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Motion Based Home Automation

Prof. J.J.Bandal (Guide)
Dept Of Electronics And Telecommunication
Rajgad Dnyanpeeth's, Rajgad Technical Campus
Dhangwadi, Bhor, Pune–412205, India

Swati R. Shikhare
Dept Of Electronics And Telecommunication
Rajgad Dnyanpeeth's, Rajgad Technical Campus
Dhangwadi, Bhor, Pune–412205, India

Vaishnavi R. Utekar
Dept Of Electronics And Telecommunication
Rajgad Dnyanpeeth's, Rajgad Technical Campus
Dhangwadi, Bhor, Pune–412205, India

Shraddha D. Patil
Dept Of Electronics And Telecommunication
Rajgad Dnyanpeeth's, Rajgad Technical Campus
Dhangwadi, Bhor, Pune–412205, India

***Abstract* - Home automation systems have transformed modern living by enhancing convenience, energy efficiency, and security through intelligent monitoring and control. This project focuses on the design and implementation of a sensor-based home automation system that integrates multiple environmental and motion sensors with a microcontroller to automate household functions. The system utilizes sensors such as temperature, humidity, light intensity, gas leakage, and motion detection to continuously monitor indoor conditions and respond automatically based on predefined thresholds. These sensors are interfaced with a microcontroller such as the Arduino Uno, which processes the data and triggers appropriate actions like switching lights, activating fans, or sending alerts. This project demonstrates a cost-effective, scalable, and user-friendly home automation solution suitable for residential applications. The implementation highlights the practical application of embedded systems, Internet of Things (IoT) technology, and sensor integration in building smart homes. The system is easy to install and operate, making it suitable for everyday home use. It reduces electricity consumption by automatically controlling appliances based on sensor data. The sensors continuously monitor the home environment to ensure safety and comfort. If any abnormal condition, such as gas leakage or unusual motion, is detected, the system immediately sends an alert to the user.**

***Index Terms* - Motion detection,Passive Infrared (PIR)sensors,**

I. INTRODUCTION

Home automation is an emerging technology that enables automatic control and monitoring of household appliances and systems. A sensor-based home automation system uses various sensors and microcontrollers to intelligently manage home devices such as lights, fans, security systems, and temperature controls. The main objective of this system is to enhance comfort, security, energy efficiency, and convenience in residential environments.

With rapid advancements in embedded systems and Internet of Things (IoT) technology, home automation has become more affordable and accessible. Sensors such as temperature sensors, motion sensors, light sensors, gas sensors, and humidity sensors continuously monitor environmental conditions and send data to a central controller (such as a microcontroller

or microprocessor). Based on the collected data, the system automatically performs actions like switching appliances on or off, adjusting lighting levels, or triggering security alarms. For example, motion sensors can automatically turn on lights when a person enters a room and turn them off when the room is vacant, thereby saving electricity. Temperature sensors can regulate fans or air conditioning systems to maintain a comfortable indoor environment. Gas and smoke sensors can detect hazardous conditions and alert occupants, improving home safety.

Sensor-based home automation systems can be controlled locally or remotely through smartphones, computers, or web applications. The integration of wireless communication technologies such as Wi-Fi, Bluetooth, or GSM further enhances flexibility and user control.

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The integration of technology into daily life has led to the development of smart homes, which utilize various sensors to automate tasks and improve quality of life. Home automation systems rely on sensors to monitor and control home environments efficiently. This paper discusses different types of sensors employed in home automation, their operation, and implications for future developments.

II. RELATED WORK

Home Automation has been on the rise in the recent times. Starting from agriculture, to the cities having the tallest of the skyscrapers are inclined towards automation. In this section, we will discuss the various existing solutions proposed by different research papers.

In [5] the author uses 433 MHz radio frequency control module to control the home appliances directly. Gadgets likesmartphones and tablets can be directly connected to the central controller using the Wi-Fi interface. The only problem with radio signals is that they can be easily intercepted and are prone to distortions due to interference.

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In [6] the author uses the Blue tooth 4.0 protocol to establish communication between the "smart home appliances" and the user. The user can use cell-phones or tablets to control these appliances remotely. The only disadvantage of using Blue tooth technology is that the devices can only be controlled from short range.

