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Implementation Of IoT-Based Sense Plug Design On The Prototype Of The FTTH Network Of The UPI Campus Transmission Laboratory In Purwakarta

Desiana Fajar Wisdawati[1], Ahmad Fauzi[2]
[1,2]Universitas Pendidikan Indonesia, Indonesia
Email: desianafw_2104199@upi.edu, ahmad.fauzi@upi.edu

ABSTRACT

The increasing demand for energy presents challenges in efficient energy management. This study aims to develop and implement an Internet of Things (IoT)-based energy monitoring system called SENSE Plug, integrated with a Fiber To The Home (FTTH) network at the Universitas Pendidikan Indonesia campus laboratory. The system is designed to monitor real-time electricity consumption, detect voltage anomalies, and manage the electrical usage of connected electronic devices. The research uses an experimental approach by designing and testing the system in the laboratory. Data was collected using the PZEM-004T sensor connected to the NodeMCU ESP8266 microcontroller, with the measurements displayed on an OLED screen and sent to the IoT Cloud for remote monitoring. The system was tested on various electronic devices to measure voltage, current, active power, and power factor. The results indicate that the SENSE Plug system achieved high accuracy, with an average error of 0.44% for voltage and 0.41% for current. The system can also detect voltage anomalies and automatically disconnect the power supply to prevent damage to devices. In conclusion, SENSE Plug contributes to improving energy efficiency and offers a solution applicable to smart labs and other building environments.

KEYWORDS *IoT; energy efficiency; power monitoring; FTTH; voltage anomaly detection; Smart Lab*

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INTRODUCTION

Energy efficiency has become a global concern, along with the increasing energy needs and environmental impacts it causes. Conventional energy management systems, such as traditional electricity meters, are still widely used but have several limitations. These meters are only able to measure the overall power

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consumption accumulated in a period, usually monthly, without providing detailed data regarding the energy usage of individual devices. In Indonesia, people still depend on conventional electricity meters provided by PLN. The meter does not have communication facilities for monitoring in real-*time*. This limitation makes it difficult for consumers to manage their electricity use efficiently. This pattern of electrical energy consumption is often not monitored and not properly controlled, so it has the potential to cause energy waste (Muralidhara et al., 2020).

Monitoring electricity in *Real-time* is a crucial first step to developing energy efficiency (Zhang et al., 2024). Some previous studies have proposed updates such as the *KWH* digital meters with algorithms to enable re-recording of electricity consumption or reset of energy records. Technology integration *Internet of Things (IoT)* deep *Smart Energy Meter,* which focuses on energy efficiency that allows monitoring and control of energy consumption through an Android app (Tahir et al., 2022). This feature offers measurement flexibility, allowing users to update energy consumption data at any time as needed. The sensors used in this system are designed to read various predetermined parameters, such as power consumption, voltage, and current. Result *Monitoring* The electricity consumption is displayed in real-time through the screen *OLED*, also managed and stored in the cloud, making it easy for users to monitor energy consumption remotely (Díaz et al., 2024).

Furthermore, the system is equipped with an advanced anomaly detection mechanism, which is capable of identifying potential problems such as significant voltage and current surges or drops. Real-time monitoring of electrical measurement parameters allows the system to detect abnormalities in the electrical flow and respond quickly to abnormal conditions. This anomaly detection not only ensures that the electrical flow operates within normal limits but also serves to protect the safety of users and prevent damage to electronic equipment. By anticipating unexpected input spikes or fluctuations, the system helps to reduce the risk of device damage and improve overall operational safety (Asorza et al., 2024).

Design *IoT* is applied in the Campus Transmission laboratory of the University of Education Indonesia in Purwakarta, which has been equipped with prototype *FTTH*. Integration between technologies *IoT* and *FTTH* in monitoring and managing energy consumption can create an environment that supports the concept of Smart Lab (Khriji et al., 2020). Prototype *FTTH* It offers a capacity *Bandwidth* large and minimal latency (Lakhan et al., 2024). Tool *Monitoring* Electricity-based *IoT* enables monitoring in *Real-time* with remote control (Tekler et al., 2020). Effectiveness *FTTH* will support stable internet connectivity on the design of *Systematic Energy Monitoring and Smart Efficiency* abbreviated to *SENSE Plug (SP).*

SENSE Plug It is designed to be able to monitor the power consumption not only of the combined electronic devices but also of *Monitoring* devices individually. Design *SENSE Plug* equipped with an anomaly detection feature guided by the IEC 60038 standard, setting the necessary voltage threshold to ensure the stability and safety of the operation of electrical devices. If the voltage drops outside this range, either too low or too high, the system will detect anomalies to ensure safety in low-voltage electrical installations 230 *V* (Directorate General of Electricity, 2016, 2014).

