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IoT Based Pole Anti Theft System

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Abstract: *The IoT-Based Pole Anti-Theft System aims to combat the increasing prevalence of electricity theft, which poses significant financial losses and infrastructural challenges for utility companies. This innovative system employs the PZEM004T energy meter and the ESP8266 Wi-Fi module to monitor power consumption across two utility poles. By continuously measuring electricity usage, the system can detect any abnormal spikes indicative of theft. When unauthorized power consumption is detected, real-time alerts are triggered. These alerts are communicated to users via the Thingspeak platform for monitoring and analysis. Additionally, a user-friendly interface developed using Kodular enables remote monitoring and control, allowing users to receive notifications on their mobile devices. The integration of IoT technologies enhances the efficiency and effectiveness of electricity monitoring, facilitating prompt responses to theft incidents. This proactive approach not only aids in reducing energy losses but also ensures better resource management and improved operational efficiency for utility providers. Ultimately, the IoT-Based Pole Anti-Theft System serves as a vital tool in safeguarding electrical infrastructure and promoting energy conservation, providing a scalable solution to a growing problem in the power sector.*

Keywords: Anti-Theft System

I. INTRODUCTION

The increasing demand for electricity has placed immense pressure on utility providers, leading to challenges in managing resources efficiently. Among these challenges, electricity theft has emerged as a significant issue, resulting in substantial financial losses for utility companies and compromising service quality for legitimate consumers. Traditional methods of monitoring energy consumption are often inadequate in detecting theft, as they rely heavily on manual inspections and outdated technologies. Consequently, the need for a modern, automated solution has become evident.

This project proposes an IoT-Based Pole Anti-Theft System, which leverages advanced technologies to enhance electricity monitoring and theft detection. By employing the PZEM004T energy meter, the system can accurately measure the voltage, current, and power factor across two designated utility poles. The ESP8266 Wi-Fi module facilitates real-time data transmission, enabling the system to communicate with cloud platforms and mobile applications for immediate monitoring and alerts.

The implementation of this IoT solution allows utility companies to transition from reactive to proactive management of their electricity distribution networks. Real-time data analysis not only aids in detecting anomalies that indicate theft but also helps identify areas for improving efficiency and reducing operational costs. The user-friendly interface developed with Kodular further empowers utility providers and customers alike, enabling them to monitor their energy consumption and receive timely notifications regarding any suspicious activities.

Furthermore, this system emphasizes the importance of community involvement in combating electricity theft. By providing users with the tools to monitor their surroundings, it encourages vigilance and fosters a collaborative approach to safeguarding resources. As utility providers embrace smart technologies, the IoT-Based Pole Anti-Theft System stands as a promising solution for reducing energy losses and promoting sustainable practices within the energy sector.

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II. PROBLEM DEFINITION

Electricity theft is a growing concern for utility companies worldwide, resulting in significant financial losses, operational inefficiencies, and compromised service delivery. Traditional methods of detecting theft, such as manual inspections and periodic monitoring, often fail to identify unauthorized consumption in real time, leading to substantial unaccounted energy losses. This inadequacy places a financial burden on legitimate consumers, increases energy prices, and hampers infrastructure development. Additionally, the lack of immediate alerts for theft incidents prolongs response times, allowing perpetrators to exploit vulnerabilities in the system. As the demand for electricity continues to rise, addressing these challenges has become imperative. The proposed IoT-Based Pole Anti-Theft System aims to provide a solution that enables real-time monitoring of electricity consumption at utility poles, facilitating the early detection of theft incidents and improving the overall management of energy resources.

III. OBJECTIVES

- Develop an IoT-based system for real-time monitoring of electricity consumption at utility poles.
- Utilize the PZEM004T energy meter for accurate measurement of voltage, current, and power.
- Implement the ESP8266 Wi-Fi module for seamless data transmission to cloud platforms.
- Create a user-friendly mobile application using Kodular for monitoring and alerts.
- Enable immediate notifications upon detecting unauthorized electricity usage.
- Enhance the operational efficiency of utility providers through proactive theft detection.
- Promote community involvement in monitoring electricity usage to deter theft.
- Provide a scalable solution that can be adapted to various utility environments.

