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Construction And Testing of Lightning Detector

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Abstract- Lightning strikes are a serious hazard to public safety since they can cause major damage to both public and private infrastructure. There is a need for ongoing research on lighting, which is becoming more dynamic owing to climate change, especially in storm-prone nations, in order to guaranty the safety of facilities and assess the causes of lightning incidents. In Nigeria, lighting detection devices are found in meteorological stations where lighting incidents are not tracked. When they are, bureaucratic procedures frequently make it difficult to obtain data for scientific research. Therefore, a fabricated one that may be utilized for scholarly and experimental research is required. A fabricated lighting detector was built to track and monitor instances of lightning strikes. Lightning detector, WiFi module, battery charger, reel time clock (RTC), CMOS, and lithium batteries are among its various sections. The module's microprocessor processes the lightning detector's digital outputs, which are then recorded on a data logger for processing and data interpretation. The gadget was set up, and throughout the two months of April and May 2025, lightning data was gathered. The number of occurrences in connection to the number of days was examined using a regression model. The data was validated using the regression coefficient R2. The degree of fitness findings for linear, quadratic, and cubic, respectively, are 0.968, 0.971, and 0.971 for April and 0.979, 0.980, and 0.983 for May. The aforementioned results are well-fitting models that can be used to estimate the frequency of lightning strikes. The detector's memory, low power consumption, small size, mobility, and affordability are just a few of its numerous benefits.

Keywords: Lightning Detector, Occurrences, Regression Model, Wi-Fi Module

I. INTRODUCTION

Lightning is an electrical discharge in the atmosphere that is followed by thunder. It usually happens during thunderstorms, though it can also happen during dust storms or volcanic eruptions (Wiesinger et al., 2005). A lightning bolt's leader can move at 60,000 m/s (130,000 mph) and reach temperatures close to 30,000 °C (54,000 °F) in an atmospheric electrical discharge. This temperature is high enough to fuse silica sand into fulgurites, which are glass channels that can reach a certain depth in the earth and are typically hollow. 16 million lightning strikes (NFPA, 2008). An average of one gigajoule of energy is released instantly during lightning, a naturally occurring electrostatic discharge that occurs when two electrically charged locations, either in the atmosphere or with one on the ground, momentarily equalize each other (Rakov, 2003). From heat produced by the fast motion of electrons to bright flashes of visible light in the form of black-body radiation, this discharge may result in a variety of electromagnetic radiation. Thunder is a sound produced by the shock wave that forms when gasses near the discharge suddenly experience a rise in pressure. Lightning occurs commonly during thunderstorms as well as other types of energetic weather systems, but volcanic lightning can also occur during volcanic eruptions. Lightning is the flash of light that we see across the sky during thunderstorms (IEC,2006). When lightning strikes in extreme forms, it can potentially become a serious natural disaster. We always see lightning during a thunderstorm before we hear the thunder because light travels so quickly. It is an electrical flash with an unbearably high temperature of up to 54,000 degrees Fahrenheit. Tall buildings, towers, artifacts, etc. may be severely damaged as a result. It occurs because lightning travels quickly and reaches the ground at its fastest speed (Rakov, 2003). The three primary types of lightning are identified by their location: inside a single thundercloud, between two distinct clouds, or between a cloud and the ground. This high-speed, slow-motion lightning footage was shot at 6,200 frames per second. There are also additional known observable variations, such as "heat lightning," which may be seen from a vast distance but cannot be heard; dry lightning, which can start forest fires; and ball lightning, which is rarely recorded in scientific settings (Visacro et al., 2004). For thousands of years, people have worshiped lightning. Lightning-related idioms, like "bolt from the blue" in English, are prevalent in many languages. Astraphobia is the term for the fear of lightning (Visacro et al., 2004). Lightning is an electrical discharge that is mostly caused by an electrical imbalance between, inside, or between clouds and the earth. Although it is breathtaking, it is also risky. A lightning flash's high current and relevant energy values have the power to kill people and animals as well as harm property (Visacro and Silveira, 2005). Approximately eight million lightning strikes occur worldwide each day, and in some regions, lightning kills 0.2–0.8 people per million annually (Hussein et al., 2004). In addition, some victims of lightning accidents may sustain a range of injuries, such as severe burns, cardiac arrest, or other symptoms that may persist for a longer time (Narita et al., 2000). One of those natural occurrences that captivates people's attention due to its seeming violence and the destructive force associated with it is lightning. It was thot that lightning and thunder were the gods' way of expressing their displeasure (Schoene et al., 2003). According to Schoene et al. (2003), the imaginary is founded on a very real phenomenon that can be reasonably well explained but cannot be combated, as evidenced by the significant damage it causes to property and its unfortunate victims. It is only possible to regulate its implications and effects to a limited extent. Lightning can be likened to a disruptive electrical discharge due to the dielectric breakdown of the air between the clouds or between the clouds and the ground. Certain clouds (cumuli nimbus) create meteorological conditions that are favorable to the accumulation of electrostatic charges (Bazelyan *et al.,* 2000). A lightning counter is a gadget that counts the number of strikes by registering the lightning impulse. Every year, there are about 16 million lightning strikes worldwide (Takami and Okabe, 2007).Internal home wiring systems, computers, telephones, equipment, and open spaces can all be harmed by lightning strikes. Numerous damages, including livestock, have been caused by lightning strikes. Neutral atoms and molecules in the air are frequently broken apart to create distinct positive and negative charges that move in opposing directions as an electric current, which causes the flow of neutralizing charges (Takami and Okabe, 2007). In lightning protection installations, lightning strike counters are very helpful tools because they offer first-hand information on whether the installation has experienced a lightning strike and, consequently, whether any further verification or additional maintenance beyond the routine inspections is required in accordance with the standards (Narita et al., 2000). Applications in technology at logger lightning event counters include lightning strike counters. A recorder of electrical activity in the down-conductor of the lightning rod, the at logger lightning event counter (AT-004G) records not only the number of strikes but also the lightning's amplitude, polarity, date, and time of impact. The at logger lightning event counter is authorized for use in explosive atmospheres (Schoene *et al.,* 2003).