In previous research, there was a type of smart light control device designed to operate responsively, allowing users to efficiently control the flow of electricity connected to the load through an Android app (Fuada et al., 2023). In other studies, measurements and *Monitoring* of Some electronic equipment can be done without interfering with the operation of the electronic device through the application of the *plug and use*, which makes it easier for users to connect electronic devices to the system without the need for complicated configuration (Muralidhara et al., 2020). Integrating ideas from previous research, *SENSE Plug* (*SP*) not only serves as a tool for *Monitoring* electricity, but it also can detect anomalies and control the flow of electricity at connected loads. Thus, the application of electronic devices becomes more varied because they can control not only lights but also various other electronic equipment. Has a primary focus on monitoring *Real-time* and long-distance connectivity by utilizing the internet connection of the network prototype *FTTH*, the design discussed in this article extends the idea of control through the Android interface and the website. This makes it an ideal solution for its application in smart labs.

Thus, this system offers comprehensive solutions for managing energy consumption, as well as opening up opportunities for further research in the development of more innovative and sustainable energy efficiency technologies (Tekler et al., 2022). One of the real applications of this concept is the design of the SENSE Plug, which can monitor electricity usage in real time and manage energy consumption limits. This SENSE Plug not only helps users accurately identify energy usage patterns but also allows for tighter control of electricity consumption through the consumption limit setting feature that can be adjusted as needed. This integration of smart technologies not only contributes to the energy efficiency of the lab room but also reflects a retrofit approach that can be applied to existing buildings without the need for major renovations. Therefore, this design is an important part of the effort towards a smarter, integrated, and environmentally friendly energy efficiency (de Oliveira et al., 2024). Table 1 shows a comparison of system features *Monitoring* electricity-based *IoT* developed in this study with several previous studies.

Table 1. Comparison of features with existing research

Author	***Plug and use***	**Anomalous Messages**	**Order Consumption Limit**	**Custom limit & *Timer***	**Consumption price information**	***Websites* and *apps***	***On off Control***
(Muralidhara et al., 2020)	✓	✓	X	X	X	X	X
(Güçyetmez and Farhan, 2023)	X	X	✓	X	✓	✓	X
(Santhosh et al., 2021)	X	✓	✓	X	X	X	X
(Sheeba et al., 2021)	X	X	✓	X	X	✓	X
(Ahammed and Khan, 2022)	X	X	✓	X	X	✓	X
SENSE Plug (SP)	✓	✓	✓	✓	✓	✓	✓

The purpose of this study is to design and implement an Internet of Things (IoT)-based SENSE Plug integrated with a Fiber To The Home (FTTH) network in the Indonesian Education University laboratory in Purwakarta. This study aims to improve energy efficiency through real-time monitoring of electricity consumption and voltage anomaly detection on electronic devices. This system is expected to provide innovative solutions in more efficient electricity management in the laboratory environment and support the smart lab concept.

The benefits of this study include several aspects, both theoretical and practical. Theoretically, this study is expected to contribute to the development of IoT technology in the context of energy efficiency and real-time monitoring of electricity consumption. The results of this study can be a reference for further research related to the use of IoT for energy management.

RESEARCH METHOD

Research Design

This research aims to develop and implement a system *Monitoring* electricity-based *IoT*, i.e., design *SENSE Plug*, which is designed to measure electrical energy consumption in real-*time*, detect anomalies, and automatically control connected devices. The design of this study combines an experimental approach to test the system in the laboratory by utilizing an internet connection through a network prototype, *Fiber To The Home* (FTTH), as a data communication medium. This approach allows for more comprehensive testing of system performance while ensuring the reliability and speed of data transmission required for effective monitoring and control. The system was developed by integrating several components, such as sensors and microcontrollers connected to the *IoT Cloud.* It allows users to remotely monitor and control energy usage through the Internet of Things platform (Ntafalias et al., 2024). The SENSE Plug has several specific purposes, including:

1. Design monitoring equipment that does not interfere with the performance of connected electronic devices.
2. Provides anomaly detection features to identify faults in voltage or current, as well as implement automatic anticipation measures to maintain system stability.
3. Improving the efficiency of electrical energy management by providing control features that can be accessed through applications and the web, allowing for more efficient decision-making in energy consumption management.
4. Develop solutions that can be implemented in various environments, including smart labs, homes, and other public buildings or facilities. The application of IoT integration and this intuitive interface aims to make it easier to *monitor* and control the system.