IV. LITERATURE SURVEY

In this existing system wireless communication system of energy meter used with Zigbee, relay control. The cryptographic method is used to secure the communication channel and zigbee for the transmission of data in a serial process. Drawback of this process is to collect the readings, going in the particular range of area and manually cut power supply if needed. [1]In 2015, S.K. JOSHI proposed an idea for the power theft detection using the devices ELM and SVM. Here Extreme Learning Machine (ELM) and Support Vector Machine(SVM), an online learning algorithm for the detection of power theft. This model firstselects the suspected consumers to be inspected onsite for illegal based on abnormal consumption behavior. The proposed approach uses customer load profile information to expose abnormal behavior that is known to be highly correlated with threat activities. But the major drawback here is that, the cost of the extreme learning machine is quite high .[2]In 2015, DANIEL NIKOV.KI, proposed an idea for the power theft system using the smart meters. It is one of the major concern for the utilities. With the invention of smart meters, the amount of collecting household energy consumption data has been increased, and thus making it easier for the improvement data analysis. In this paper they have proposed a smart meter which is temperature dependent. The model was tested for varying amounts of power thefts and also for different types of circuit connections. The results are encouraging but the drawback is that the circuit connections are quite complex.[3]In 2016, JITENDRA R.RANA, proposed an idea based on the zigbees. In this paper, the author said that using Zigbee Technology is one of the most easier technology and also cost efficient. And here the electricity is by passed. This method presents an efficient and simpler way to adulterate the wireless technique used in this research paper. It also costs less compared to the other present systems. This wireless system is used to overcome the theft of the energy meter and hence it also controls the power theft.

V. PROPOSED METHODOLOGY

The methodology for the IoT-Based Pole Anti-Theft System involves several key components, including hardware and software integration for effective monitoring and alerting. Initially, the PZEM004T energy meter is installed at two utility poles to measure real-time voltage, current, and power consumption. This meter provides accurate data essential for identifying any anomalies indicative of electricity theft.

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The ESP8266 Wi-Fi module serves as the communication bridge, allowing the system to transmit data wirelessly to the Thingspeak platform for real-time monitoring. The ESP8266 is programmed to send data packets containing power readings at regular intervals, ensuring that any fluctuations in consumption are promptly reported.

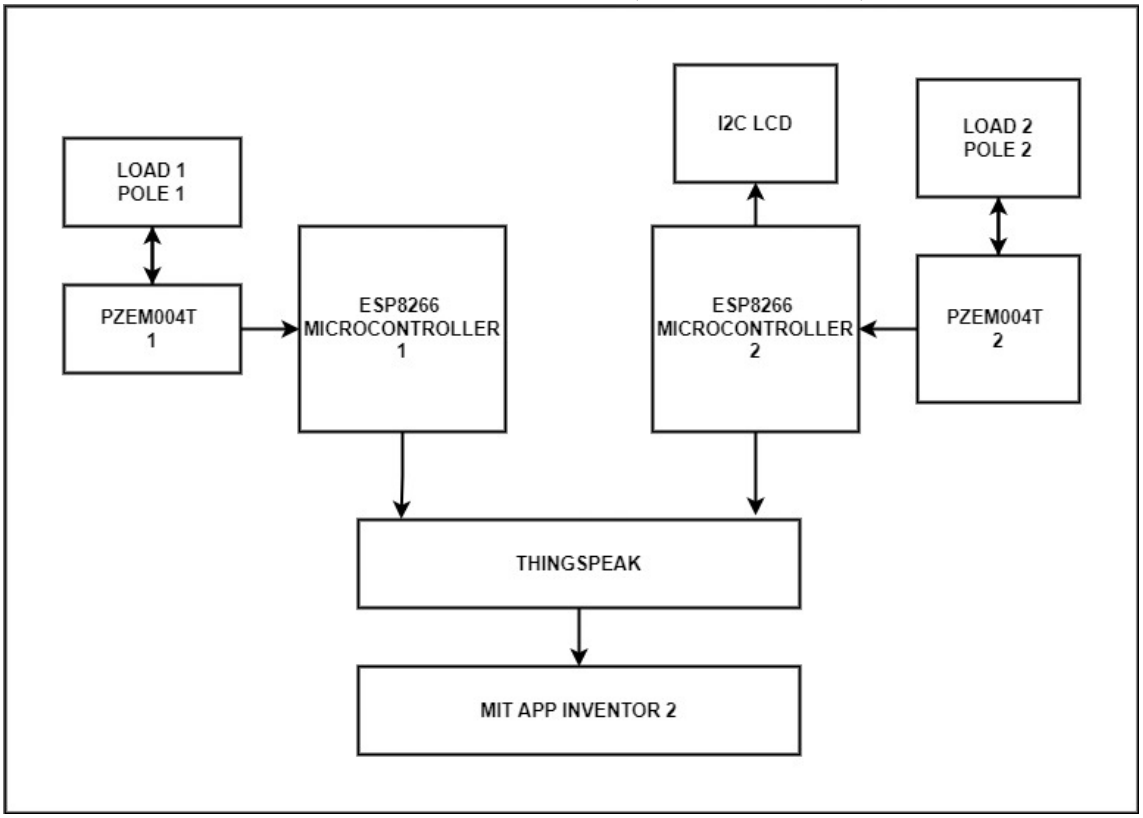
The data collected on Thingspeak can be visualized through various graphs and charts, enabling utility providers to analyze trends in electricity usage. To enhance user engagement, a mobile application is developed using Kodular. This app provides a user-friendly interface, allowing utility personnel to monitor power consumption remotely, receive alerts, and access historical data.

