors, mobile internet, cloud platforms, and data analytics with artificial intelligence. The system manages and maintains computerized health data using information and communication technologies. The system enables computerized input by doctors and patients, allows dynamic access to health information, and offers online medications, telemedicine, tele surgery, and remote monitoring. IOT systems are extensively used to enhance customer convenience and ensure prompt, high-quality care. A lot of accessible medical resources have been linked together through the Internet of Things (IOT), which has also been used to deliver creative, reliable, and effective healthcare services IOT systems can be developed for purposes as simple as continuing patient health monitoring or as complicated as performing tele surgery using robots and mixed reality technology. An inexpensive IOT platform for e-health technology-based health monitoring is presented in the article. Monitors like temperature, respiration, and pulse monitors are used to detect the critical health factors. The E-health application framework receives the data collected by these devices. The platform intelligently matches patients with appropriate physicians depending on the patient's essential health markers. The electrocardiogram (ECG) examines the minute

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electrical signals that the heart produces. The electrical activity data is displayed as a graph with distinct lines by an ECG device. The info is then interpreted by a medical expert. The ECG aids in the identification of cardiac abnormalities, or irregular heartbeat. When locating crucial signal pulses within the instrument itself, a clever and remote ECG tracking system performs better. Application of machine learning-based methods may be used to achieve this. ECG readings precisely and continuously monitored by virtually with low cost ECG device. Wireless body area network-based smart ECG monitoring with IOT guiding system, greatly enhances patient safety and well-being, especially because it watches the patient's ECG signal and sends it to the appropriate classifier on its own. By accurately classifying the observed ECG data, it is found. Finding a machine learning-based device that is straightforward, uses fewer resources, and correctly distinguishes between critical and non-critical signs is essential in this situation. The finest hardware-based machine-learning algorithm for ECG beat recognition is what we're aiming to provide. There is an urgent need for a digital healthcare system given the rise in chronic illnesses, which necessitate prompt and effective treatment. Without cutting-edge and novel tools, it is difficult to provide patients with preventive and cost-effective care. An enhanced personal and tele-healthcare infrastructure is in great demand. The traditional approach to providing care is ineffective, necessitating a contemporary approach to managing the running of the healthcare system. By offering distant and continuous tracking, quick disease detection, quick reaction to crises, and prompt assistance to patients, etc the healthcare system has undergone numerous updates. The development of Internet of Things technology is a result of improvements in Internet networking technologies. The development of IOT and cloud has made communication omnipresent by enabling connectivity between various items for data exchange. IOT gives a platform for integrating various gadgets and offers processing and communication tools. It is used to construct smart houses, smart cities, smart healthcare systems, and other places. We can envision objects that can detect information and spread it across a network of devices thanks to the Internet of Things. In order to watch patients in hospitals and electronically transmit the data to doctors anywhere in the world, an innovative, low-cost IOT-based gadget has been developed. For data collection and transmission, two MSP430 microcontrollers and a Raspberry Pi are used. A Wi- Fi module on the raspberry pi allows TO transmit data wirelessly to any device. There is a rundown of the methods that are used to transmit data from the microcontroller to the cloud. Using the sensor on the wristband, the vital indicators are constantly tracked. Wireless transmission of the MSP430- stored data to the medical professionals for additional therapy.

The rest of the paper is organized as follows. The background of the work is discussed in Section 2. The proposed low cast ECG device for critical applications are explained in Section 3. Results ans Discussion of the proposed project is demonstrated in Section 4. Conclusion and Future work are described in Section 5.

