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AUTOMATED ELECTRICITY MONITORING AND REPORTING SYSTEM

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ABSTRACT

In traditional power outage reporting systems, consumers are often responsible for reporting the issue, which can cause delays in resolving the problem as they may not know the full extent of the outage. This research aims to create a device designed to continuously monitor electricity and notify providers of outages. Due to its portability and low power consumption, the researchers utilized the Arduino Nano. In addition to this, they incorporated the Split Core AC Transformer Module, the ZMPT ACS power line sensor, and an I2C 20x4 LCD screen. Furthermore, a SIM GSM Module was employed to facilitate communication with a pre-registered mobile number. To determine the functionality a series of tests were conducted. The device was tested by turning the power supply off three times for determining the speed of power detection. Then it was turned back on, and continuously monitored the electricity for three minutes. The SMS alert system was also tested by simulating a power outage and verifying that it sent a text message to the pre-registered number with the message "Power Outage Detected!!!" In addition, the LCD displayed "Status: Failure!" to indicate the power outage It can detect a power outage at an average of 8.53 seconds, while 6.64 seconds to detect power restoration. The prototype can also successfully display its status on the LCD screen, as well as send an SMS to the preregistered mobile number. The device prototype is functional in terms of continuous electricity monitoring, and power outage detection.

Keywords: *electricity, power outage, monitoring, reporting*

INTRODUCTION

Power outages, also known as "brownouts" in the Philippines, are common and disruptive in both residential and commercial settings. According to Meralco, these outages arise due to several factors, including scheduled facility upgrades, emergency situations, and maintenance operations. Unplanned outages are typically caused by adverse weather, hardware faults, generation shortages, or objects interfering with power lines. These disruptions affect daily routines, life quality, health, safety, and essential services, and may even result in damage to buildings and financial systems (Hachem-Vermette & Yadav, 2023).

Traditional methods of detecting and reporting outages in the Philippines rely on consumers manually notifying electricity providers via email, SMS, or calls, which can delay response times. To improve response efficiency, researchers have explored alternative methods for outage detection. Sun et al. (2016) proposed using social media data, particularly Twitter (now X), to locate power outages in real-time without relying on infrastructure. Khan et al. (2019) introduced a real-time system using social sensing and predictive algorithms for disruption management. Various Internet of Things (IoT) devices have also been developed for power outage detection, including a sensing gadget by Fauzi et al. (2021) in Indonesia, which monitors outages and transmits data to response teams.

However, despite these technological advances, the Philippines lacks devices and methods to automatically detect and report outages directly to power providers, resulting in prolonged disruptions. To address this gap, this study introduces the Automated Electricity Monitoring and Reporting System (A.E.M.R.S.), designed to continuously monitor electricity flow and automatically notify the provider of outages. The system aims to enhance the efficiency of outage reporting and reduce downtime for consumers.

Statement of the Problem

Generally, this study aimed to develop a reliable system for continuous monitoring of electricity flow using ACS (Alternating Current Sensors).

Specifically, this study aimed to answer the following questions:

1. Is A.E.M.R.S. functional in terms of:
    a. continuous electricity monitoring;
    b. power outage detection; and
    c. speed of power outage detection.
2. Can GSM (Global System for Mobile Communications) module be integrated to facilitate real-time SMS notifications to the electricity provider when a power outage is detected?

Objectives of the Study

Generally, this study aimed to develop a reliable system for continuous monitoring of electricity flow using ACS (Alternating Current Sensors).

Specifically, this study aimed to determine if:

1. The A.E.M.R.S. is functional in terms of:
    a. continuous electricity monitoring;
    b. power outage detection; and
    c. speed of power outage detection.
2. GSM (Global System for Mobile Communications) module can be integrated to facilitate real-time SMS notifications to the electricity provider when a power outage is detected.

Hypotheses of the Study

Based on the problems verbalized, the following assumption is drawn:

1. The A.E.M.R.S. is functional in terms of:
    a. continuous electricity monitoring;
    b. power outage detection; and
    c. speed of power outage detection.
2. GSM (Global System for Mobile Communications) module can be integrated to facilitate real-time SMS notifications to the electricity provider when a power outage is detected.