The system includes a defined threshold for power consumption, set based on average usage patterns. If the measured power exceeds this threshold, indicating potential theft, the system triggers an alert. This alert can be in the form of push notifications through the Kodular app and can also be logged on the Thingspeak platform for further analysis.

To ensure the reliability of the system, multiple testing phases will be conducted. This includes simulating theft scenarios to verify the system's responsiveness and accuracy in detecting unauthorized consumption. Feedback from utility providers and end-users will also be incorporated to refine the interface and functionality, ensuring the system meets the practical needs of its users.

Finally, documentation and training sessions will be provided for utility personnel to familiarize them with the system's operation and features, ensuring a smooth transition to this innovative solution for combating electricity theft.

VI. SYSTEM ARCHITECTURE (BLOCK DIAGRAM)



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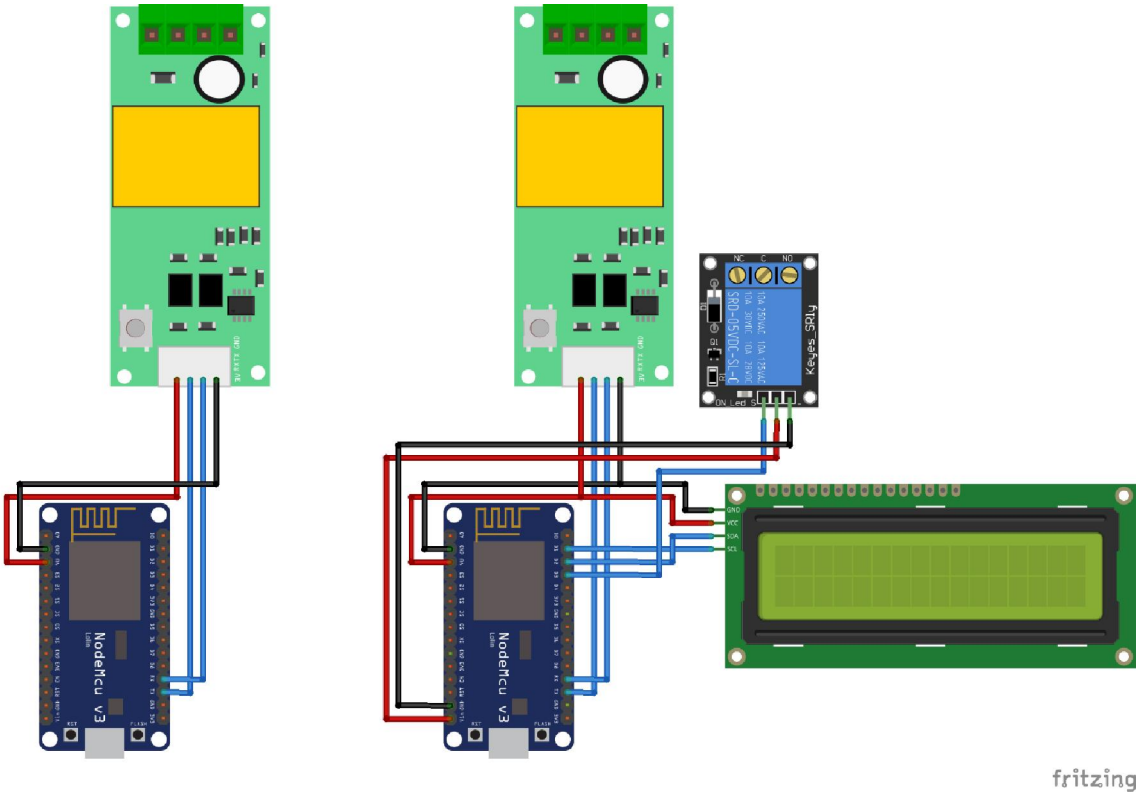
CIRCUIT DIAGRAM