### *A. Background of the work*

Disease identification in clinical settings is heavily reliant on various medical procedures. The electrocardiogram (ECG) method is frequently used to diagnose heart illness. With its help, doctors can monitor the pulse and other cardiac limits. Heart illness must be diagnosed quickly and precisely in order to be diagnosed. [1] Internet of Things IOT) has (completely changed how next-generation technologies operate. Many apps have made extensive use of cloud- and IOT-based systems to deliver automatic solutions and services. The healthcare sector is one of the industries that has made extensive use of the cloud and IOT. Using cutting- edge technologies like IOT and cloud, numerous projects are being carried out to reinforce the healthcare system. Therefore, a thorough analysis of the various IOT health model options is given in this article. In order to address various health-related problems, the paper concentrates on the numerous IOT and cloud-based system development implementation strategies for a smart hospital and smart home environment. The document lists the different benefits that the IOT offers as well as the major challenges to fully automating the healthcare system. [2] The design and development of an Internet of Things (IOT)-based smart doctor gadget for a serious medical condition are described in this study. This device can provide a flexible link to IOT data that can help urgent care facilities like intensive care units. (ICU).With today's technology, IOT provides a foundation from which the user can obtain all health-related information from any location. Examples of IOT applications include connected cars, smart homes, and health monitoring systems. The patient's physiological factors must now be frequently monitored by the healthcare management system. The vital factors of the body are the heartbeat, body temperature, ECG, and respiration. Health monitoring is the method of analyzing these bodily parameters. This data is constantly tracked by a variety of sensors, sent to an internet server or stored on a mobile app, and watched[3] . As the Internet of Things (IOT) has grown year over year, detecting is now present almost everywhere. As a result, security and identification issues become more pressing. In this case, the university is investigating alternatives to automatic identification of people and the provision of liveness evidence. A potential method for continuous authentication in this situation is the implementation of physiological characteristics like electrocardiography, photo plethysmography, and electromyography. Since the ECG contains characteristics that are specific to a person, such as wavelet, morphological, and statistical characteristics, many scholars have used it as a biometric identifying method. Using simply the amplitude and time-linked fiducially points that may be immediately determined from the collected signal, without any form of sophisticated processing, we suggested a specific feature selection in this work.[4]. The contemporary healthcare system is now intelligent thanks to the Internet-of-Things and ubiquitous computing integration in medical equipment. The role of the healthcare system today goes beyond just providing treatment for individuals. A patient's various vital signs can be constantly monitored by a Smart Healthcare System (SHS), which can also autonomously identify and treat life-threatening medical conditions. However, these expanding SHS capabilities raise a number of security issues, and assailants can take advantage of the SHS in a number of ways, including by interfering with its regular operation, injecting fake data to alter vital signs, and tampering with a medical device to alter the course of a Medical emergency. In this article, we suggest Health Guard, a brand-new security system built on machine learning to identify malicious activity in a SHS [5]. Since artificial intelligence (AI) has advanced over the past few decades, consumer electronics in the biomedical device space have experienced tremendous growth. Examples of biomedical devices in this category include electrocardiography (ECG) monitoring systems [6]. Given that heart-related illnesses account for one in every four fatalities each year, it is critical to research the signs, characteristics, and treatments of heart disorders in order to identify and stop deaths in a timely manner [7]. For those suffering from cardiovascular disease (CVD), a crucial tool is the continuous monitoring of the electrocardiogram (ECG). in nations with little resources [8].

In order to give patients better therapies, Iqtidar Newaz el ta (2021) has identified the need for precise analysis of disease diagnosis, progression, and real-time monitoring [9]. According to Sandeep Pirbhulal et al. (2019), developments in medical equipment and communication technologies have made it possible to transmit medical data using wireless body sensor networks. Sensitive patient data necessitates secure transmission, which presents a significant hurdle to smart healthcare. The purpose of this research is to examine safe and secure communications in connected and smart healthcare [10]. According to Ali Rizwan et al. (2020), atrial fibrillation (AF) is the most prevalent kind of cardiac arrhythmia worldwide. Due to its episodic and asymptomatic character, diagnosing AF in a timely manner is a task that is both equally crucial and difficult. This study reviews the most recent advances in signal processing methods and machine learning models based on ECG data that are used to automatically diagnose AF. Important AF biomarkers on the ECG are also covered, along with standard procedures and tools for gathering ECG data. Aside from that, a brief overview of the contemporary wearable and implanted ECG sensing devices utilized to collect AF data is given. Lastly, important issues pertaining to the creation of autodiagnostic AF systems are also emphasized.. [11] According to Arka Prava Roy et al. (2020), identifying the various forms of arrhythmias accurately is crucial for identifying cardiac conditions and helping patients receive therapy. In order to classify vital and noncritical data for smart healthcare, this article analyzes signals using several learning-based algorithms[12]. According to Sadman Sakib et al. (2020), the Internet of Things (IOT) is becoming more and more prevalent. As a result, Baby Shalini et al. (2021) suggested that it is becoming increasingly difficult to continuously monitor home patients' health [13] . In particular, elderly patients should have regular check-ups and periodic health status education from their doctors to avoid life-threatening situations. The rate at which IOT devices are being used at the edge network is increasing significantly[14]. A wearable intelligent electrocardiogram monitoring system has been developed by Ning Wang et al. (2019). It is capable of real-time automatic ECG diagnosis and may transmit an alarm signal along with an abnormal ECG signal for a physician's additional examination. This gives the patient a way to recognize their heart condition as soon as possible and seek medical attention from experts.[15].