Theoretical Framework

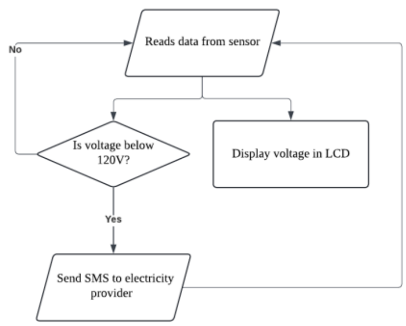
The design principles of the Automated Electricity Monitoring and Reporting System (A.E.M.R.S.) integrate several concepts such as embedded systems, sensor technologies, the Internet of Things (IoT), and real-time networks. The system primarily relies on an Arduino Nano, which is a small and low-power microcontroller that processes data from sensors and performs functions like sending alerts. Another reason for the effectiveness and operability of power failure monitoring in the real-time environment is due to the embedded systems concepts. This includes Split Core AC Transformer Module, and ZMPT ACS power line sensors that assist in the measurement and monitoring of electrical parameters while converting these metrics into Arduino readable formats for identifying electrical outages. This highlights the importance of the accuracy of sensors as well as the reliability of the sensors when there is a real-time detection and action.

According to IoT and real time communication theories data exchange and communication is supposed to be done as fast as possible especially in places where the power has been cut off effectively controlled. A.E.M.R.S. is able to relay information on electricity cut offs to the distributor of electricity, through the use of the SIM800L GSM module, explaining the reasons for the messages and real time alerts on the occurrence of the cut offs, to enable the distributor take action in good time. Such communications are enhanced in reliability because they also have error correction features. Power management system parameters are also included into the general system design. In this instance a 18650 Li-ion battery is used to power the system and this allows for 10 days of uninterrupted operation of the device with the aim of ensuring the preservation of the system even when there are long power cuts and when it may not be possible to restore power immediately.

Conceptual Framework

The design of the Automated Electricity Monitoring and Reporting System (A.E.M.R.S.) allows for the continuous monitoring of the voltage levels due to the presence of sensors that check the electrical supply in real-time. If the voltage surpasses 120V, this is indicated on an LCD screen for the sake of visibility. On the other hand, when the voltage reading falls below 120V, meaning there is a likelihood of a power cut, the system goes further to activate by sending an SMS to the service provider. This guarantees timely detection and monitoring, as well as communication to control the down time during power outages.

Figure 1
Conceptual Framework of the Study



Literature Review

Social Media Solutions. As Sun et al., (2016) claimed, power outages can be detected in real-time by utilizing social media, in this case, the creators used Twitter (now X), as a tool that acts like a 'social sensor'. The tweets were found to be effective in implementing the proposed model and it was shown that social media can assist utility personnel in locating the areas affected without relying on normal measurement infrastructures. In the same way, Khan et al. (2019) enhanced this idea by creating a real time system for situation awareness through social sensing, which is dedicated to caters to the needs of restoring electricity supply during such disturbances. They showed that it is possible to employ machine learning techniques like a multi-layer perceptron with vector representation to achieve enhanced outages detection rather than regression approaches that are used traditionally.

Application of the Internet of Things (IoT). Power outages issues have been addressed through the use of IoT technologies which have produced several devices aside from social media solutions. Fauzi Et Al. (2021) designed a power outage detection device for use in Indonesia and specifically for the country's power distribution systems. This IoT device tracks the length and frequency of blackouts continually and transmits the information to the database without the assistance of the end users. It also helps in dispatching the repair teams to the exact point of outage location and thus helps in cutting down the repair time. Another IoT oriented approach came from Jamshed et al (2022) who developed a device that observes the three phases of power and informs of the changes through both LCD and SMS. Their system does not limit itself to real-time data presentation in form of text message to prescribed cellular phones but also incorporates a representation of power situation and the position of the outages in a landscaped field. Sinkala and Phiri, (2020) went ahead and added to the existing body of knowledge by coming up with an online power outage detection and management system. By connecting a microcontroller to the distribution lines, this system is able to self-monitor power cuts and alert electric companies through the web, thus lessening the need for human effort.