VII. WORKING

The IoT-Based Pole Anti-Theft System operates through a series of interconnected components that facilitate real-time monitoring and alerting for electricity theft. The system's core is the PZEM004T energy meter, which is strategically installed on two utility poles. This energy meter continuously measures the voltage, current, and power consumption at each pole, providing accurate readings essential for detecting anomalies.

Once the system is powered on, the ESP8266 Wi-Fi module takes over communication duties. This module is configured to transmit the collected data from the PZEM004T to the Thingspeak cloud platform at regular intervals. The ESP8266 ensures that the data transfer is reliable and timely, allowing for continuous monitoring of the electricity usage at the poles.

The collected data is then visualized on the Thingspeak platform, where utility providers can access real-time graphs and charts illustrating power consumption trends. This visualization is crucial for identifying any unusual spikes in electricity usage that may indicate theft. To enhance user interaction, a mobile application is developed using Kodular, enabling users to receive alerts and monitor power usage directly from their smartphones.

The system incorporates a predefined threshold for normal electricity consumption based on historical usage patterns. If the power readings exceed this threshold, indicating a potential theft incident, the system triggers an alert mechanism. Users receive immediate notifications through the Kodular app, informing them of the suspected theft. Additionally, the data is logged on Thingspeak for further analysis, allowing utility companies to investigate the incident.

The real-time monitoring capabilities of this system not only facilitate quick responses to theft incidents but also contribute to better resource management by allowing utility providers to identify consumption trends and optimize their operations. The integration of IoT technologies thus empowers utility companies to transition from reactive measures to proactive management, reducing the impact of electricity theft on their operations.

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Furthermore, the system promotes community involvement by providing users with the tools to monitor their surroundings and report suspicious activities. By engaging local communities in electricity monitoring, the system fosters a collaborative approach to deterring theft and promoting energy conservation.

VIII. HARDWARE USED

1. NodeMCU ESP-12E

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open-source projects, such as lua-cjson and SPIFFS.

2. I2C LCD

I2C_LCD is an easy-to-use display module; it can make display easier. Using it can reduce the difficulty of make, so that makers can focus on the core of the work. The Arduino library for I2C_LCD, user just need a few lines of the code can achieve complex graphics and text display features. It can replace the serial monitor of Arduino in some place, you can get running information's without a computer. Through the bitmap convert software you can get picture displayed on I2C_LCD, without the need for complex programming.

3. PZEM 004T Sensor

This Peacefair PZEM-004T Multi-function AC Power Monitor is very popular in electrical consumption measurement projects. It is capable of measuring four interrelated electrical variables as voltage, current, power, and energy.

This tiny PZEM-004T circuit is great for measuring AC (RMS) voltage, current, and power (single-phase). The unit easily interfaces with Arduino and other hardware using the code library.