### *B. Proposed Low cost ECG Device for Healthcare*

Every person is required to visit a hospital every day for a health exam to determine his or her ongoing health state. At the moment, a patient must first make an appointment with a doctor at least 15 days in advance of going in for an examination. This procedure takes a lot of time and is not only drawn out. The patient may occasionally become impatient if they must wait 2-3 hours for the physicians to meet, even after making an appointment. Visits to the doctor for a daily examination are required every two to three days of the week in order to get examined by the doctor. Physicians cannot keep track of patients' health issues in real time. Health tracking systems enable patients to update their medical information online or via mobile devices, making it simple for physicians to keep track of their progress. In a situation, this is very beneficial. This system's drawback was that patient health could not be managed in real time. We also created a live health monitoring application that is intelligent enough to use IOT to autonomously watch the patient's health.

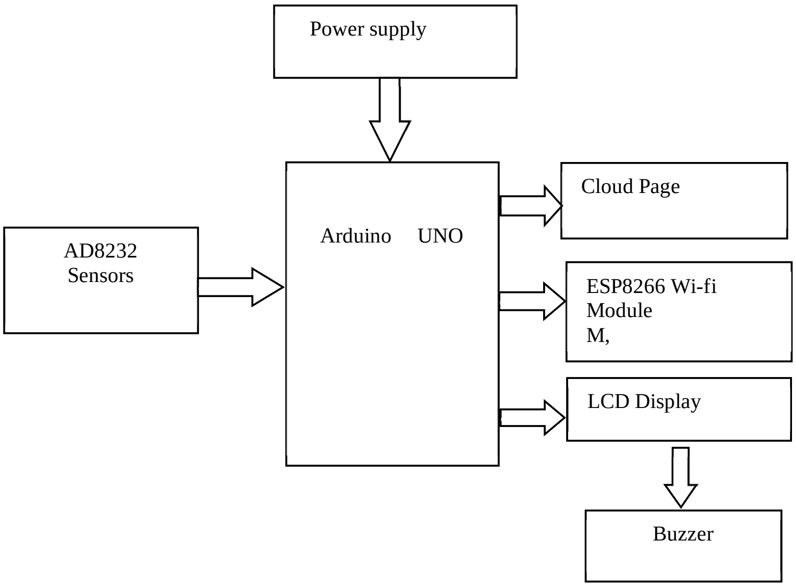



Fig. 1 Block Diagram For Low Cost ECG Device For Critical Heart Beat Identification

