ENHANCING E –LIFE WITH IOT: ASMART APPROACH TO EFFICIENTELECTRICITY MANAGEMENT

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Abstract**—**In the contemporary era, energy conservation stands out as a pivotal challenge in striving towards a sustainable lifestyle. Regrettably, it often falls by the wayside due to alack of awareness and the uncertainty surroundings the lifespan of electrical and electronic equipment. Nonetheless, energy conservation remains the most economically viable approach to address energy deficits. Introducing "E-Life," a ground breaking product, offers a solution to this dilemma while fostering public consciousness. Traditional electricity-intensive devices, despite having specified power requirements and lifespans, frequently outlast their projected longevity. However, they tend to consume more power thanindicated due to aging effects. For instance, empirical investigations reveal that a 40-watt incandescent light consumes an additional 25% of its original power post- lifespan. To mitigate such inefficiencies and monitor excessive power consumption across all electronic equipment, we propose integrating the E-life algorithm into an IoT-enabled device. This device, based on the ESP32 platform and capable of managing two loads, provides real-time monitoring and prompts replacement when necessary. Experimental results demonstrate that this innovative gadget can yield energy savings of over 37% within a six-month timeframe for constrained loads.

Keywords**—**Energy Saving; Efficiency; Energy Management; Energy Conservation; IoT; E- Life;ESP32

I.INTRODUCTION

In today's world, energy conservation is one of the most difficult and significant aspects of living a green life; despite this, it is often ignored owning to a lack of understanding and an inability to accurately forecast how long electric or electronic items will continue to operate. Because we rely on energy for pretty much everything we do on a daily basis, this topic is incredibly significant to each and every individual. The generation of electricity is typically accomplished through the use of natural resources such as coal and water. Nevertheless, excessive usage of electricity leads to the depletion of these natural resources, which in turn contributes to climate change. Even if it means fewer energy services, energy conservation should result in better environmental quality, increased personal and national economic security, and greater savings. At a somewhat more macro level, energy conservation may represent a very significant component of energy strategy.

The most common and cost effective approach to dealing with energy shortages is to practice energy conservation. We want to design a product/load life indicator that will be known as e-Life in order to solve this issue and educate consumers about the amount of power that is used by the electric or electronic items that they own. Because we frequently consider energy in terms of how much we accomplish each day, it is critical for all of us. The most basic kinds of energy come from the earth itself, and that means things like fossil fuels, water, and air. While coal is responsible for 56.1% of the total power production in India, fossil fuels in general and coal in particular are responsible for 72% of the total power generation throughout the globe. Fossil fuel combustion is responsible for 40 percent of the emissions of carbon dioxide, which, when mixed with mercury and Sulphur dioxide, are the primary contributors to acid rain and respiratory diseases. Because of the excessive use of power, the depletion of these natural resources contributes to the warning of the planet.

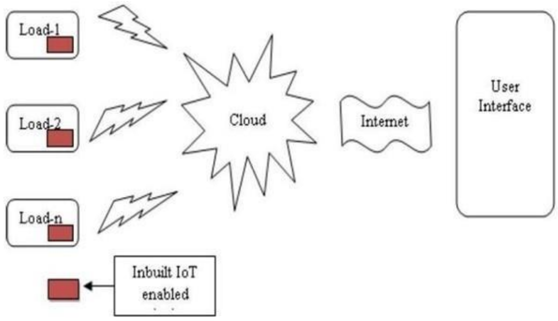


Fig 1. Basic Block Diagram of Enabled IoT in Loads

Despite the fact that energy conservation the number of available energy services, it is expected to have a positive impact on environmental greenery, national and personal economic stability, and savings. It's feasible that energy conservation will be an essential part of the energy plan on a much larger scale, and this possibility should not be discounted. A 5-year-old refrigerator uses up to 10% more electricity than it did when you first purchased it. A refrigerator that is ten years old uses twenty percent more power that it did when it was first purchased. After 15 years, the extra electricity utilized amounts to 30 percent. The power-hungry goods that we often buy each come with their own set of power requirements as well as a lifespan; yet the vast majority of these products continue to function for a period of time that is far longer than the lifetime that was originally indicated for them. However, the amount of electricity that they is far greater than what is specified. This is because of a natural process known as ageing. According to the findings of a recent study, a standard light bulb with 40watts of light uses an additional 25 percent of its power once it has reached the end of its life cycle. Now, when we simply examine the bulb, this may not seem like a very significant issue; but, when we consider a whole home, street, town, district, or state, it becomes clear that this is a significant issue.

II.RELATED WORK

The current sensor and the energy metering module are both parts of the power measurement module. In order to measure power, the energy metering module needs to know the mains voltage and current.