II. STATEMENT OF THE PROBLEM

Both living and non-living creatures are greatly impacted by lightning. ranging from causing harm to buildings and other assets to posing a threat to human and animal life, including death. Additionally, lightning-detecting devices are found in meteorological units, where the quantity of lightning strikes is noted for scientific research. As a result, a device that can be useful for academic and experimental research is required. With the use of this fabricated lightning detector, one may determine the frequency of lightning strikes in a certain location during a given time frame, particularly during the day and at night.

III. AIMS AND OBJECTIVES OF THE STUDY

The aim of this study is to construct and test a fabricated lightning detector.

IV. OBJECTIVES OF THE STUDY

However, the specific objectives of this research work are therefore to:

i. Fabricate a smart device that can detect and record lightning strikes per time
ii. Develop a device that can be used for research purposes

V. SCOPE OF THE STUDY

The scope of this research work was restricted to Benjamen Area of Eleyele, Ibadan North – West Local Government, Oyo State, Nigeria.

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VI. SIGNIFICANCE OF THE STUDY

The frequencies of lightning events is determinant factor to predict raining events on day to days activities, having a lightning detection is useful tools for daily life activities such as in aviation, industries and to predict to farmers the coming of rains and planting seasons

VII. METHODOLOGY

The construction of a lightning detector for academic and research purposes is one of the main motivations behind this endeavor. Consequently, the apparatus was set up in a scientific garden where lightning-induced electrostatic charges are monitored, measured, and recorded onto mobile electronics devices for processing.

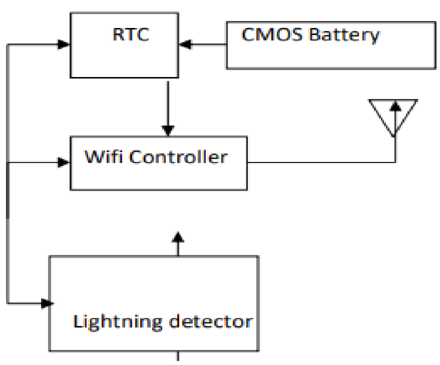

Fig 1: Block diagram of the fabricated lightning detector

The first section or stage from block diagram is lightning detector which is very sensitive static electricity detector that can provide an early warning of approaching storm from inter cloud discharge well before an earth to sky returns strikes take place. An antenna formed a short length of the wire detect storm within a two miles radius. This part of the lightning detector uses a very low frequency VLF receiver with a radio frequency range of 1 Hz to 300 MHz, adjusted to 300 KHz. It is intended to detect the crackle of impending lightning. The strength and proximity of the storm are shown by a bright bulb flashing in time with lightning bolts. It features a Wi-Fi controller that interprets the signal and transmits it to the logger, a smart application designed for the gadget that displays the time and date of the lightning strike. Furthermore, the purpose of the RTC portion is to log an event into the system by recording its time.