Subject/Object Characteristic

The object of this research is the *SENSE Plug electrical monitoring system* applied in the transmission laboratory of the University of Education Indonesia Campus in Purwakarta, which has been equipped with an FTTH *prototype* as the main internet network. *The SENSE Plug*, which is connected to the internet through the *FTTH network, allows* real-time *measurement and monitoring of electrical energy consumption* on each connected device.

As shown in Figure 1, the main components used in *the SENSE Plug* system include:

1. The PZEM 004T sensor used can measure voltage (*V*), current (*I*), active power (*P*), energy (*kWh),* Power factor *(PF*), and frequency. This PZEM-004t sensor can perform measurements with an error of less than 1% (Sanchez-Sutil & Cano-Ortega, 2023).
2. The NodeMCU microcontroller ESP8266 is equipped with a Wi-Fi module, allowing data transmission to *IoT Cloud* and connection to the internet via network *FTTH* (Raju & Laxmi, 2020).
3. 3 V Relay Module, which functions as an automatic switch to disconnect or connect the power flow based on the detected condition or control from the user. On the input and ground relay are given capacitors to reduce *noise* and electromagnetic interference (EMI) that may affect the performance of the relay (Wen et al., 2023).
4. The OLED *screen* serves as an interface to display the measurement results in *real time* and can be viewed directly on the *SENSE Plug*.

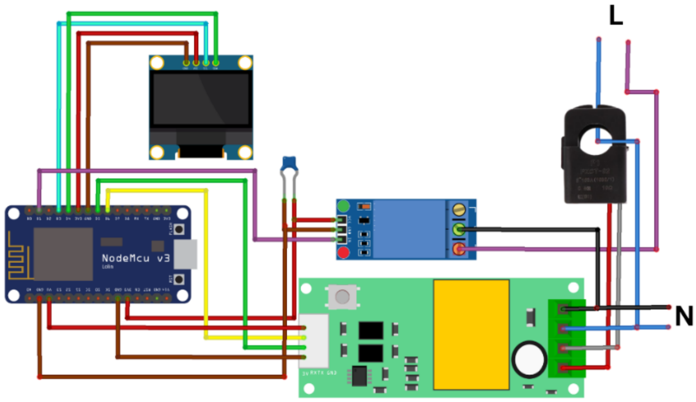


Figure 1. Component range

Data Collection Technique

In this developed SENSE Plug design, electricity consumption data is measured using a PZEM 004T sensor connected to a NodeMCU ESP8266 microcontroller. This microcontroller can be programmed to manage sensor measurement results and display eight electrical parameters, namely voltage (V), current (I), active power (P), energy (kWh), power factor (PF), frequency, apparent power, and reactive power. All of these parameters are displayed *in real-time* via *an OLED* screen for direct observation of the physical *SENSE Plug*. However, due to the limitations of the free features of the *IoT Cloud* platform used, only four main parameters can be uploaded and monitored online, namely voltage (V), current (I), energy (P), and power factor (PF). The decision to choose these four parameters is based on the importance of these parameters in analyzing energy consumption and operational efficiency of electrical devices. The data uploaded through the NodeMCU microcontroller ESP8266 to the *IoT Cloud* can be accessed in *real-time* via an application or web interface, allowing users to remotely monitor electricity consumption and specified electricity parameters.