Consumer-Grade Solutions. Other similar products, such as Accumax, iSocket, NoPowerSMS, Smartplugs, give the customer the capacity to monitor either their home or business for power loss occurrences. However, these consumer solutions are limited, as they usually do not go beyond informing the end-user and do not notify the electricity provider. Thus, they cannot help restore electricity in a very short time. There is no solution in such countries like the Philippines as well, where consumers face even prolonged and more frequent sudden outages with little to no help or responses from utility providers. It therefore calls for localized solutions that involve two-way communication with utility providers to speed up restoration of services after such interruptions.

Other Models. Parikh et al. (2020) recommended the use of smart meters and grid sensors that can detect anomalies in power distribution systems and report them automatically. Predictive analysis techniques are included in this technique in the form of machine learning algorithms that can be trained to identify patterns in data and predict outages before they happen. On the other hand, Martinez et al. (2021) introduced an extra model that consists of IoT and cloud networks in addition to a blockchain based system for efficient outage detection. The blockchain in the system protects the data logs from any bogus information whereas the data collection and dissemination occurs via various IoT devices. Hypothetically, the system has been designed in such a way that the integrity of the data contained within is assured at all times even when there are extreme interruptions in the normal operations of the organization’s systems, making it ideal for controlling power losses as they occur.

RESEARCH METHOD

Research Design

The present research adopted an experiment-based descriptive design aimed at ensuring a workable system for electric power flow measurement through the use of ACS sensors. Systematic evaluation emphasizes on testing and perfecting the system and its components for functions, accuracy and efficiency, while descriptive evaluation explains the processes and results of the system's creation. The main aim was to design, implement and assess a power consumption monitoring system which records consumption on an hourly basis, is able to detect any power cuts and informs the utility. This allowed for the comprehensive assessment of the system’s behavior in different settings, and hence was both theoretical and practical.

General Procedure

For accurate measurement of the electricity flow, a detailed calibration of the ACS (Alternating Current Sensor) sensors has been conducted. This entails the application of known electrical loads where adjustments on sensor output is carried out to ensure measurements correspond to real conditions. During this stage, calibration factors were incorporated to the unprocessed data acquired from the sensors to mitigate the difference between sensor output and actual power consumption levels. After sensor calibration, a stable and adequately designed power supply circuit was put in place for the proper functioning of the system as a whole. The power supply had to ensure that all the components of the system, including, the ACS sensors, Arduino microcontroller, GSM module, LCD screen and other attachments, could be powered at the same time and continuously for a long period of time.

The circuit layout shown in Figure 2 has been constructed with suitable measures to reduce any electrical noise and electromagnetic interference, which could jeopardize the sensor data collected. The circuit design made use of filtering elements such as capacitors and inductors in order to even out power supply, as well as to get rid of any high-frequency noise. Moreover, the component layout on the printed circuit board was also configured to minimize interference from surrounding circuitry so that the output signals from the ACS sensors were clean and accurate.

Figure 2 *Schematic Diagram of A.E.M.R.S.*

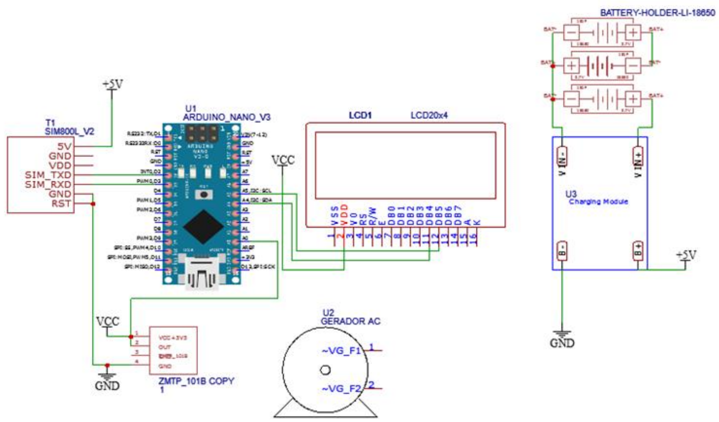
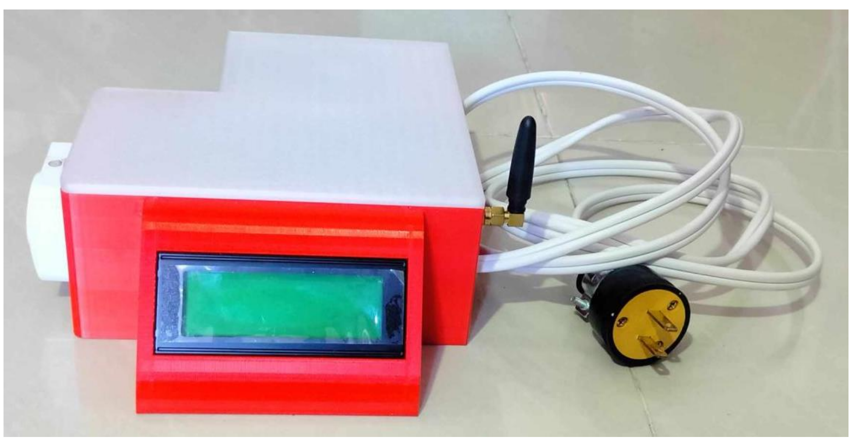