This is a section for lightning detector that is using very low frequency VLF receiver of radio frequency range of 1Hz to 300MHz but tuned to 300KHz and designed to detect the crackle of approaching lightning. A bright lamp flashes is synchronize with the lightning bolts indicating the proximity and intensity of the storm. It has Wi-Fi controller which processes the signal and sends it into logger which is the smart application adapted for the device to show the date and time that the lightning occurs. More so, the RTC, section is to record the time that an event occurs and log it into the system.

VIII. LIGHTING DETECTOR

It had a simple receiver which consists of a tuned amplifier driving a modified flash circuit. The flasher is biased so that it will not flash until a burst of radio frequency amplified by the 2N3903 PNP Transistor. The receiver current is about 350 microampere.

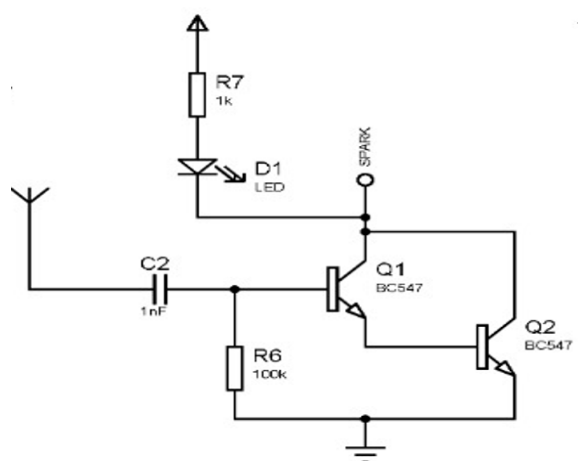

Fig: 2 Schematic circuit of fabricated Lighting Detector

IX. WIFI CONTROLLER

This was implemented using a Dallas RTC chip, DS1307 with a CMOS backup battery to ensure the time of an event keep running, when there is power

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failure. Also, software (I Smart) was installed which served as a database in which the number of events, days, and time were stored. Wi-Fi module served as a intermediary between the software called "Thunder-logger".