The SENSE Plug design is also equipped with automated decision-making capabilities based on the results of the measured parameters, specifically to detect voltage anomalies and cut off power when needed. The SENSE Plug is designed to detect anomalies in voltage or current, such as sudden spikes or significant voltage drops. The automated decision-making feature on the SENSE Plug makes it more than just a monitoring tool; it also serves as a proactive protection system. Able to detect and respond quickly to electrical fluctuations, the SENSE Plug can prevent device damage due to electrical anomalies. This anomaly detection is based on the international voltage tolerance standard (IEC 60038), where the allowable voltage limit is within ±10% of the nominal voltage of 230 V ("IEC Standard Voltages," 2021). If an anomaly is detected, such as a voltage drop outside the anomaly limit or out of the range of 207 V to 253 V, the relay will automatically cut off power to the connected device as an anticipatory measure. In addition, this feature plays an important role in improving energy efficiency by keeping electricity use stable and controlled. Suboptimal voltage conditions, such as voltage being too low, can make the device work less efficiently and require more current, ultimately increasing energy consumption. Conversely, too high a voltage can lead to overheating, which not only wastes energy but also risks damaging electronic components. By addressing these issues, the SENSE Plug reduces the risk of energy waste and ensures more efficient use of electricity (Brinkel et al., 2020).

The *SENSE Plug (SP)* flow uses *the plug & use* concept, by simply connecting an electronic device to *the SP* through *the plug*, the device can be measured and monitored automatically. The SENSE Plug internet connection is obtained through *the internet access point* of the FTTH network *prototype*, which enables remote operation and control through *the IoT Cloud* interface. Figure 2 shows the overall workflow of the designed system.

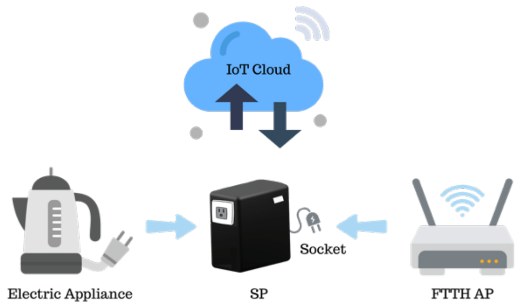


Figure 2. System-wide workflow

Data Collection Technique

Data analysis involves measuring several electrical parameters to evaluate energy use efficiency and detect anomalies. The collected data were analyzed as follows:

1. Active Power Measurement (P)

Active power is calculated using the formula:

$CP = V \times I \times \cos\phi$ (Yu et al., 2020)

Where

V:Voltage

I :current

Cos φ : power factor.

The power factor describes the efficiency of the use of electrical energy by the device. This power factor is in the range of 0 to 1 and measures the ratio between active and pseudo-power in the system. A power factor that is valued at or close to 1 indicates high efficiency, while a low power factor indicates the presence of reactive power, which means that some of the electrical energy is not used effectively (Ikram et al., 2024).

The focus of this analysis is on the accuracy and validation of measurements with standard measuring tools. This aims to ensure the performance and reliability of the sensor in monitoring electricity consumption, which includes voltage (V), current (I), and active power (P) parameters. The power factor or cos φ value for each device is taken from the measurements taken by the SENSE Plug to provide a more complete picture of the energy efficiency used by the device.

2. Error and Accuracy Calculation

A comparison is made between the sensor measurement results and a standard measuring instrument for voltage (V), current (I), and active power (P) parameters. The two formulas used to evaluate the quality of the measurements are:

a. *Error* (%):

$$Error\ (\%) = \left|\frac{Nilai\ Alat\ Ukur - Nilai\ Sensor}{Nilai\ Alat\ Ukur}\right| \times 100$$ (Trevathan et al., 2022)

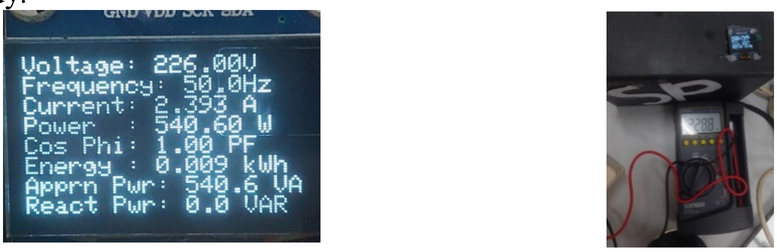
The error is calculated to measure the deviation between the sensor measurement and the standard measuring instrument.

b. *Accuracy* (%):

$$Akurasi\ (\%) = 100 - Error(\%)$$ (Jais et al., 2024)

Accuracy shows how close the sensor measurement results are to the actual value.

These error and accuracy *calculations* are performed for each set of voltage (V), current (I), and active power (P) measurement data that will be presented in a table for easy analysis. Figure 3 shows the display of *the SENSE Plug* designed in this study.



a) b)

Figure 3. a) Sensor measurement results displayed through *OLED*; b) *SENSE Plug* and measuring instruments.