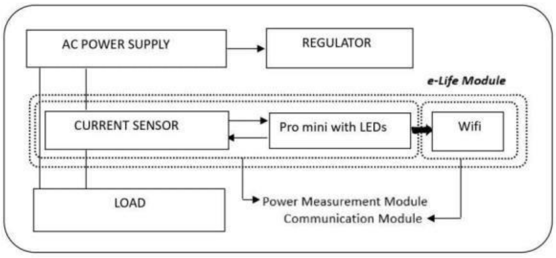


Fig 2. Basic Block Diagram of e-life Module and Associated connections

The amount of current that is moving through the wire that is connected to the device whose power consumption is being monitored. The transformer that is used to provide power for the functioning of the current sensor also has an extra secondary tap that is accessible, and this tap is used to measure the voltage.

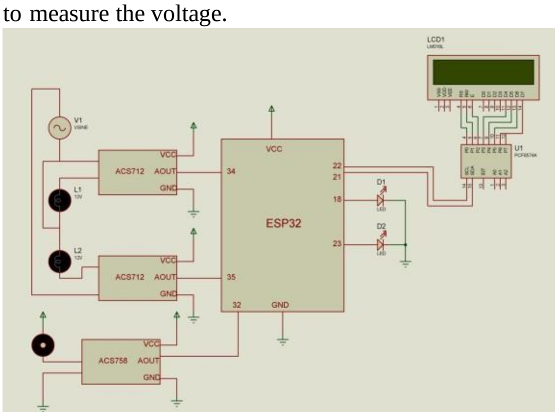


Fig 3. ESP32 with Dual ACS712 Current Sensor Circuit Diagram.

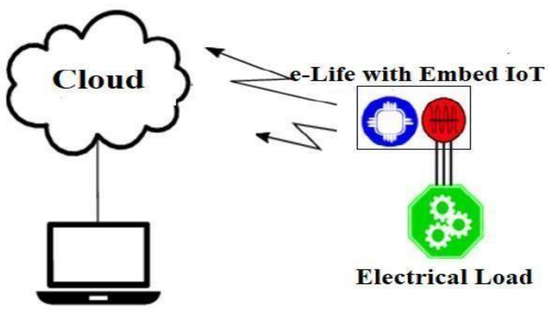


Fig 4. Cloud Interface with Load via e-life

Both invasive and non-invasive types of current sensors are available, in this experiment, investigators use hall effect based current sensor (ACHS-719x) is used.

This Unified Hall effect- oriented stand alone linear current sensors are used to detect AC or DC current in industry and communications systems. Each ACHS-719x integrated circuit contains a small, accurate linear Hall circuitry with a metal conduction route located near the chip's surface .. When an external current is sent over this copper conductor, a magnetic field is produced. Differential Hall sensors then take this magnetic field and transform it into an electric signal. Because of the closeness of the magnetic pulse to the Hall sensors, the accuracy of the device is maintained regardless of the operating temperature of the surrounding environment. During operation, there will be no core movement since the case has a click-fit structure that secures the cores in their proper positions. Because of the way the case is designed, users are able to effortlessly detach the e- life device from one wire and reattach it to another without causing any disruption to the mains wiring. The current sensor and associated circuitry linked to the energy measurement module. Then, the output of the energy metering module is sent to the processing module, where the power value is calibrated, encrypted, and sent[8].

Communication Module:

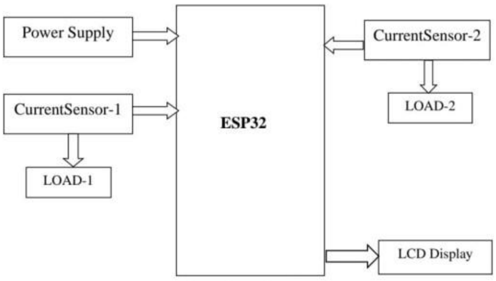
A Wi-Fi System on chip is used to accomplish the processing and communication functions. It is a compact Wi-Fi chip that has a high level of integration and it is easy to program using a variety of software, such as the Arduino IDE, the ESPRESSIF SDK , and Node MCU. For the sake of simplicity and since there is existingsupport available, we have programmed the Wi-Fi moduleusing the ESP32.

Elife algorithm is based on rated power (Prat) and consumed power (PCON) of given electrical appliance.Any electrical appliance has its own data sheet, where manufacturer mentioned how much power it consumed and life time of each of these appliance according to switching count. But most of these appliances works well even its life time vanished, the fore most important point here is, these appliances consumes more than rated powerafter specified life span. According to E-life algorithm, ifconsumed power is more than rated power (PCON > Prat) then appliance life span is over and the same is indicated with RED Colour glow LED by means of ready to replacethe appliance. Otherwise it shows Green Colour glow LEDis showing by means of Safe, no need to replace the appliance []. C. Cloud Environment Here Google firebase cloud environment is used for storing periodical data frome-life device. This cloud environment has SSID and password for the wireless network already registered for data storage. It is necessary to have these characteristics in order to connect the power monitoring sensor to the Wi- Fi network and guarantee permitted access. In order to transfer the encrypted value of the instantaneous power to the distant server, we have the option of using either the Transmission Control Protocol (TCP) or the User Datagram Protocol (UDP). TCP's transmissions have proven to be more reliable than those of UDP, which is why we chose to adopt it.

