IOSR Journal of VLSI and Signal Processing (IOSR-JVSP)
Volume 16, Issue 4 (July. - August. 2026), pp. 27-31
e-ISSN: 2319-4200, p-ISSN: 2319-4197
www.iosrjournals.org

Medical Equipment Energy Monitoring And Asset Tracking System

Naresh D., J. Shravya, P. Snehitha Reddy, K. Jagadeesh
Department Of Electronics And Communication Engineering, Guru Nanak Institutions Technical Campus, Hyderabad, India

Abstract:
Good management of medical equipment is very important to improve healthcare services and reduce operational expenses. Current hospital asset management systems are reliant on manual tracking, which can cause asset misplacement, the increase in search time and wasteful energy usage. The suggested system comprises a microprocessor and current and voltage sensors for monitoring energy consumption of medical equipment and Bluetooth Low Energy (BLE) beacons for indoor location tracking. The data is then transferred over Wi-Fi to a cloud platform for real-time monitoring and analysis. Status of the equipment is shown on an OLED display and a buzzer generates alarms in case of abnormal conditions. The solution allows medical staff to rapidly find equipment, monitor energy usage and improve asset utilisation. The approach is cost effective, scalable and acceptable to deploy in modern health care institutions. The integration of energy monitoring with indoor location tracking improves operational efficiency, enables better resource management, and contributes to the development of smart hospital infrastructure. The proposed system will reduce equipment down time by providing the ability to identify and monitor medical assets in a timely manner. "Contributing to sustainable hospital operations through energy efficiency and real-time asset visibility.

Keywords: *Medical Equipment Management, Energy Monitoring, Bluetooth Low Energy (BLE), Hospital Asset Management, Smart Healthcare.*

Date of Submission: 15-07-2026 Date of Acceptance: 25-07-2026

I. Introduction

The rapid evolution of the healthcare technology has raised the demand for the effective administration of the medical equipment to assure uninterrupted patient care and lower the operating costs. Traditional hospital asset management systems are largely manual and rely on periodic inspections, which frequently lead to equipment misplacement, slow retrieval, inefficient usage and wasteful energy consumption. Such limits compromise operational efficiency and impact availability of vital medical devices in emergency scenarios.

Recent breakthroughs in the Internet of Things (IoT) have made it possible to adopt smart healthcare solutions that can provide real-time monitoring and remote administration of medical assets. IoT-enabled sensors, wireless communication technologies and cloud-based platforms permit ongoing tracking of equipment status, energy usage and location, thus boosting asset visibility and allowing efficient decision making. Such systems also help with predictive maintenance, decreased downtime and optimised utilisation of resources in hospitals.

This study proposes a Medical Equipment Energy Monitoring and Asset Tracking System combining microcontroller, current and voltage sensors and Bluetooth Low Energy (BLE) beacons. The technology being developed constantly monitors the energy consumption of medical devices, detects their location indoors and sends the data to a cloud platform over Wi-Fi to enable real-time monitoring and analysis. The system optimises equipment availability, decreases search time, improves energy efficiency and provides a cost-effective and scalable approach for the present smart healthcare environment.

II. Literature Survey

Recent research on hospital asset management has highlighted the significance of IoT and Real-Time Locating Systems (RTLS) in tracking and utilisation of medical equipment. Traditional inventory systems are based on manual record keeping leading to misplacement of equipment, delay in maintenance and poor utilisation of resources. These limits lower operating efficiency and can impact the quality of patient treatment.

Researchers have put forward systems that utilise Bluetooth Low Energy (BLE), Wi-Fi, and smart sensors to enable continuous tracking of the position of medical equipment. Smart plugs with current and voltage sensors provide real-time energy monitoring, cloud-based systems provide remote access, centralised data storage and historical analysis of equipment movement and energy use.

While these solutions increase equipment monitoring and energy management, problems such as interior

signal interference, deployment costs and limited integration still exist. Thus, an integrated real-time energy monitoring and position tracking system offers an effective solution to improve equipment utilisation, reduce energy consumption, minimise operational expenses and improve overall hospital management and patient care.