RESULT AND DISCUSSION

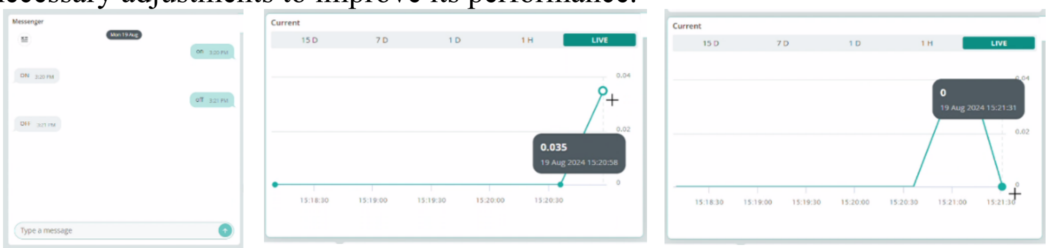
In this section, the design performance *of the SENSE Plug*-in control management through *the IoT Cloud interface,* as well as the validation of sensor measurement results with standard measuring tools, will be discussed.

SENSE Plug Features

System control is carried out through an intuitive interface on the application and web, where every command entered through the *message widget* will be automatically recorded and visualized in the form of a graph, as shown in Figure 4. This graph depicts the system's response to a given command and provides a clear visualization of the performance and effectiveness of the controls applied. These features include:

1. On & Off *Control*

As seen in Figure 4 when the *"on"* command is given, the graph shows an increase in current, reflecting that the current flows to the load and is in use. In contrast, the graph shows that the current drops to zero when *the "off"* command is applied. With this visualization, every action taken can be carefully analyzed and evaluated, ensuring that the system is functioning as expected and allowing for the necessary adjustments to improve its performance.



a) b) c)

Picture 4. a) *Widget message* with the command *"on"* and *"off"*; b) Current graph if *"on";* c) Current graph if *"off"*

2. Set consumption limits

This SENSE Plug is equipped with various additional features that increase its functionality and ease of use. One of its key features is the ability to set energy consumption limits. If the energy consumption reaches or exceeds the predetermined limits, as shown in Figure 5a. In this case, the SENSE Plug will disconnect the power to the load to prevent the overuse of energy or reduce energy waste.

3. Reset energy consumption

As shown in Figure 5b, this feature returns the energy data on the graph to zero. This allows the system to be able to start recalculating energy consumption from scratch. This feature is very useful to facilitate repeated measurements by deleting previous consumption data.

4. Displays the eight parameters displayed in *the OLED* & electricity consumption bill

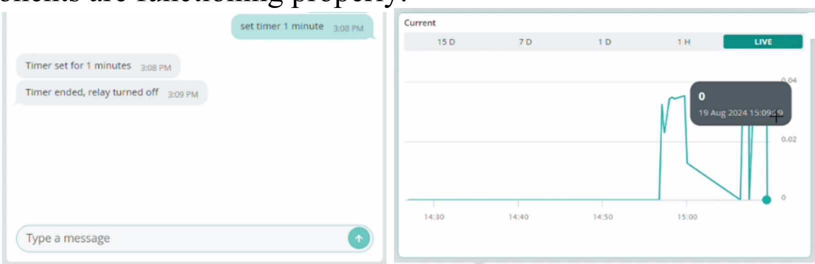
Displays information on eight measurement parameters on the *OLED* screen at a time by entering the commands "*show all*" and "*bill*" to find out the electricity bill. All related information will be displayed in full, as seen in Figure 5c.

a) b) c)

Figure 5. a) Set limits and automatic messages if consumption reaches the limit; b) Energy graph when reset; c) Display 8 parameters of sensor & bill measurement results

5. Timer features

In Figure 6, the timer is set via *the message widget* to set the time limit for the current flow to the load. Then, the way this tool works is visualized in the form of graphs on the *IoT Cloud interface* that displays the *monitoring* results. This graph provides a clear picture of the system's response to a given command, making it possible to monitor the performance of the tool in *real-time* and ensure that all components are functioning properly.