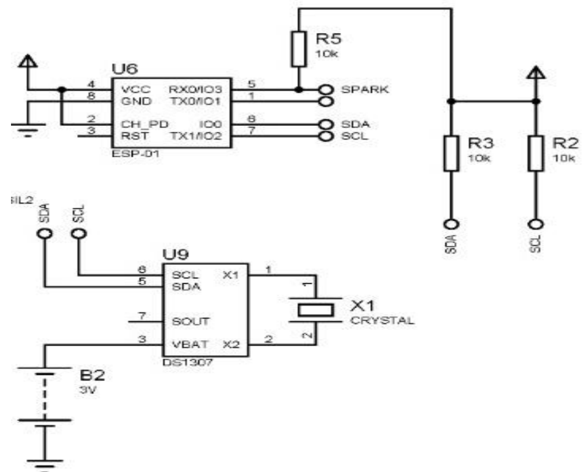

Fig 3: Schematic Circuit of WiFi Controller

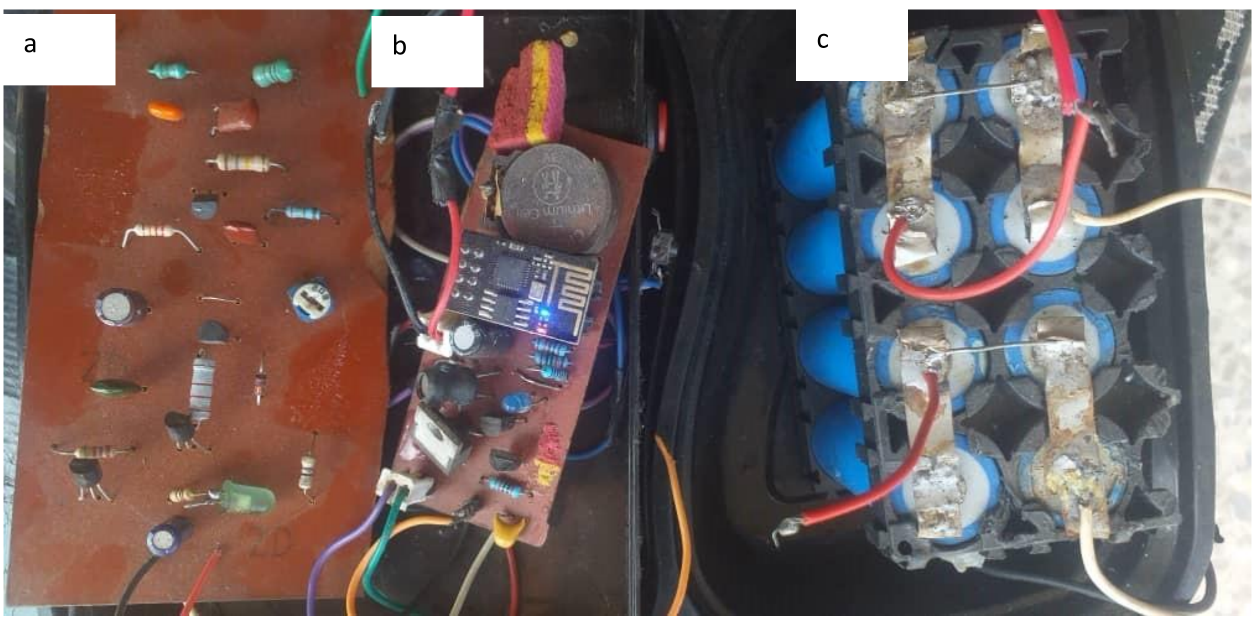

Figure 4: Fabricated Lighting Detector (a) Lighting Detector (b) WiFi Controller (c) Lithium Batteries

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Figure 5: Fabricated Lighting Detector

X. SYSTEM TESTING

The multi-meter was used to verify every connection and component in the circuit once all essential connections, corrections, and soldering were completed. This ensured that the project's input and output voltage, current, and resistance were determined. Benjamen, Eleyele, Ibadan Northwest Local Government, Ibadan, Oyo State, Nigeria, was the site of the testing.The long-wire antenna was positioned outdoors on a plastic rod that was fixed to the atmosphere, while the manufactured lightning detector was installed inside the one-story building. When lightning strikes, the antenna pick up the electrostatic signal and send it to the detector, which uses an Arduino and microprocessor to identify lightning signals. The Wi-Fi module received the lightning signals, which were then sent to the I Smart logger application loaded on the Android phone. The application displayed the date and time of the lightning strike in minutes and seconds. Every day, the recording was made using a mobile application. Ismart for the months of June and July of 2025.


Figure 5: Installation and Testing

XI. RESULT

The regression models were used to analyze the data obtained.

