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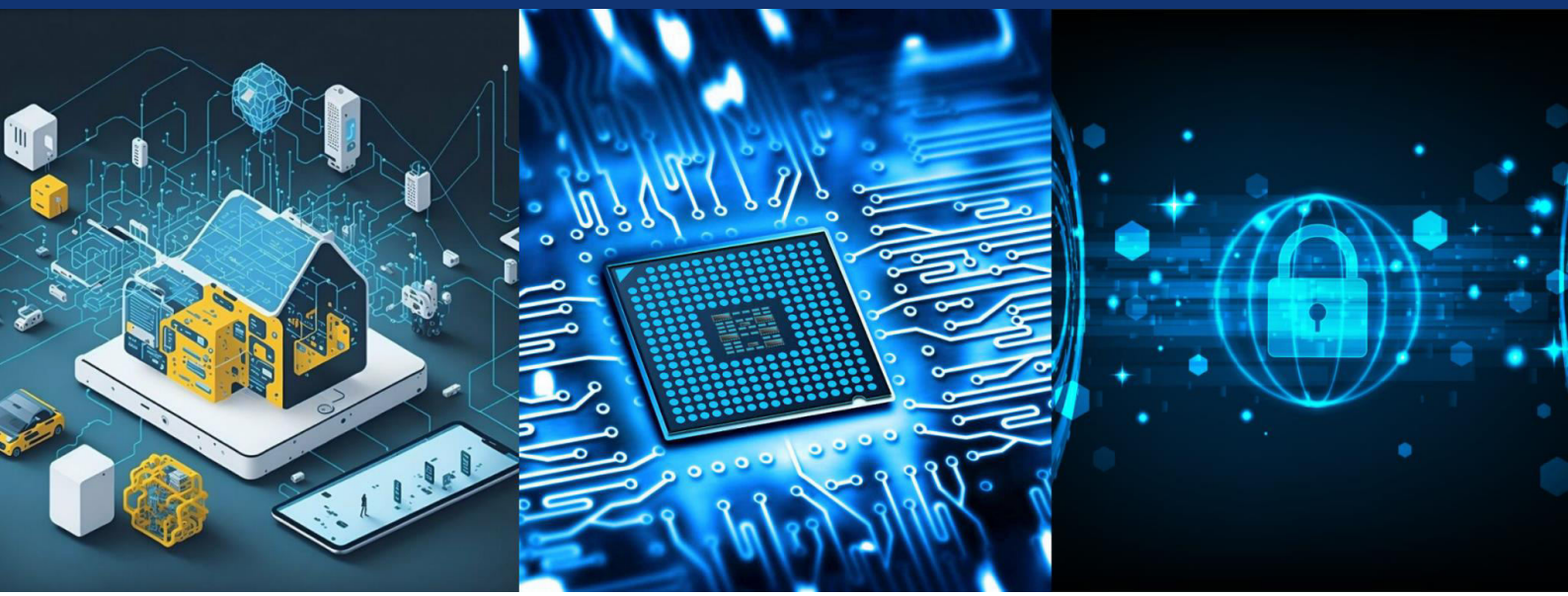