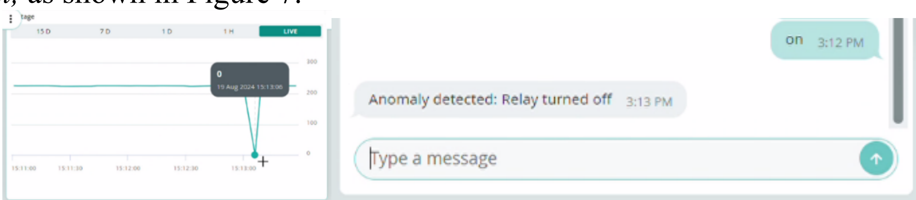


a) b)

Figure 6. a) Setting the timer via *Widget Message*; b) Graph of current that does not flow when *Timer*The finished

6. Anomaly detection

Anomaly detection on *the SENSE Plug* is designed to detect voltage changes that are outside the tolerance limits. During the testing process, the voltage in the transmission lab has a stable voltage stability that is in the range of 222 – 230 *V*. So, to test the detection of this anomaly, the power flow from the source was deliberately cut off temporarily. This step is carried out to evaluate the performance of the system in responding to voltage anomaly conditions. When an anomaly is detected from a predetermined threshold, the SP system will automatically cut off the temporary electrical input and provide an animal message in the *message widget,* as shown in Figure 7.



a) b)

Picture 7. a) Graphs showing voltages outside the limit of the anomaly; b) Automated messaging system

Measurement Results

The performance of the system was comprehensively tested using several electronic devices, with a total power of about 1600 Watts. The test starts with the smallest power load and gradually increases to maximum power, ensuring the sensor is capable of handling a wide range of load conditions. Tables 2 through 5 display the measurement results for voltage (V), current (I), active power (P), and power factor (PF). The measurement results show that the average error for voltage is 0.44% with 99.56% accuracy, current 0.41% with 99.59% accuracy, and power 0.48% with 99.52% accuracy. It also indicates that the sensor shows optimal performance under a wide range of load conditions, ensuring measurement accuracy and consistency across the entire power range.

Table 2. Comparison of measurement results *Voltage (V)*

Appliance	**Voltmeter *(V)***	**SP *(V)***	***Error (%)***	**Accuracy*(%)***
Table Lamp	226.90	227.90	0.44	99.56
Spectrum Analizer	227.30	228.30	0.44	99.56
Drill	225.60	226.60	0.44	99.56
Dispenser	224.50	225.50	0.44	99.56
Electric Kettle	224.80	225.80	0.44	99.56
Hairdryer	225.40	226.40	0.44	99.56
Hairdryer + Drill	224.50	225.50	0.44	99.56
Electric Teapot + Hairdryer	224.00	225.0	0.44	99.56
Electric Teapot + Hairdryer + Drill	224.50	225.50	0.44	99.56
Electric Teapot + Hairdryer + Drill + Dispenser	222.70	223.70	0.44	99.56
Average			0.44	99.56

Table 3. Comparison of measurement results *current* (*A*)

Appliance	**Ampemeter *(A)***	**SP *(A)***	***Error (%)***	**Accuracy *(%)***
Table Lamp	0.034	0.034	0.0	100.0
Spectrum Analizer	0.133	0.136	2.21	97.79.
Drill	0.955	0.958	0.31	99.69
Dispenser	1.666	1.674	0.48	99.52
Electric Kettle	2.388	2.389	0.04	99.96
Hairdryer	2.482	2.492	0.40	99.60
Hairdryer + Drill	3.333	3.327	0.18	99.82
Electric Teapot + Hairdryer	4.807	4.804	0.06	99.94
Electric Teapot + Hairdryer + Drill	5.703	5.702	0.01	99.98
Electric Teapot + Hairdryer + Drill + Dispenser	7.255	7.281	0.36	99.64
Average			0.41	99.59

Table 4. Comparison of measurement results with varying power loads (*Watt*)

Appliance	**Account ($P = V \times I \times \cos\phi$) (W)**	**SP (W)**	***Error (%)***	**Accuracy *(%)***