Simply power the board with a power supply (or you can use the AC source you are measuring) and connect the circular sensor to the board. Run the wire through the circular sensor and you`re ready to start measuring the voltage, current, and power. The circuit also comes with a TTL to USB adapter wire for easy connection to a computer or microcontroller.

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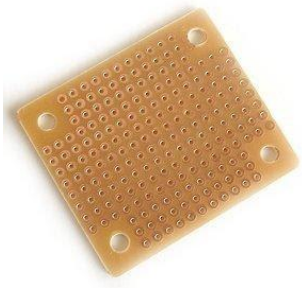
This module features a TTL serial data communication interface, you can read and set the relevant parameters via the serial port; but if you want to communicate with a device which has USB or RS232 (such as a computer), you need to be equipped with different TTL pinboard (USB communication needs to be equipped with TTL to USB pinboard; RS232 communication needs to be equipped with TTL to RS232 pinboard).

4. Connecting Wires

Since stranded wire is more flexible than solid core wire of equal size, it can be used when the wire needs to move around frequently.

5. Zero PCB



Perfboard is a material for prototyping electronic circuits (also called DOT PCB). It is a thin, rigid sheet with holes pre-drilled at standard intervals across a grid, usually a square grid of 0.1 inches (2.54 mm) spacing. These holes are ringed by round or square copper pads, though bare boards are also available. Inexpensive perfboard may have pads on only one side of the board, while better quality perfboard can have pads on both sides (plate-through holes). Since each pad is electrically isolated, the builder makes all connections with either wire wrap or miniature point to point wiring techniques. Discrete components are soldered to the prototype board such as resistors, capacitors, and integrated circuits. The substrate is typically made of paper laminated with phenolic resin (such as FR-2) or a fiberglass-reinforced epoxy laminate (FR-4).

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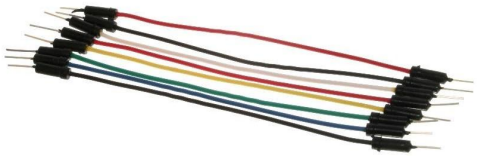
6. Male Headers (Burg Strips)

Pin headers are stiff metallic connectors that are soldered to a circuit board and stick up to receive a connection from a female socket. While pin headers (often called PH, or headers) are male by definition, female equivalents are also quite common, and we refer to them as female headers (FH) or header connectors.

7. Female Headers (Burg Strips)

The *female connector* is generally a receptacle that receives and holds the male *connector*.

8. Jumper Wires

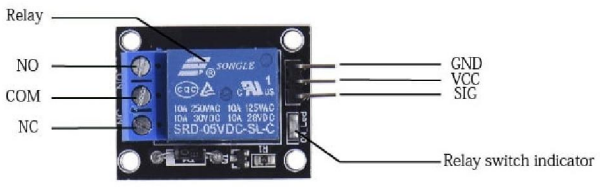


Jumper wires allows an electrical current to travel from one point on a circuit to another because electricity needs a medium through which it can move. Most of the jumper wires are made up of copper or aluminium. Copper is cheap and good conductivity. Instead of the copper, we can also use silver which has high conductivity but it is too costly to use.

9. USB

USB stands for Universal Serial Bus. It is used as a data cable for programming as well as for supplying power.

10. Relay



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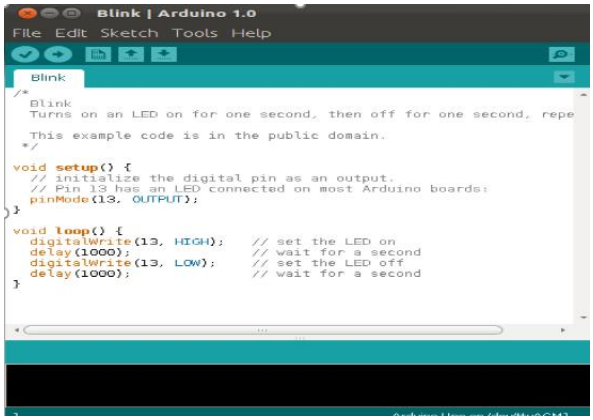
This 1-channel 5V control Single-Pole Double-Throw (SPDT) High-level trigger AC power relay board can be controlled directly via a microcontroller and switch up to 10A at 250 VAC. The inputs of 1 Channel 5V Relay Module are isolated to protect any delicate control circuitry. The default state of the relay when the power is off for COM (Power) to be connected to NC (Normally Closed). This is the equivalent of setting the relay board IN pin to HIGH (has +5V sent to it). A wide range of microcontrollers such as Arduino, AVR, PIC, ARM, etc can be used to control this 5V relay module