Figure 3
Actual A.E.M.R.S.



The device is powered by an 18650 Li-Ion Battery. The programming language for A.E.M.R.S was developed using C++ programming language through the Arduino IDE. To monitor the current and volts of the electricity the device uses a Split Core AC Transformer Module that monitors the AC of the device. The device also uses a ZMPT ACS power line sensor that converts the AC voltage into a signal that the board understands. The status of the power supply will then be displayed on the LCD screen. The SIM GSM Module allows the device to send an SMS signal to the preregistered mobile number to send the information from the device.

Data Gathering

A.E.M.R.S. undergone a series of trials to evaluate its performance in detecting power outages, monitoring electricity flow, and sending timely notifications via SMS. Three separate trials were conducted to assess the system's accuracy, reliability, and response time in real-world scenarios.

To evaluate the system’s power outage detection capability, the device was tested by manually cutting off the power supply three times. Each time the power was turned off, the response time was recorded to measure how quickly the system could detect the outage. Once the power was restored, the device continued to monitor the electricity for a duration of three minutes. During this period, the power levels were consistently observed and recorded to determine if the sensors accurately tracked the electricity flow.

In addition to power monitoring, the functionality of the SMS alert system was tested by simulating a power outage. The system was expected to send an SMS notification to the pre-registered mobile number with the message "Power Outage Detected!!!" when an outage occurred. The system’s LCD was also observed during this process to confirm that it displayed the message "Status: Failure!" to indicate the detected outage. These tests were repeated three times to ensure the system’s accuracy and consistency in both local and remote reporting mechanisms.

Data on the time taken to detect power outages, the accuracy of continuous monitoring, and the reliability of SMS alerts were gathered and analyzed to assess the overall functionality of the A.E.M.R.S.

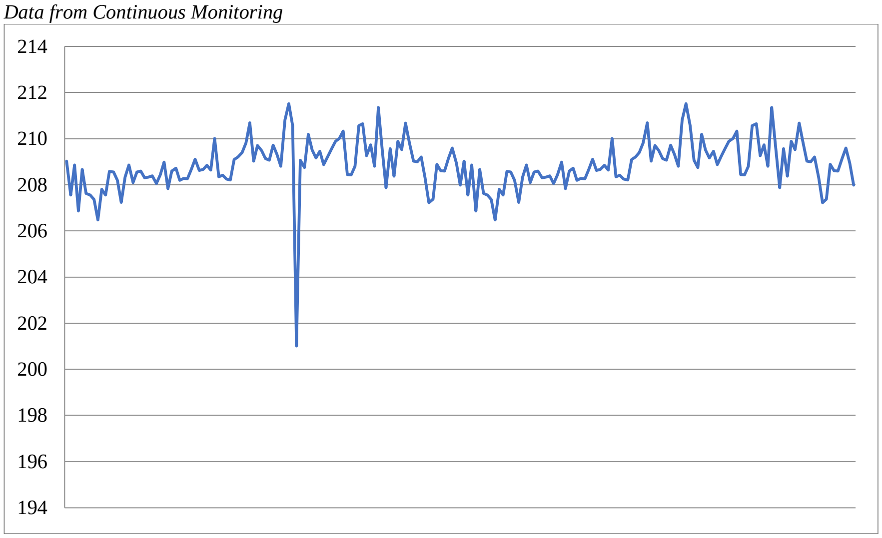
RESULTS

Functionality of A.E.M.R.S in Terms of Continuous Electricity Monitoring

The LCD screen displayed accurate and continuous electricity monitoring for more than 3 minutes. The display provides precise and fast readings of the continuous data collected by the ACS power sensors, allowing for accurate tracking of electricity flow.