Table Lamp	4.5	4.50	0.00	100.00
Spectrum Analizer	23.4	23.40	0.00	100.00
Drill	207.75	209.30	0.74	99.26
Dispenser	374.01	377.48	0.92	99.08
Electric Kettle	536.82	539.43	0.48	99.52
Hairdryer	559.44	564.18	0.84	99.16
Hairdryer + Drill	748.25	750.23	0.26	99.74
Electric Teapot + Hairdryer	1076.76	1080.90	0.38	99.62
Electric Teapot + Hairdryer + Drill	1280.32	1285.80	0.43	99.57
Electric Teapot + Hairdryer + Drill + Dispenser	1615.68	1628.75	0.80	99.20
Average			0.48	99.52

Table 5. Power factor measurement results using SENSE Plug (SP)

Appliance	***Power Factor***
Table Lamp	0.58
Spectrum Analizer	0.75
Drill	0.96
Dispenser	1.00
Electric Kettle	1.00
Hairdryer	1.00
Hairdryer + Drill	1.00
Electric Teapot + Hairdryer	1.00
Electric Teapot + Hairdryer + Drill	1.00
Electric Teapot + Hairdryer + Drill + Dispenser	1.00

Power factor variations provide important insights into the energy efficiency of each device measured. As an indicator, the power factor can assess how effective the device is in utilizing the available power. The table lamp and the spectrum analyzer have a power factor of 0.58 and 0.75, respectively, indicating that the two devices are less efficient in energy use. In contrast, devices such as dispensers and electric kettles show a power factor of 1, which signifies optimal power usage and high efficiency.

The overall test results show that the SENSE Plug design can provide accurate monitoring in real-time, enabling optimization of energy use through features such as consumption limit setting and anomaly detection. This is in line with the principle of energy efficiency, where electricity use can be controlled and optimized as needed while minimizing energy waste. This technology supports environmental protection efforts by reducing excessive electricity consumption and contributing to sustainable development goals. By utilizing features such as consumption limit setting and anomaly detection, the system plays a role in reducing the carbon footprint and encouraging more efficient use of electricity.

SENSE Plug is not only designed to meet the needs of the smart lab environment but can also be applied to support more controlled electricity use in homes, buildings, and other public facilities. By integrating advanced technology, SENSE Plug serves as an innovative solution that allows users to monitor and manage energy consumption in real time. This is an important step in achieving sustainable development goals, where technology not only serves as a tool but also as a driver of positive change and supports energy savings, as well as protecting natural resources for future generations.

CONCLUSION

This research has developed SENSE Plug, an IoT-based electrical monitoring device that is integrated with an FTTH network prototype and equipped with a control system for real-time management of electrical energy. It has advanced features such as consumption limit setting, voltage anomaly detection, reset capabilities for repeated measurements, and other control features that support energy efficiency management. Testing shows that the system has a high level of accuracy, with an average error of about 0.4% in voltage, current, and power measurements, and can respond well to a wide range of load conditions. The SENSE Plug design ensures safety and effectiveness in the use of electrical energy while contributing to creating a smart lab environment that supports energy efficiency and sustainability. This research opens up opportunities for further development in the application of more innovative energy efficiency technologies in the future.

REFERENCES

Asorza, J. E. G., Colqui, J. S. L., & Pissolato Filho, J. (2024). Analysis Of Overvoltage And Backflashover Of An Unified Double-Circuit Ohtl—A Case Study. *Electric Power Systems Research*, *236*, 110913.

Brinkel, N. B. G., Gerritsma, M. K., Alskaif, T. A., Lampropoulos, I., Van Voorden, A. M., Fidder, H. A., & Van Sark, W. (2020). Impact Of Rapid Pv Fluctuations On Power Quality In The Low-Voltage Grid And Mitigation Strategies Using Electric Vehicles. *International Journal Of Electrical Power & Energy Systems*, *118*, 105741.

De Oliveira, C. C., Vaz, I. C. M., & Ghisi, E. (2024). Retrofit Strategies To Improve Energy Efficiency In Buildings: An Integrative Review. *Energy And Buildings*, 114624.

Díaz, A. F., Prieto, B., Escobar, J. J., & Lampert, T. (2024). Vampire: A Smart Energy Meter For Synchronous Monitoring In A Distributed Computer System. *Journal Of Parallel And Distributed Computing*, *184*, 104794.

Fuada, S., Duttagupta, S., & Majid, N. W. A. (2023). Low-Cost Wireless Lamp Socket And Power Plug For Smart Homes And Its Comparison With Available Commercial Competitors. *International Journal Of Interactive Mobile Technologies*, *17*(19).