III.PROPOSED METHOD

The Proposed Methodology revolves around integrating the E-life algorithm into an IoT enabled device specifically based on the ESP32 platform, to monitor and manage two electric loads efficiently:

Fig 5 .Block Diagram of Proposed Method



ESP32 Platform:

ESP32 is a versatile microcontroller widely used in IoT applications due to its built-in Wi- Fi and Bluetooth capabilities, as well as its low power consumption. The ESP32 serves as the foundation for the IoT-enabled device in this methodology.

E-life Algorithm:

The E-life algorithm is designed to monitor the power consumption and lifespan of electrical loads. It works by continuously measuring the power usage of connected devices and analyzing the data to determine if they are operating efficiently or if they have surpassed their expected lifespan.

Load Monitoring:

IoT-enabled device is equipped with sensors or circuitry to monitor the power consumption of the connected loads. These sensors could include current sensors, voltage sensors, or power meters, depending on the type of load being monitored.

Data Analysis:

The collected data on power consumption is analyzed in real-time using the Elife algorithm. This analysis involves comparing the actual power consumption of the loads with their expected consumption and lifespan. If the device detects any deviations or inefficiencies, it triggers appropriate actions.

Alerts and Notifications:

When the E-life algorithm identifies that a load is consuming excessive power or has exceeded its expected lifespan, it generates alerts or notifications. These alerts can be sent to the user's smartphone, email, or displayed on a connected dashboard for real-time monitoring.

Product Replacement Recommendations:

Based on the analysis, the IoT-enabled device provides recommendations for replacing or servicing the load if necessary. This ensures that inefficient or aging devices are replaced promptly, thereby optimizing energy usage and preventing unnecessary energy wastage.

Remote Control and Management:

Additionally, the IoT-enabled device may offer remote control and management features, allowing users to monitor and control their electrical loads fromanywhere via a smartphone app or web interface. This enhances convenience and facilitates proactive energymanagement.

IV.RESULT ANALYSIS

The functionality of the suggested power monitoring system is evaluated, and some insights on the basis of reliability, efficiency, and the cost of the necessary materials are provided below. E-Life experimental setup and Measurement. The development of a secured Wi-Fi-based power monitor sensor that is simple, compact, and inexpensive is proposed. It has been effectively installed all around the college premises, and it has been tested there as well. It has been shown that the precision of power measurement is sufficient for the reliable use as a life monitoring sensor. Numerous sensors may be used to monitor the power consumption of multiple electrical appliances at the same time. Due to their compact size, low cost, and ease of use, multiple sensors are ideal for this task. Consumers will be able to monitor safe operating period of electrical appliance more efficiently.

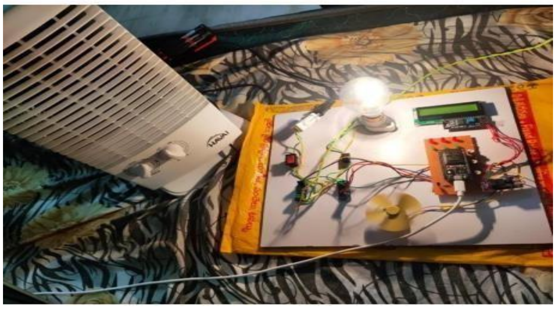


Fig 6: Hardware Implementation.

If the Current values Exceeded the Standard Values given during manufacturing, The indicator present in the circuit glows Red LED showing that the load is to be replaced. If the current value is within the Standard range, the indicator glows Green LED.

Fig 7: Indicator indicating the safe and replace conditions.

The readings form current sensors is transferred to google firebase web platform through in-built Wi-Fi presenting theESP-32 module.

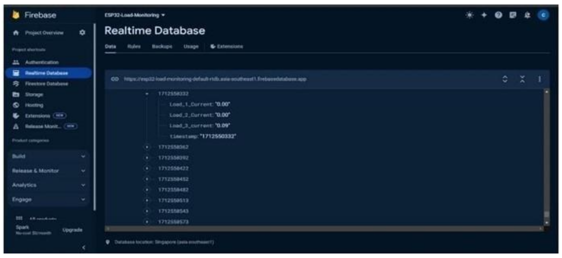


Fig 8. Output in Google Firebase Before Power Supply.