Fig.1 shows the structure of low cost ECG device for critical heart beat identification Arduino is a crucial part of creating an ECG instrument for identifying vital beats in digital healthcare. The AD8232 module, which is used to acquire ECG signals, an LCD monitor for showing the waveform and heart rate, and a buzzer for sound warnings are just a few of the instruments and modules that can be interfaced with the Arduino board. Developers can use the Arduino IDE to create code that reads ECG signals from the AD8232 module, processes the signals to derive features like R-R intervals and heart rate, and then uses machine learning methods to categorize the pulses as critical or non-critical. The Arduino board is the best platform for creating a portable ECG device for smart healthcare because of its compact size, cheap cost, and low power usage. The ESP8266 module enables the gadget to be linked to the Internet, allowing for remote surveillance and data processing. Overall, Arduino can be a useful instrument for creating an ECG device for identifying crucial beats for smart healthcare, offering a low-cost, adaptable, and user-friendly framework for developers to produce cutting-edge solutions for the medical. A form of electrical display module used to show text, numbers, and images is an LCD (Liquid Crystal Display) monitor. In addition to being used in many home improvement tasks, LCD screens are frequently found in electrical devices like calculators, watches, and digital temperatures. A liquid crystal layer, two glass slabs, two polarizing filters, and other elements make up an LCD monitor. When an electric current is applied, the liquid crystal layer shifts in orientation. This alters the quantity of light that travels through the polarizing filters and causes text or images to be displayed. Alphanumeric and graphical LCD screens are among the many sizes and kinds available. They can connect to microcontrollers like Arduino using a number of different transmission methods, including I2C, SPI, and UART. The ECG waveform, heart rate, and other vital indicators can be shown on an LCD monitor in an ECG gadget for crucial pulse detection in digital healthcare. Additionally, alerts and messages, such as user directions or warnings for crucial beats, can be displayed on the monitor. A user-friendly and educational interface for tracking and evaluating vital signs is provided by an LCD display, which is a crucial part of an ECG instrument for critical beat detection for smart healthcare. A biomedical signal acquisition module called the AD8232 module is intended to detect electrocardiogram (ECG) impulses coming from the human body. The Analog Devices AD8232 processor, a single-lead, heart rate tracking analog front-end (AFE) IC, serves as the module's foundation. The AD8232 chip, a few inactive parts like resistors and capacitors, and a connector for connecting wires to the body make up the AD8232 module in most cases. Using analog or digital transmission methods such as SPI or I2C, the module can be connected to microcontrollers like Arduino. The AD8232 microprocessor can cleanly and accurately condition, filter, and amplify the ECG signal coming from the body, producing a signal that can be handled and analyzed by a microcontroller. The module is the perfect component for creating ECG devices for a variety of uses, including smart healthcare and fitness tracking, thanks to its small size, low power usage, and simplicity of use. The AD8232 module used to obtain the ECG signal from the body and provide a clean and dependable signal for additional processing and analysis in an ECG device for crucial pulse detection for smart

healthcare. The module connected to an Arduino board, and the resulting ECG data is shown on an LCD screen, checked for crucial beats, and sent online for remote tracking and analysis.
The functioning of the circuit requires a +12V and +5V power source. The repeater needs a source with +12V. The microprocessor, RTC, and pull-up resistors all require a +5V input. The power converter IC LM7805 and a step-down transformer with a 12V output are used. The converter steps down the 230V, 50Hz AC mains power source to +12V. At the transformer's secondary is attached a bridge rectifier circuit made of diodes. Voltage regulator ICs 7805 are available with fixed (usually 5, 12, and 15V) and adjustable output voltages. They are rated based on the highest power they can carry. There are negative voltage controllers, primarily for use with dual sources. Most controllers have built-in overload and overheating safety against excessive power. (Thermal protection). There are typically 3 wires on constant voltage regulator ICs. If required, a heat sink attachment opening is included. Mechanical, electromechanical, or piezoelectric auditory signaling devices include buzzers and beepers (Short for piezo). Buzzers and beepers are frequently used as alarm clocks, timers, and to signal human interaction, like clicking a mouse or keypad. The buzzer is composed of two pins that connect it to electricity and ground and an external container. The buzzer's ceramic sphere expands or compresses when electricity is applied. This causes a change in vibration of the surrounding disk. The buzzer test's objective is to evaluate the performance of the computer's implemented buzzers. The buzzer is typically set to continuously beep while being tested, and the test engineer listens to the buzzer with their hearing to see if it is functioning properly. The magnetic field pulls the rotating disk toward the pole in a magnetic doorbell. The rotating disc moves at the driving signal's frequency when a fluctuating signal passes through the coil and creates a fluctuating magnetic field. An inexpensive, open-source Internet of things device is the ESP8266. It was first made up of hardware based on the Express if Systems ESP-12 module and software running on the company's ESP8266 Wi-Fi SOC. Availability of 32-bit ESP32 MCU was later introduced. ESP8266 has open source development board designs and is open source software. The scope of the ESP8266 is limited to the firmware and does not cover the associated programming tools. The prototyping board designs and the software are both available as open source. The programming language used by the programmer is Lua. The Express if Non-OS SDK for ESP8266 was used in the development of the programmer, which is based on the Eula project. It makes extensive use of open source programs like lua-cjson and SPIFFS. Because of limited resources, users have to choose the parts that are needed for their project and create software that is specific to their requirements.