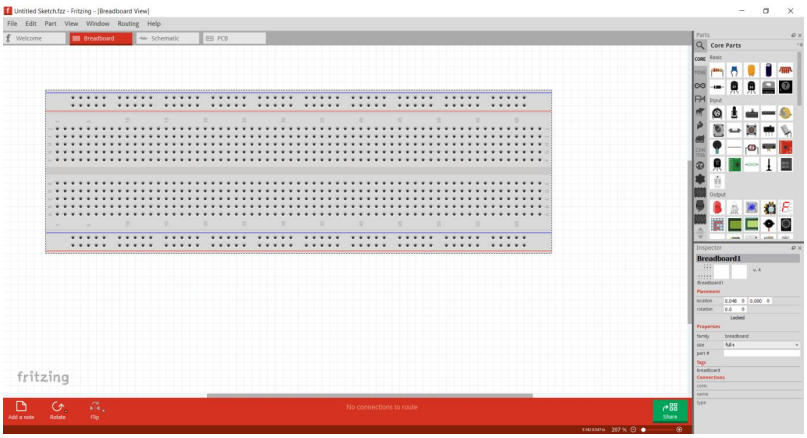
IX. SOFTWARE USED

1. Arduino IDE



The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino board. The source code for the IDE is released under the GNU General Public License, version. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

2. Fritzing



Fritzing is an open-source hardware initiative that makes electronics accessible as a creative material for anyone. We offer a software tool, a community website and services in the spirit of Processing and Arduino, fostering a creative

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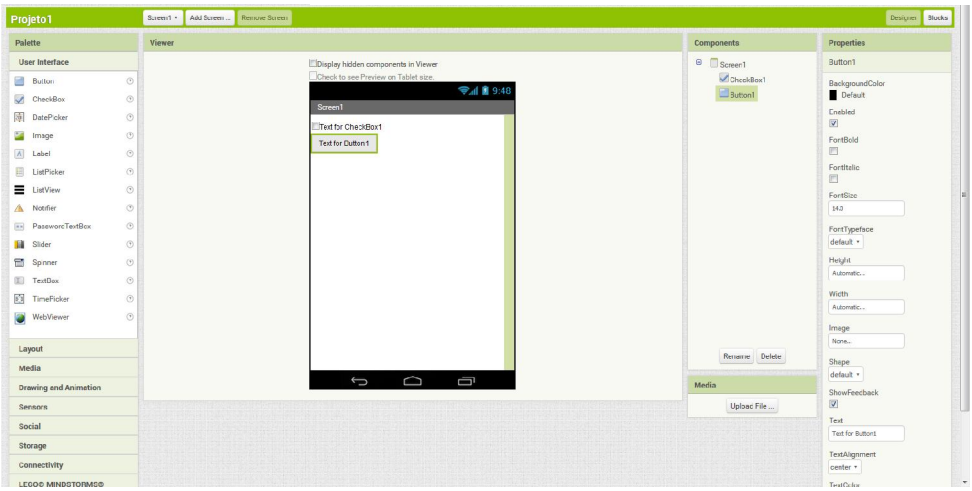
ecosystem that allows users to document their prototypes, share them with others, teach electronics in a classroom, and layout and manufacture professional pcbs.

3. MIT App Inventor 2



App Inventor is a web application integrated development environment originally provided by Google, and now maintained by the Massachusetts Institute of Technology (MIT). It allows newcomers to computer programming to create application software (apps) for two operating systems (OS): Android, and iOS, which, as of 8 July 2019, is in final beta testing, scheduled to be released publicly in summer 2019. It is free and open-source software released under dual licensing: a Creative Commons Attribution ShareAlike 3.0 Unported license, and an Apache License 2.0 for the source code.