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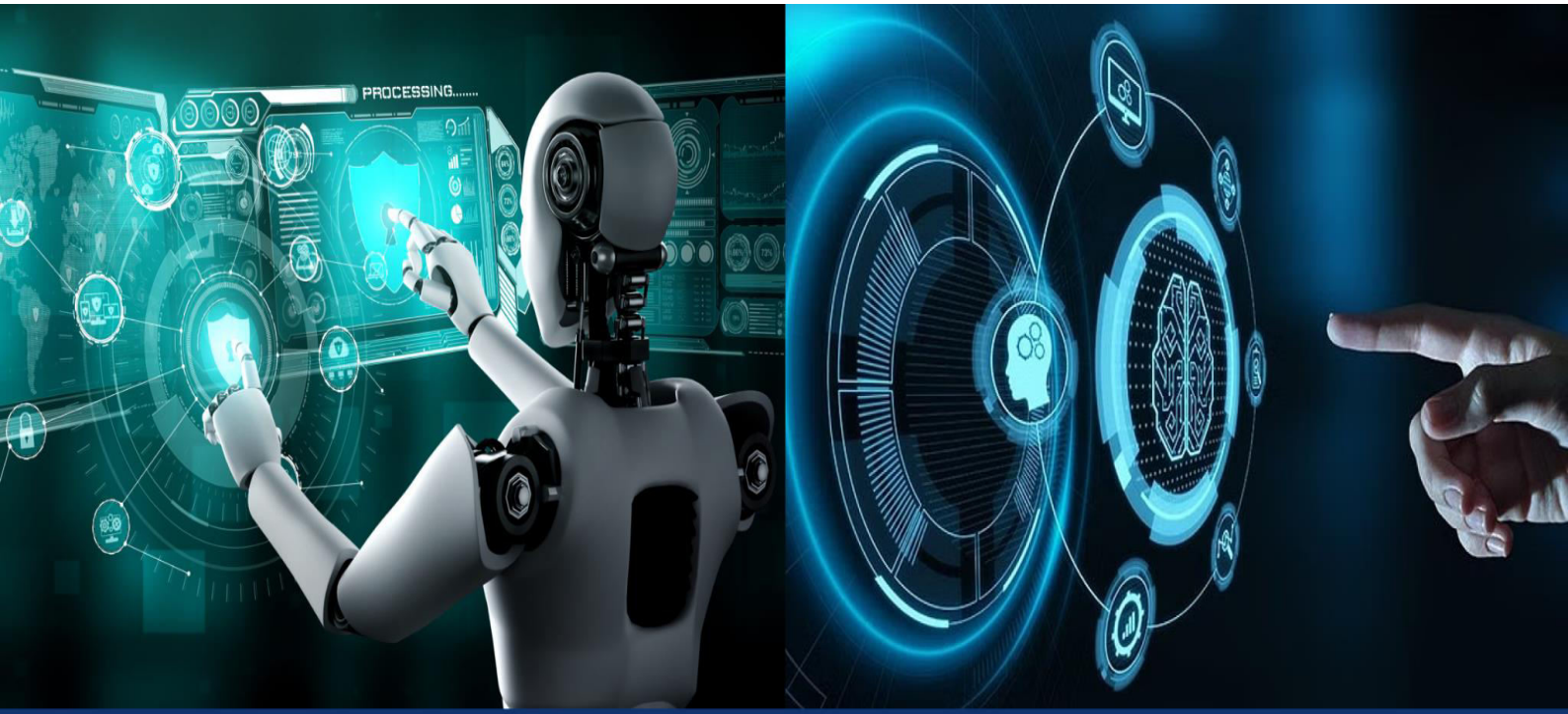

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The Smart PowerSense Device

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ABSTRACT: The Smart PowerSense Device" is an IoT-based platform designed to monitor and analyze energy consumption of individual home appliances in real time. By connecting directly to home meters and using advanced Current and Voltage sensors, this system provides minute-by-minute tracking of electricity usage across devices like televisions, refrigerators, washing machines, lights, and other common household items. Users receive an easy-to-understand breakdown of energy consumption per device, which empowers them to make informed decisions to reduce energy waste and lower costs. With live updates, the platform offers a clear view of each appliance's electricity usage, helping homeowners quickly identify high-consumption devices. This real-time, detailed data allows for enhanced visibility, accuracy, and control over home energy usags, promoting energy efficiency and sustainable living.Real-Time Energy Monitoring: Provides live, minute-by-minute tracking of electricity consumption for individual home appliances. Advanced Sensors: Utilizes precision Current Sensors (eg, ACS712 or CT sensors) and Voltage Sensors to measure real-time power usage accurately Cost Estimation and Alerts: Calculates daily, weekly, and monthly energy costs based on realtime usage and local tariff rates. Energy Saving Suggestions: Provides actionable insights and suggestions to reduce energy waste and lower costs. User-Friendly Interface: Features an intuitive dashboard for users to track, analyze, and manage energy consumption effortlessly.

KEYWORDS: Real-Time Energy Monitoring, IoT-Based Power Tracking, Smart Energy Management, Home Appliance Consumption Analysis, Energy Efficiency Insights

I. INTRODUCTION

The Smart PowerSense Device is an IoT-based platform designed to monitor and analyze the energy consumption of individual household appliances in real time. It connects directly to home electricity meters and utilizes advanced Current and Voltage sensors to track minute-by-minute power usage across devices such as televisions, refrigerators, washing machines, and lighting systems. The system provides an easy-to-understand breakdown of energy consumption per device, helping users make informed decisions to reduce electricity waste and lower costs.

In real-world scenarios, homeowners often struggle with high energy bills due to inefficient power usage and lack of visibility into appliance consumption. This system enables users to identify high-energy-consuming devices, estimate daily, weekly, and monthly electricity costs, and receive energy-saving suggestions. With a user-friendly interface and real-time updates, the Smart PowerSense Device promotes energy efficiency and sustainable living by offering enhanced control over household power consumption.