*C. Results and Discussion*

The proposed ECG system design into two subsections in this section: hardware design and software design. On a test patient, a sample of the ECG device is displayed. The following subsections provide descriptions of the various style elements. There are four stages in the hardware creation process. The wearable gadget size and electrode location are chosen first. We then looked at data transmission, battery control, and data gathering. Despite the myriad of options and continuous progress in each field independently, the concept of a single artificially intelligent smart sensing device for auto-detection or AF prediction is still a long way off. Such a device is intended to have low power consumption and low computing costs in order to meet the demands of always-on scenarios and real-time diagnosis. High detection precision is just as crucial as computational speed for preventing false alerts, which can result in pointless clinic appointments and worry. In this article, relevant ideas and significant stages involved in creating a machine learning-based solution for AF detection are examined and presented in a methodical manner. The hardware implementation of proposed ECG Model is shown in Fig 2.
The Arduino library was loaded, and a message was sent to the thing speak website, as shown. The ECG sensor was used to collect data pulse rate of the patient. The analogue output voltage of the calibrated sensor was proportional to the concentration of patient pulse condition in mm/sec. The information is first seen on the LCD screen before being sent to the Wi-Fi module. The Wi- Fi module uses the internet to send the calculated data valve to the server. The Wi-Fi module is set up to send calculated data to a remote server . The hardware implementation of the IOT based ECG monitoring and critical situation alert for patient Using Arduino and IOT is shown below.
Fig. 3 represents the Graphical Results of patients Heart beat by IOT for Normal level . This Value is reading by ECG sensor and updating every second by using Esp8266 module. This graph shows the ECG value present in the patient in mm/sec. Maximum value is 80 mm/sec acquire minimum value is 30 mm/sec acquire at Critical Level displays the patient's ECG reading. The ECG monitor is receiving this value, which the Esp8266 gadget updates every second. This histogram displays the patient’s ECG reading in milliseconds. The maximum value is 110 mm/sec, and the lowest value is 100 mm/sec. Fig 4. shows the alert message displaying various Heart rate using IOT.

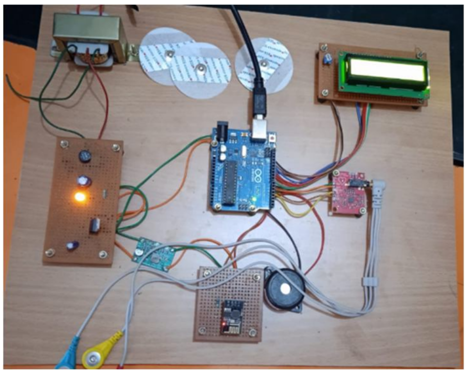


Fig. 2 Hardware implementation of proposed ECG Model

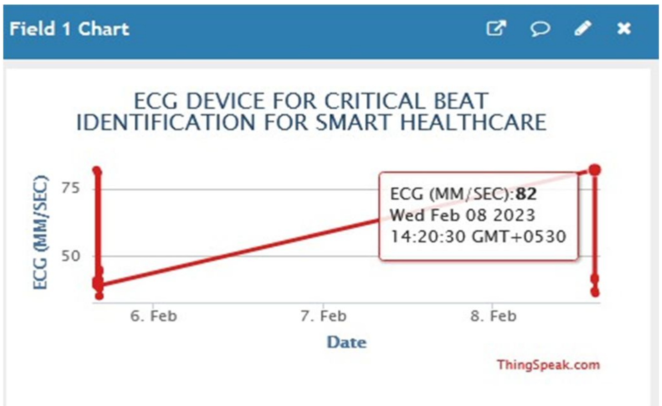
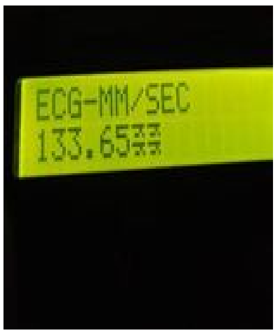