III. Proposed System / Methodology

The suggested system is an IoT based system for real time energy monitoring and location tracking of medical equipment in hospitals. The device is based on a Raspberry Pi Pico microprocessor and current and voltage sensors to measure the power consumption of each item. The IR sensor is used to sense the operational status of the equipment, and a Bluetooth module is used to communicate with the adjacent beacons to determine the indoor location. The microcontroller continually gathers data from all connected sensors, interprets the data and shows crucial information on an OLED display. The data collected is also sent wirelessly to a central monitoring platform, so that the hospital personnel can see the location of the equipment, its functioning state and its energy consumption remotely in real time.

The methodology starts with sensing electrical parameters and equipment activity and then processing the acquired data by the microcontroller. The localisation based on Bluetooth locates the equipment position, which enables speedier retrieval in case of crises and reduces the search time. All energy usage and movement records are saved for future analysis to help administrators spot idle equipment or equipment that consumes a lot of energy. The integrated approach increases the equipment utilisation, lowers the needless power consumption, supports preventative maintenance, minimises the operating expenses, enhances the overall efficiency and quality of the hospital management.

System Architecture:

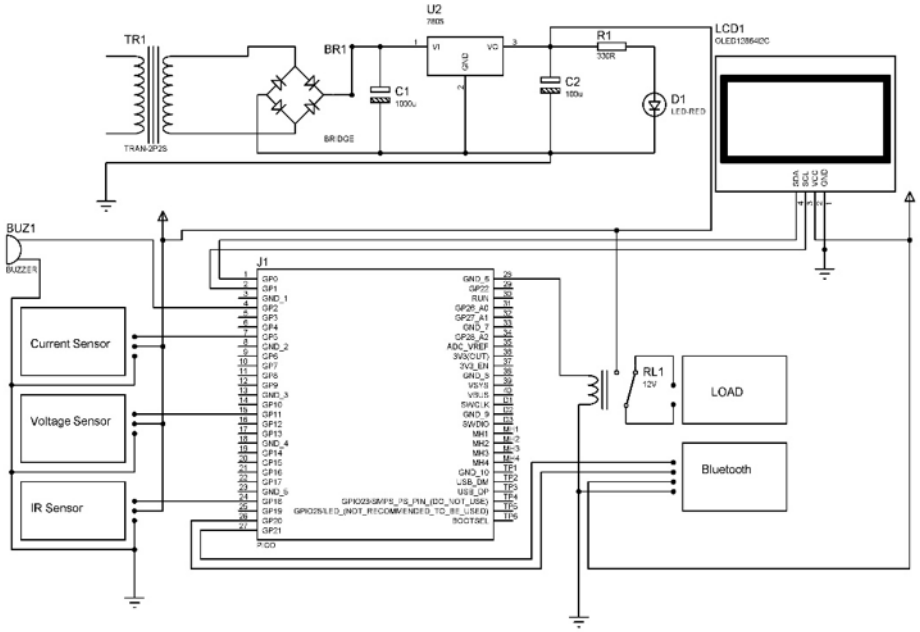


Fig:3 System Architecture of Medical Equipment Energy Monitoring and Asset Tracking System

IV. System Design / Implementation

Working Principle:

The proposed system operates by integrating energy monitoring and indoor location tracking to improve the management of medical equipment in hospitals. A Raspberry Pi Pico microcontroller serves as the central processing unit, connecting with current, voltage, IR, and Bluetooth modules. The system continuously collects information from the connected sensors and processes it to provide real-time updates on equipment status, energy consumption, and location. This enables hospital staff to monitor valuable medical assets efficiently and respond quickly whenever equipment is required.

The current sensor measures the amount of current drawn by the medical equipment, while the voltage sensor measures the supply voltage. Using these values, the microcontroller calculates the power consumed by the equipment. The IR sensor detects whether the equipment is in operation or idle, allowing the system to distinguish active devices from unused ones and identify unnecessary energy consumption.

For location tracking, the Bluetooth module exchanges signals with nearby Bluetooth beacons installed

at different points within the hospital. Based on the received signal strength, the system estimates the equipment's location and updates it continuously. The processed information is displayed on an OLED screen and transmitted wirelessly to a centralized monitoring platform for remote access. The recorded energy and movement data are stored for future analysis, enabling preventive maintenance, improved equipment utilization, reduced energy wastage, faster asset retrieval, lower operational costs, and enhanced hospital management.