It uses a graphical user interface (GUI) very similar to the programming languages Scratch and the StarLogo TNG user interface, which allows users to drag and drop visual objects to create an application that can run on mobile devices. In creating App Inventor, Google drew upon significant prior research in educational computing, and work done within Google on online development environments.

App Inventor and the projects on which it is based are informed by constructionist learning theories, which emphasize that programming can be a vehicle for engaging powerful ideas through active learning. As such, it is part of an ongoing movement in computers and education that began with the work of Seymour Papert and the MIT Logo Group in the 1960s, and has also manifested itself with Mitchel Resnick's work on Lego Mindstorms and StarLogo.F.

ADVANTAGES

- Real-Time Monitoring: Allows for immediate detection of electricity theft, facilitating swift responses.
- Accurate Measurements: Utilizes PZEM004T for precise monitoring of voltage, current, and power consumption.
- User-Friendly Interface: The Kodular app provides an accessible platform for users to monitor power usage and receive alerts.
- Cloud Integration: Data is stored and analyzed on Thingspeak, enabling historical trend analysis and better resource management.
- Community Engagement: Encourages community involvement in monitoring electricity usage, fostering vigilance against theft.
- Cost-Effective Solution: Reduces financial losses for utility companies by promptly identifying and addressing theft incidents.
- Scalability: The system can be adapted to various utility environments, making it suitable for diverse applications.

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- Proactive Management: Transforms electricity monitoring from reactive to proactive, improving overall operational efficiency.

DISADVANTAGES

- Initial Setup Costs: The installation of the PZEM004T meters and ESP8266 modules may incur significant upfront costs.
- Dependence on Internet Connectivity: The system requires a stable internet connection for real-time data transmission and monitoring.

APPLICATIONS

- Utility Companies: To monitor and manage electricity consumption across various distribution points.
- Smart Cities: Integration into smart city initiatives for comprehensive energy management.
- Commercial Buildings: For monitoring power usage and preventing theft in commercial settings.
- Industrial Facilities: To track electricity consumption and detect unauthorized usage in factories.
- Residential Areas: Empowering communities to monitor electricity usage and report theft.
- Remote Areas: Useful for monitoring electricity theft in rural or remote utility poles.
- Research Purposes: Data collected can be used for research on energy consumption patterns and theft incidents.
- Environmental Monitoring: Contributes to energy conservation efforts by identifying and reducing losses.

X. CONCLUSION

The IoT-Based Pole Anti-Theft System represents a significant advancement in combating electricity theft through innovative technology. By integrating real-time monitoring with user-friendly applications, the system empowers utility providers and communities alike to take proactive measures against unauthorized power consumption. Utilizing the PZEM004T energy meter and ESP8266 Wi-Fi module, the system offers accurate data collection and seamless communication with cloud platforms, facilitating timely alerts and efficient resource management. This project not only addresses the pressing issue of electricity theft but also promotes a culture of energy conservation and community engagement. As utility providers increasingly adopt smart technologies, the IoT-Based Pole Anti-Theft System sets a benchmark for future developments in energy monitoring solutions, enhancing operational efficiency and reducing financial losses associated with theft. Ultimately, this system contributes to the sustainable management of energy resources, paving the way for smarter and more resilient utility infrastructures.

XI. FUTURE SCOPE

The future scope of the IoT-Based Pole Anti-Theft System is vast, with potential enhancements and adaptations that can significantly improve its functionality and effectiveness. Integrating advanced machine learning algorithms could enable the system to learn from historical data, providing predictive analytics to anticipate theft incidents before they occur. Moreover, incorporating additional sensors, such as infrared or thermal sensors, could further enhance the system's ability to detect unauthorized power usage in various environmental conditions.

Expanding the system's capabilities to include integration with other smart city technologies, such as smart meters and grid management systems, could create a comprehensive energy management solution. Additionally, expanding its reach to include water and gas theft detection could provide a holistic approach to resource management for utility companies. Finally, enhancing the mobile application with more features, such as user-defined thresholds and analytics dashboards, can empower users to take an active role in monitoring their environments, leading to increased community engagement and vigilance against theft.

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