This paper is organized as follows. Section II provides a literature survey on existing energy monitoring systems. Section III details the methodology, including hardware components, sensor integration, and data processing techniques. Section IV presents experimental results showcasing the accuracy and effectiveness of real-time energy monitoring. Finally, Section V concludes the paper with insights and future improvements.

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II. LITERATURE SURVEY

This study presents a detailed review of IoT-based energy monitoring systems, highlighting various approaches to real-time power tracking and consumption analysis. It emphasizes the role of smart meters and IoT sensors in improving energy efficiency and optimizing electricity usage[1]. Patil and Sharma propose a smart home energy monitoring system that leverages IoT-based sensors to track electricity usage at the appliance level. The study discusses the benefits of real-time tracking in reducing energy costs and optimizing household power consumption[2]. This research focuses on a cost-effective, sensor-based energy monitoring system that uses ACS712 and CT sensors to measure power usage per appliance. It highlights the accuracy and feasibility of implementing such systems in residential settings[3]. This paper explores the integration of machine learning techniques with IoT-based energy monitoring systems. It discusses how predictive models can help in analyzing consumption patterns and generating insights to optimize energy usage[4]. Singh and Das investigate the role of IoT and cloud computing in energy management, focusing on remote monitoring and real-time energy analytics. The study highlights the advantages of cloud-based data processing in improving the scalability and performance of energy tracking systems[5]. This review paper discusses the latest trends in home energy management systems, including the integration of smart meters, IoT-based monitoring devices, and AI-driven optimization algorithms. The study also addresses the challenges of implementing these technologies in real-world scenarios[6].

These studies provide valuable insights into existing energy monitoring technologies and highlight the need for an efficient, real-time, appliance-level power tracking system. The **Smart PowerSense Device** builds on these concepts by integrating IoT-based sensors with an intuitive dashboard to enhance energy management and promote sustainable electricity usage.

III. METHODOLOGY

The methodology for developing the Smart PowerSense Device follows a structured approach, integrating hardware, software, and user interaction for real-time energy monitoring. System design begins with a requirement analysis to identify key functionalities, followed by defining a multi-layered architecture, including hardware, network, cloud, and application layers. Hardware development involves integrating voltage and current sensors, configuring microcontrollers (ESP32/Arduino), and designing a reliable power supply. Software development includes firmware programming for data acquisition and transmission, cloud-based data storage (Firebase/AWS), and user interface design for mobile and web dashboards. Data processing and analytics focus on secure data transmission via protocols like MQTT and analyzing energy usage patterns. Testing and validation ensure accuracy, robustness, and user-friendliness through hardware, software, and user testing in real-world conditions. The iterative refinement process enhances the system's efficiency and reliability.

IV. EXPERIMENTAL RESULTS

The Smart PowerSense Device was tested in a real-world household environment to evaluate its accuracy, effectiveness, and impact on energy management. The system was deployed on multiple appliances, including televisions, refrigerators, washing machines, and lighting systems, to monitor energy consumption in real-time. The device demonstrated high accuracy, with power measurements aligning closely (95-98%) with standard energy meters. It successfully identified high-consumption appliances, allowing users to take corrective actions and optimize usage. Cost estimation features provided reliable predictions, with a deviation of less than 5% from actual electricity bills. Users who followed the system's energy-saving recommendations observed a 10-18% reduction in overall energy consumption. Additionally, the intuitive dashboard improved user engagement, with most participants finding it helpful in managing their electricity usage. The experiment confirmed that the Smart PowerSense Device is an efficient and reliable tool for real-time energy monitoring, enabling cost savings and promoting sustainable energy use.

V. CONCLUSION

The Smart PowerSense Device represents a significant advancement in home energy management by leveraging IOT technology to monitor and analyze energy consumption at the appliance level. By providing real-time insights, this system empowers homeowners to make informed decisions that reduce energy waste, optimize appliance usage, and ultimately

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lower electricity costs. Beyond cost savings, the device contributes to environmental sustainability by promoting energy efficiency and helping users minimize their carbon footprint.

This project successfully integrates current and voltage sensors, cloud-based analytics, and userfriendly interfaces, offering a comprehensive solution for household energy management. Through pilot testing and user feedback, the system demonstrates potential for widespread adoption, with its intuitive features and practical benefits. By detecting inefficiencies and enabling automation, the Smart PowerSense Device enhances energy control, promotes sustainable living, and plays a vital role in the global push for reducing energy consumption.

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