Figure 4

Data from Continuous Monitoring



Functionality of A.E.M.R.S. in Terms of Power Outage Detection and Notification

The table below shows that the device is functional in terms of power outage detection, and notification. When the device is disconnected from the power source, a “Status: Failure!!” message is displayed on the LCD screen, and then a “Power Outage Detected!” message is sent to the preregistered mobile number to notify that the device did not detect an electricity flow higher than 120V.

Table 1

Power Outage Detection and Notification

Parameter	Trial		
	1	**2**	**3**
Detects and Notifies Power Outage through SMS	Yes	Yes	Yes

Functionality of A.E.M.R.S in Terms Speed of Power Outage Detection

The data below shows that it takes an average of 8.53 seconds for the device to detect that it was disconnected from a power source, while 6.64 seconds to detect power restoration.

Table 2

Speed of Power Outage/Restoration

Electricity Flow	Speed of Power Outage/Restoration Detection (in s)			Average
	1	**2**	**3**	
Without Power	8.67	8.64	8.29	8.53
With Power	6.70	6.76	6.46	6.64

DISCUSSION

The findings from this study contribute significantly to the existing body of knowledge regarding automated systems for electricity monitoring and power outage detection. The A.E.M.R.S. demonstrated a notable average detection time of 8.53 seconds for power outages and 6.64 seconds for restoration, which is essential in minimizing downtime for consumers. Also, the real time alerts by means of a GSM module incorporated in the system, improves the response time of the power management companies in the event of outages. The ability to do so exists due to the necessity for timely communication in power management that has prompted research on different ways of detecting outages (Sun et al., 2016; Khan et al., 2019), for instance, in this case, the research is considered of importance in the communication technologies used during the surveillance of power disruptions. In particular, this uplifts the role of technology in ensuring electricity service is reliable and responsive to the demand, in the country such as the Philippines where these systems are still developing.

Although the research demonstrates a working proof of concept prototype with notable features such as precise monitoring and sending SMS alerts to its users, it also puts forward a couple of restrictions which ought to be looked into. First of all, the limited number of trials (three) casts doubts on the validity and the scope of the findings considering the fact that the testing was limited to laboratory settings only and did not involve real homes or commercial buildings. Furthermore, water ingress susceptibility and the dependence on rechargeable batteries of the prototype may create operational and servicing limitations to the end users. Notwithstanding that, this work is the biggest improvement over prior efforts because it seeks to embed monitoring and notification features within the study, unlike these other studies which proposed devices that only informed the consumers but not the energy providers.

Results of this study indicate that improving communication systems, for example by disseminating SMS alerts along with monitoring systems, enhances the speed and operational effectiveness of electricity providers. In addition, this research emphasizes the urgent need for improvements in existing power management systems, especially in areas that experience serious challenges due to frequent and long power outages. The study contributes to the understanding of energy monitoring and management, offers innovative approaches and methods, and indicates the development of automated systems in the future to reduce the consequences of power cuts on consumers and utility companies.

Conclusions

The study’s findings validate the functionality of A.E.M.R.S. in continuous electric monitoring, prompt identification of power interruptions, and automatic SMS notifications. The system has achieved an average time of 8.53 seconds for detecting an outage and 6.64 seconds for restoration. These results prove that A.E.M.R.S. is a good tool for real time monitoring and reporting of electricity outages enhancing communication between the electricity providers and consumers thanks to GSM integration.

Recommendations

Based on the findings of this study, it is recommended that future research focus on expanding the testing of the A.E.M.R.S. in real-world residential and commercial settings to validate its performance under diverse conditions. Additionally, addressing the prototype's limitations, such as waterproofing and battery dependency, will enhance its practicality and reliability. Furthermore, exploring the integration of advanced communication technologies and machine learning algorithms may improve the accuracy of outage predictions and the overall efficiency of power management systems in the Philippines and similar developing regions.

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