Block Diagram

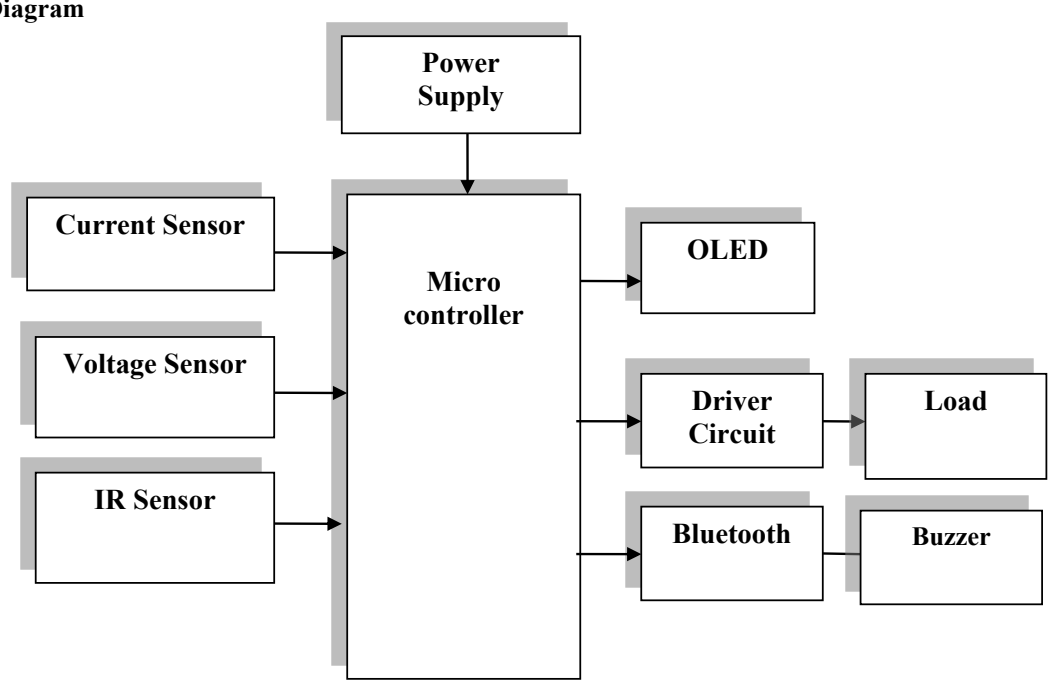


Fig.4.1. Block diagram of Medical Equipment Energy Monitoring and Asset Tracking System

Working Model:

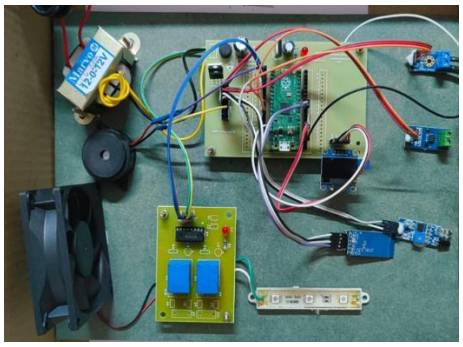
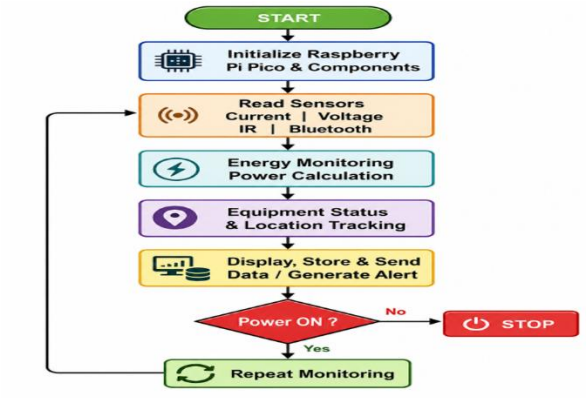


Fig. 4.2. Working Model of Medical Equipment Energy Monitoring and Asset Tracking System

Algorithm / Program Flow:



V. Results And Discussion

The suggested Real-Time Energy Monitoring and Location Tracking System for Medical Equipment Management aims to enhance hospital asset management. The system combines well embedded hardware, wireless communication and real-time monitoring approaches. As illustrated in the figure, the system provides a complete solution for monitoring medical equipment. It has 6 main modules, (A) Hardware Setup, (B) Real-time Dashboard Interface, (C) Location Tracking, (D) Energy Consumption Analysis, (E) Equipment Status Summary and (F) Discussion.