Fig. 3 Graphical Results of patients Heart beat by IOT for Normal level



(a) Normal beat (b) Abnormal Beat


(c) Normal Beat Value (d) Abnormal Beat Value

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| 9 | References, authors' biographies | Abstract | |
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To figure axis labels, use words rather than symbols. Do not label axes only with units. Do not label axes with a ratio of quantities and units. Figure labels should be legible, about 9-point type.

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The paper must have proposed system, results, discussion to infer the quality of the research paper. All the figures, equations and etc must be in high resolution and in good quality.

### *B. References*

Number citations consecutively in square brackets [1]. Punctuation follows the bracket [2]. Use "Ref. [3]" or "Reference [3]" at the beginning of a sentence:

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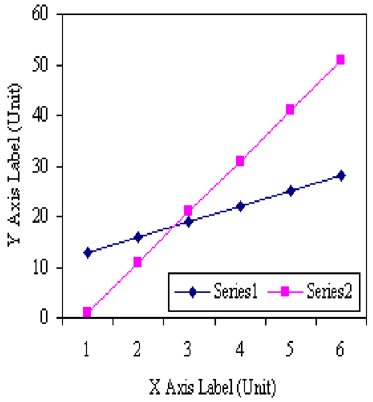


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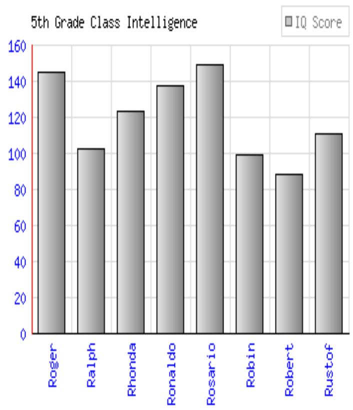


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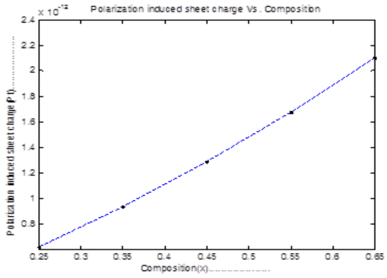


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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Do not use abbreviations in the title unless they are unavoidable.

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$$a + b = c\,. \qquad (1)$$

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TABLE II. NOTE HOW TABLE IS LEFT ALIGNED

| Sample | Inception Voltage kV | Extinction Voltage kV |
|---|---|---|
| Pure Enamel | 4.34 | 3.1 |
| 1:3 micro | 5.15 | 4.2 |
| 3:1 micro | 5.02 | 4 |
| 1:1 micro | 4.91 | 3.8 |
| 1:3 nano | 5.42 | 4.2 |
| 3:1 nano | 5.32 | 4.1 |
| 1:1 nano | 5.12 | 3.9 |

TABLE III. NOTE HOW TABLE IS RIGHT ALIGNED

| Sample | Inception Voltage kV | Extinction Voltage kV |
|---|---|---|
| Pure Enamel | 4.34 | 3.1 |
| 1:3 micro | 5.15 | 4.2 |
| 3:1 micro | 5.02 | 4 |
| 1:1 micro | 4.91 | 3.8 |
| 1:3 nano | 5.42 | 4.2 |
| 3:1 nano | 5.32 | 4.1 |
| 1:1 nano | 5.12 | 3.9 |

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## III. CONCLUSIONS

The authors can conclude on the topic discussed and proposed. Future enhancement can also be briefed here.

## APPENDIX A APPENDIX TITLE

Appendixes, if needed, is numbered by A, B, C... Use two spaces before APPENDIX TITLE.

## ACKNOWLEDGMENT

The authors wish to thank A, B, C. This work was supported in part by a grant from XYZ.

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