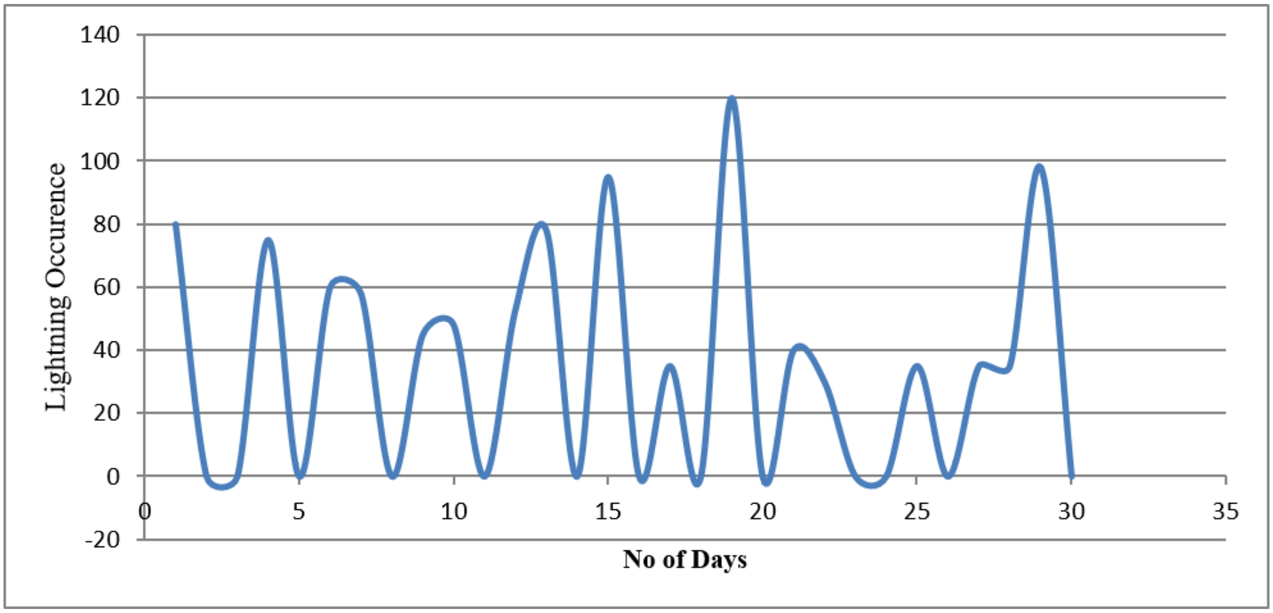

Figure 6: Variation of Lightning Occurrence Against the Number of Days for the Month of June, 2025.

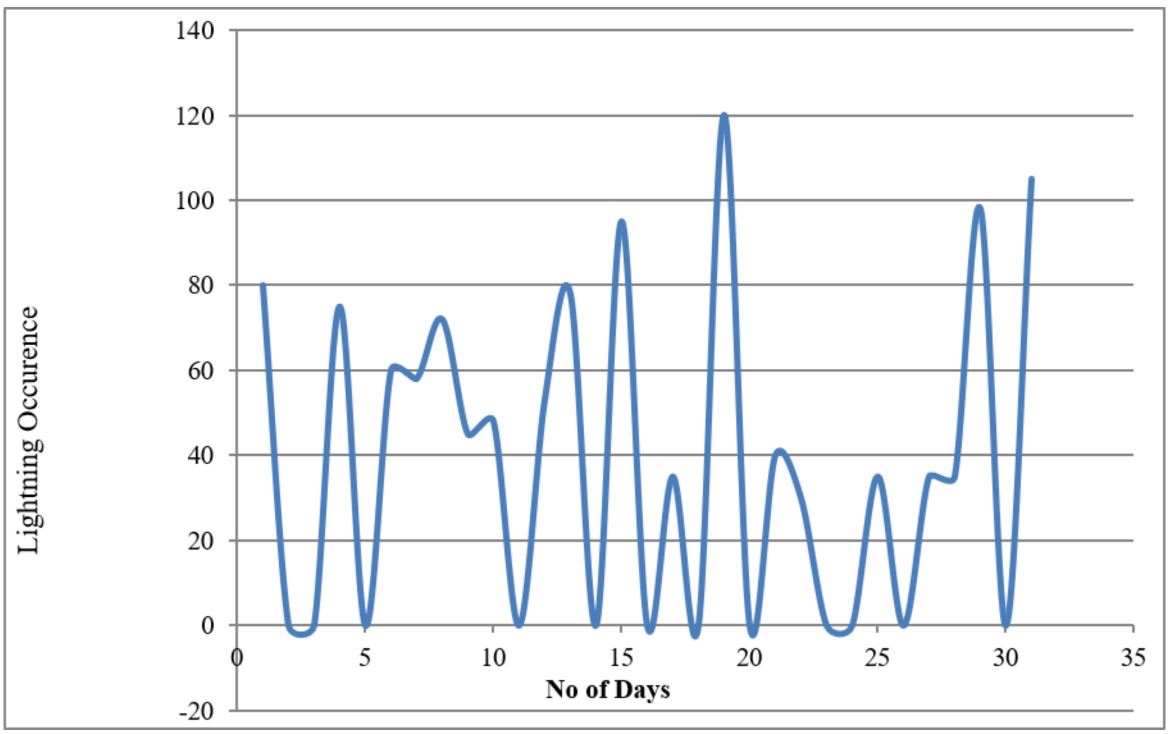

Figure 7: Variation of Lightning Occurrence Against the Number of Days for the Month of June, 2025.