The hardware consists of an ESP32 microcontroller, ACS712 current sensor, SIM800L GSM module, GPS module (Neo-6M) and OLED display. The present sensor continuously monitors the power consumption of the medical equipment. The GPS module is used to locate the exact position. The sensor data is transferred to a cloud or hospital server where managers can obtain real-time data remotely through the GSM module's wireless connectivity capabilities. OLED display lets you observe energy use and position information in real-time, even when there is no network connection. That means you always have the information you need.

You can examine the state of the equipment and its energy usage in real time with the dashboard interface. Dashboard displays the total number of medical devices that are being monitored i.e. 28. Of these 25 are working regularly and 3 are producing alarms. ENERGY CONSUMED during the reporting period was 18.62 kWh. The data is shown as a live line chart that is regularly updated. Colour-coded indicators signal the normal, warning and critical states of the equipment, so medical workers may readily see damaged or energy-hungry gadgets. Recent warnings are shown with time stamps, equipment ID numbers, alert class and location to assist users in making timely repair decisions.

Location tracking module promotes hospital asset visibility by displaying the present location of equipment on a digital floor plan. For example: ICU – Bed 05 where the monitored ventilator (Equipment ID: VNT-07) may be found and you are tracking its movement time accurately. Real-time tracking helps to prevent equipment loss, cut down on search time, and ensure that important instruments are available during medical emergencies. The combination of communication and GPS technology enables optimising equipment usage and operating efficiency.

The findings of the investigation of the energy usage in relation to the change in power utilisation over a 24 hour period are shown in Figure 7. The data shows that the highest power demand was 2.31 kW at about 2:00 PM, the average power consumption was 0.78 kW and the total energy used was 18.62 kWh. With the visual presentation of this, the hospital management can see the times of the highest energy use, optimise the scheduling of the equipment, and take efficient energy saving measures. Regular checks can help you identify unusual power usage patterns early on, which can help you reduce your electricity bill and prevent equipment breakdown.

The equipment status report contains information about all monitored equipment, including type, power rating, daily energy usage, operational state and physical location. Of the monitored devices, 22 units (78.6%) are operating normally, 3 units (10.7%) indicate that some action is needed, and 3 units (10.7%) are rated critical due to high power consumption or operational failures. This classification can help the equipment maintenance experts to reduce equipment down-time by assigning priority to service jobs.

The proposed system has overall been able to incorporate many healthcare administration features into one platform. This includes real-time energy monitoring, cloud communication, intelligent dashboard visualisation, GPS-enabled position tracking, and Internet of Things (IoT) based sensing. The results show that the system may provide accurate monitoring of energy use, improved equipment traceability, improved maintenance efficiency and faster decision making. The proposed approach is a significant advancement for intelligent healthcare infrastructure and better hospital resource management, with the goal of reducing operational costs, minimising equipment wastage, and making life-saving medical equipment accessible.

VI. Conclusion / Future Scope

This project gives an effective way to monitor the energy consumption and trace the location of medical equipment. This system consists of a raspberry pi pico, current and voltage sensors, IR sensor, Bluetooth technology and an OLED display for ongoing monitoring and real time asset tracking. It reduces the time taken for the equipment search, cuts down on energy loss and helps in preventive maintenance by collecting and analysing data on a continual basis. The centralised monitoring strategy improves equipment utilisation, decreases operational cost and promotes the overall efficiency of the facility. The suggested system provides a robust, economical and scalable approach for better management of healthcare resources, better patient care and sustainable use of energy in modern hospitals.

The proposed method can be further improved by improving the accuracy and scalability of indoor location tracking for big healthcare facilities. Future development could include the inclusion of more sophisticated location technologies such as UWB or Wi-Fi fingerprinting for improved localisation accuracy. The system can also be connected with Hospital Management Systems (HMS) for centralised asset monitoring and automated inventory management. Cloud based data storage and mobile applications can give safe remote access

to equipment information in real-time. In addition, predictive analytics can be used to anticipate equipment maintenance requirements based on usage patterns and energy consumption. These improvements will result in better use of resources, better operational efficiency and energy management, and better overall quality of health care services.