Ikram, M. K., Asghar, M. S. J., Seyedmahmoudian, M., Mekhlilef, S., Stojcevski, A., & Al-Assaf, A. (2024). Advanced Real And Reactive Power Measurement Using Analog Multiplier And Phase-Controlled Switching Technique. *Sensors And Actuators A: Physical*, *378*, 115812.

Jais, N. A. M., Abdullah, A. F., Kassim, M. S. M., Abd Karim, M. M., Abdulsalam, M., & Muhadi, N. (2024). Improved Accuracy In Iot-Based Water Quality Monitoring For Aquaculture Tanks Using Low-Cost Sensors: Asian Seabass Fish Farming. *Heliyon*, *10*(8).

Khriji, S., El Houssaini, D., Barioul, R., Rehman, T., & Kanoun, O. (2020). Smart-Lab: Design And Implementation Of An Iot-Based Laboratory Platform. *2020 Ieee 6th World Forum On Internet Of Things (Wf-Iot)*, 1–5.

Lakhan, A., Nedoma, J., Mohammed, M. A., Deveci, M., Fajkus, M., Marhoon, H. A., Memon, S., & Martinek, R. (2024). Fiber-Optics Iot Healthcare System Based On Deep Reinforcement Learning Combinatorial Constraint Scheduling For Hybrid Telemedicine Applications. *Computers In Biology And Medicine*, 108694.

Muralidhara, S., Hegde, N., & Rekha, P. M. (2020). An Internet Of Things-Based Smart Energy Meter For Monitoring Device-Level Consumption Of Energy. *Computers & Electrical Engineering*, *87*, 106772.

Ntafalias, A., Papadopoulos, P., Ramallo-González, A. P., Skarmeta-Gómez, A. F., Sánchez-Valverde, J., Vlachou, M. C., Marín-Pérez, R., Quesada-Sánchez, A., Purcell, F., & Wright, S. (2024). Smart Buildings With Legacy Equipment: A Case Study On Energy Savings And Cost Reduction Through An Iot Platform In Ireland And Greece. *Results In Engineering*, *22*, 102095.

Raju, M. P., & Laxmi, A. J. (2020). Iot Based Online Load Forecasting Using Machine Learning Algorithms. *Procedia Computer Science*, *171*, 551–560.

Sanchez-Sutil, F., & Cano-Ortega, A. (2023). Smart Plug For Monitoring And Controlling Electrical Devices With A Wireless Communication System Integrated In A Lorawan. *Expert Systems With Applications*, *213*, 118976.

Tahir, M., Ismat, N., Rizvi, H. H., Zaffar, A., Nabeel Mustafa, S. M., & Khan, A. A. (2022). Implementation Of A Smart Energy Meter Using Blockchain And Internet Of Things: A Step Toward Energy Conservation. *Frontiers In Energy Research*, *10*, 1029113.

Tekler, Z. D., Low, R., Yuen, C., & Blessing, L. (2022). Plug-Mate: An Iot-Based Occupancy-Driven Plug Load Management System In Smart Buildings. *Building And Environment*, *223*, 109472.

Tekler, Z. D., Low, R., Zhou, Y., Yuen, C., Blessing, L., & Spanos, C. (2020). Near-Real-Time Plug Load Identification Using Low-Frequency Power Data In Office Spaces: Experiments And Applications. *Applied Energy*, *275*, 115391.

Trevathan, J., Read, W., & Sattar, A. (2022). Implementation And Calibration Of An Iot Light Attenuation Turbidity Sensor. *Internet Of Things*, *19*, 100576.

Wen, L., Yan, Z., Zhu, Y., Guan, L., Guo, X., Zhao, B., Zhang, J., Hao, J., & Zhang, R. (2023). Recent Progress On The Electromagnetic Wave Absorption Of One-Dimensional Carbon-Based Nanomaterials. *Journal Of Materials Research And Technology*.

Yu, Y., Zhao, W., Chen, L., Wang, Q., & Huang, S. (2020). Power Measurement Accuracy Analysis In The Presence Of Interharmonics. *Measurement*, *154*, 107484.

Zhang, L., Xiong, G., Ni, R., Chiu, Y., Pang, Q., Shi, Z., & Wang, X. (2024). Improving Energy-Related Efficiency Towards Sdg7 In China: What Role Does Energy Poverty Play? *Journal Of Environmental Management*, *369*, 122289.