Table 1: Regression model fittings

MONTH	LIGHTENING OCCURRENCE {days}	LIGHTENING DURATION (MINS)	REGRESSION MODEL	R^2 VALUES
June	17.00	1020	Linear N =	0.977
			Quadratic N =	0.978
			Cubic W =	0.985
July	19.00	1197	Linear N =	0.977
			Quadratic N =	0.973
			Cubic W =	0.983

XII. DISCUSSION OF FINDINGS

Fig 1: Rechargeable complimentary metal-oxide semi-conductor batteries (CMOS) power the Wi-Fi system controller, which logs data into the Ismart application system. The block diagram of the manufactured lightning detector uses the real-time controller (RTC) section to record the time that an event occurs during the day and evening.

The schematic circuit of the manufactured lightning detector is shown in Fig. 2. To boost the detector's sensitivity, the potentiometer was correctly adjusted using a multi-turn trimmer capacitor. The capacity to set a lightning detector close to self-oscillation and maximize its relaxation using the value of the bias resistors is one of its main features. The feedback is sent to the transistor's collector and it is direct current coupled. Additionally, all electrostatic discharge in the environment is picked up by the antenna and sent to a differentiator circuit, which transforms the discharge into a sharp pulse before sending it to transistors, which act as logic switches for the Wi-Fi controller.

Figure 3: WiFi controller schematic circuit In order to guaranty that the time of an event continues to run in the event of a power outage, this was implemented utilizing a Dallas RTC chip, DS1307, with a CMOS backup battery. Additionally, ISmart software was installed, which functioned as a database to store the quantity of events, days, and time. The "Thunder-logger" program was mediated via the Wi-Fi module. Figure 4 and 5: Fabricated Lighting Detector (a) Lighting Detector (b) WiFi Controller (c) Lithium Batteries. The lightning detector was developed through eight stages or sections. The first section is battery charger which was connected to A.C source to charge the battery. The second section is battery, which was connected in parallel to supply 3.7 volts which was needed to power the device. The third section is the antenna, it use the radio frequency of 1 mHz – 1GHz any lightning signals within that range was fed into lightning detector section. The fourth section is lightning detector which was able to detect the electrostatic signal using in the atmosphere through the antenna and transmitted it to the Wi-Fi controller.

The fifth component is the Wi-Fi controller, which interprets the signal and transmits it to the logger, an Ismart program customized for the gadget that displays the time and date of the lightning strike. The RTC (real time clock) component of the wifi controller, which displays the date and time in minutes and seconds, is the sixth portion. The final section is the CMOS battery, which is used to maintain the time and date, particularly when the battery is low or flat and cannot power the gadget until it is charged.

Additionally, the data collected over a two-month period was tabulated, and analyzes using the regression model fitting in the table revealed the linear, quadratic, and cubic fittings. It can be inferred that all the parameters are increasing, as are the R2 values. The total duration of lightning events during the period was 1020 minutes, and the correlation regression coefficient R2 values for the linear, quadratic, and cubic fittings were 0.977, 0.978, and 0.985, respectively.

The correction regression coefficient R2 values for linear, quadratic, and cubic lightning were 0.977, 0.973, and 0.983, respectively. During the month of July, there were 19 days with 1197 minutes of total lightning events.

XIII. CONCLUSION

Based on testing and actual performance, it can be concluded that the fabricated lightning detector functions well. During the two months of June and July 2025, it detects lightning signals that occur in the vicinity of Benjamen, Eleyele. The actualization of the stated goals and objectives of this work and the prediction of rain are confirmed by the experimental findings from the various testing and data analysis from the device. Based on testing and actual performance, it can be concluded that the fabricated lightning detector functions well. During the two months of June and July 2025, it detects lightning signals that occur in the vicinity of Benjamin Eleyele. The prediction of rain and the achievement of the stated goals and objectives of this work are confirmed by the experimental findings from the various testing and data analysis from the device.

XIV. RECOMMENDATION

This tool will be useful in the field of metrology mostly for predicting weather patterns, such as the likelihood of rainfall. Additionally, it will provide town planners, builders, landowners, contractors, and other pertinent entities with information regarding lightning incidents in the area. Because of the device's good performance, meteorologists and other environmental authorities are advised to use it for academic purposes.

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