References

[1]. A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, And M. Ayyash, "Internet Of Things: A Survey On Enabling Technologies, Protocols, And Applications," Ieee Communications Surveys & Tutorials, Vol. 17, No. 4, Pp. 2347–2376, 2015.

[2]. M. M. Islam, M. Rahaman, And M. R. Islam, "Development Of Smart Healthcare Monitoring System In Iot Environment," Sn Computer Science, Vol. 1, No. 185, Pp. 1–11, 2020.

[3]. N. F. Tzeng, S. Y. Chen, And Y. C. Chen, "Iot-Based Smart Healthcare Monitoring System: A Review," Ieee Access, Vol. 9, Pp. 18173–18195, 2021.

[4]. A. Yassin, Y. Nasser, M. Awad, A. Al-Dubai, R. Raulefs, E. Aboutanios, M. Abaza, And H. Yanikomeroglu, "Recent Advances In Indoor Localization: A Survey On Theoretical Approaches And Applications," Ieee Communications Surveys & Tutorials, Vol. 19, No. 2, Pp. 1327–1346, 2017.

[5]. Bluetooth Special Interest Group, Bluetooth Core Specification Version 5.3, Kirkland, Wa, Usa, 2021.

[6]. Raspberry Pi Foundation, Raspberry Pi Pico Datasheet, Cambridge, U.K., 2023.

[7]. Allegro Micro Systems, Acs712 Fully Integrated Hall-Effect Current Sensor Ic Datasheet, Worcester, Ma, Usa, 2022.

[8]. Espressif Systems, Bluetooth Low Energy (Ble) Technology Overview, Shanghai, China, 2023.

[9]. World Health Organization (Who), Medical Equipment Maintenance Programme Overview, Geneva, Switzerland, 2021.

[10]. L. Mainetti, L. Patrono, And A. Vilei, "Evolution Of Wireless Sensor Networks Towards The Internet Of Things: A Survey," International Conference On Software, Telecommunications And Computer Networks (Softcom), Split, Croatia, Pp. 1–6, 2011.

[11]. H. Alemdar And C. Ersoy, "Wireless Sensor Networks For Healthcare: A Survey," Computer Networks, Vol. 54, No. 15, Pp. 2688–2710, 2010.

[12]. S. Madakam, R. Ramaswamy, And S. Tripathi, "Internet Of Things (Iot): A Literature Review," Journal Of Computer And Communications, Vol. 3, No. 5, Pp. 164–173, 2015.

[13]. Tellez, Mauricio, Samy El-Tawab, And Hossain M. Heydari. "Improving The Security Of Wireless Sensor Networks In An Iot Environmental Monitoring System." In Systems And Information Engineering Design Symposium (Sieds), 2016 Ieee, Pp. 72-77. Ieee, 2016.

[14]. Tellez, Mauricio, Samy El-Tawab, And M. Hossain Heydari. "Iot Security Attacks Using Reverse Engineering Methods On Wsn Applications." In Internet Of Things (Wf-Iot), 2016 Ieee 3rd World Forum On, Pp. 182-187. Ieee, 2016.

[15]. Elhamshary, Moustafa, And Moustafa Youssef. "Sem Sense: Automatic Construction Of Semantic Indoor Floorplans." In Indoor Positioning And Indoor Navigation (Ipin), 2015 International Conference On, Pp. 1- 11. Ieee, 2015.

[16]. El-Tawab, Samy, Raymond Oram, Michael Garcia, Chris Johns And Byungkyu Brian Park. “Data Analysis Of Transit Systems Using Low Cost Iot Technology,” In Pervasive Computing And Communications Workshops (Percom Workshops), 2017 Ieee International Conference On, Ieee, 2017.

[17]. Boulos, Maged N. Kamel, And Geoff Berry. "Real-Time Locating Systems (Rtls) In Healthcare: A Condensed Primer." International Journal Of Health Geographics 11, No. 1 (2015): 25.