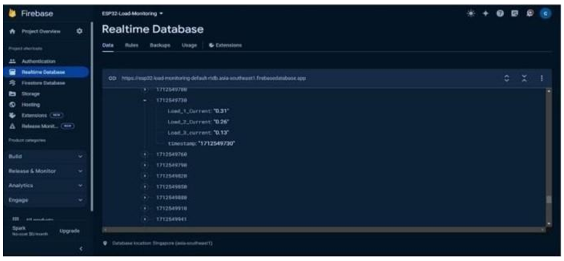


Fig 9. Output in Google Firebase After Power Supply.

Experimental results demonstrate that the E-Life device can achieve significant energy savings, with a reduction of over 37% in energy consumption observed with in a six-month timeframe for constrained loads.

Table1 : Comparision between existing and proposed models

Parameter	Existing Model	Proposed Model
Processing Power	50-100mA	10-100mA
Wireless Connectivity	Requires additional components for connectivity	Built-in Wi-Fi and Bluetooth Capabilities are present for wireless connectivity
Support for Over-the-Air (OTA)	Does not contain Buit-in Support for OTA	Supports OTA Firmware updates
Processing Speed	Slower due to 8-bit microcontroller present in Arduino-Uno	Faster due to 32-bit microcontroller present in ESP-32
Energy efficiency	Less energy efficient	More energy efficient due to advanced features such as processing capability and built-in connectivity
Programming	C/C++ with Arduino IDE	C/C++ with Arduino IDE, Micro Python, Java Script with ESP-IDF
Use cases	Educational purposes, Artistic installations and hobbyist projects	IoT devices, smart home applications, and industrial automation.
Other Supporting communication protocols	Requires Respective shields and modules to support any advanced communication protocols	Ethernet, Lo Ra, CAN Bus, Bluetooth(Classic and LE), I2C,UART,SPI

Table2: Comparison of loads to be replaced and safe

Parameter	Bulb		Fan		Motor	
Condition	Old one	New one	Old one	New one	Old one	New one
Rated Current range	0.5A	0.5A	0.6A	0.6A	0.2A	0.1A
Average Current Readings	0.65A	0.43A	0.75A	0.55A	0.17A	0.09A
Rated Power	60W	60W	75W	75W	1.8W	1.8W
Average Power	65W	55W	80W	70W	1.57W	0.9W
Noise level(dB)	-	-	55	50	-	-
Efficiency(%)	92.31	109.09	93.75	107.14	90.91	111.1
Heat generation (BTU/r)	150	136	-	-	-	-

V.CONCLUSION AND FUTURE SCOPE

In conclusion, the integration of the E-life algorithm into an IoT-enabled device, leveraging the ESP32 platform for load monitoring and management, offers a promising solution for enhancing energy conservation and efficiency. By continuously monitoring the power consumption and lifespan of electrical loads, this methodology enables proactive identification of inefficiencies and aging devices, leading to optimized energy usage.

The real-time analysis provided by the E-life algorithm empowers users with actionable insights, including alerts and recommendations for replacing or servicing inefficient loads. This proactive approach not only helps in reducing energy wastage but also promotes a more sustainable lifestyle by encouraging responsible energy consumption.

Furthermore, the remote control and management capabilities of the IoT-enabled device add convenience and flexibility, allowing users to monitor and control their electrical loads from anywhere, anytime.

Overall, the proposed methodology holds significant potential in addressing the challenges of energy conservation and promoting public awareness towards sustainable living. By embracing technologies like IoT and leveraging innovative algorithms like E-life,we can move towards a greener and more energy-efficientfuture.

In the realm of energy management and conservation, the future scope of E-life technology holds immense promise. As advancements in artificial intelligence and IoT continue to accelerate, we can anticipate the evolution of more sophisticated energy management systems. These systems would not only monitor and optimize energy usage in real-time but also predict maintenance needs and offer tailored recommendations for efficiency improvements.

Moreover, with the growing emphasis on renewable energy sources, there's a compelling opportunity to integrate E-life technology with solar, wind, and other Clean energy systems ,thereby enhancing their reliability and effectiveness .The expansion of smart city initiatives and sustainable infrastructure projects presents another avenue for the application of E-life, where it could play a pivotal role in ensuring efficient resource utilization and reducing environmental impact on a large scale. Furthermore, as consumer awareness about energy conservation continues to rise, E-life technology can empower individuals and businesses to make informed decisions and actively contribute to sustainability efforts. Collaborative research endeavors and policy integration are also essential components of the future landscape, fostering innovation in energy-efficient product design and shaping regulatory frameworks to incentivize sustainable practices. In essence, the future of E-life technology is not only about optimizing energy usage but so about fostering a culture of responsibility.

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