As an Example in [7], the author's proposed Blue tooth based home automation systems. In this solution, the home appliances are controlled based on Android smartphones without the Internet controllability. All the home appliances are physically connected to the Blue tooth controller and it is controlled by using Smartphone. However, in this solution, the home appliances are not remotely connected and not able to operate remotely. IoT based home automation using android phones [8] is proposed. In this, the authors used two types of home automation, i.e., Blue tooth and Ethernet-based. Also, the customized Android-based mobile application was used to control the home applications like Fan, TV, AC, etc. Nonetheless, data sources in the prototype is not clear and it leads deadlock situation when multiple Android phones try to access same web portal.

In [9] a smart data acquisition system and energy management system has been created which displays the necessary data on a web page with the help of SMS, GPRS and email alerts. The ARM microcontroller has been used for controlling the devices and for wireless communication. The system was designed based on the IEEE1451 protocol which focuses on defining transducer electronic data sheet for all the transducers used. The low cost, flexible and ubiquitous smart home system is presented

[10]. In this, Arduino Ethernet is used to communicate over the Internet with the customized application installed in on Android mobile. The Arduino device is integrated with various sensors like humidity sensors, temperature sensors, smoke/gas sensors. All these sensors are controlled by the mobile application used by the user. The proposed prototype is tested and has analyzed the efficiency. However, the proposed system generated alerts in the form e-mail messages, when the particular home application reaches the given threshold.

In [11] an Ethernet-based smart home automation and energy management system has been proposed based on the Intel Galileo development board. Various sensors have been used to control the home appliances as well as to maintain the security of the house.

In [12] a TI Wi-Fi CC3200 Launch pad has been integrated with a PIR sensor to detect motion and send a voice call to the owner of the house. The owner can then decide whether to disable the security system or not. He can also remotely control the home appliances. This implementation also does very little regarding automation.

III. PROPOSED METHODOLOGY

The Block diagram represents the working of the Motion Based Home Automation System. The system starts with the power supply unit, which converts the AC 230V input into

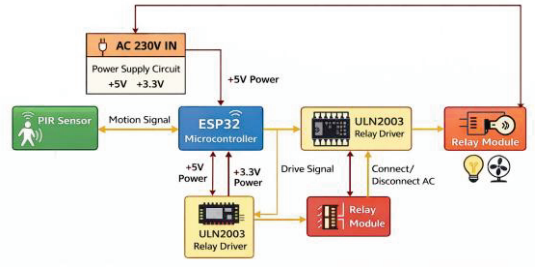

Fig. 1. Block Diagram Of motion Based Home Automation

regulated DC voltages of 5V and 3.3V required for the circuit components.

- The PIR (Passive Infrared) sensor is used to detect human motion. When a person enters the detection area, the sensor generates a signal.
- This signal is given to the ESP32 microcontroller, which acts as the main control unit. The ESP32 processes the input signal and decides whether to turn the appliance ON or OFF.
- The output from the ESP32 is sent to the ULN2003 relay driver, which is used to amplify the signal and safely drive the relay.
- The relay module acts as a switch to control high-voltage AC appliances like lights and fans. When the relay is activated, the appliance turns ON, and when deactivated, it turns OFF.
- Thus, the system automatically controls electrical appliances based on motion detection, improving energy efficiency and convenience

IV. IMPLEMENTION

The proposed system configuration and prototype is shown in Fig. 1 The following sections explain about the working modules, involved in the proposed solution This document outlines a functional draft for implementing a motion-based home automation system, focusing on energy efficiency, security, and convenience. The system uses motion sensors to trigger actions such as lighting and HVAC control,

V. HARDWARE IMPLEMENTION

The circuit diagram represents a microcontroller-based control system built around the ESP32-WROOM-32, which serves as the central processing unit. The ESP32 is powered by a regulated 3.3V supply derived from an external input through filtering and decoupling capacitors to ensure stable operation. A USB-to-serial interface using the FT231XS is incorporated to enable programming and communication between the ESP32 and a computer. The TXD and RXD lines facilitate serial data exchange, while control signals such as RTS and DTR are connected to the EN and IO0 pins of the ESP32 to support automatic reset and boot mode selection during firmware uploading.

The circuit also includes multiple relay driver sections controlled by the ESP32 GPIO pins, allowing the system to switch

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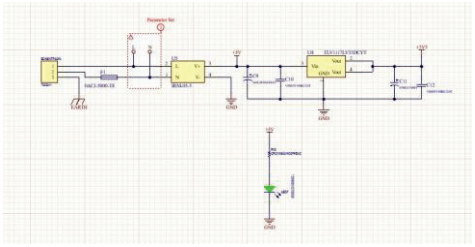

Fig. 2. Circuit Diagram Of Analog Power Input

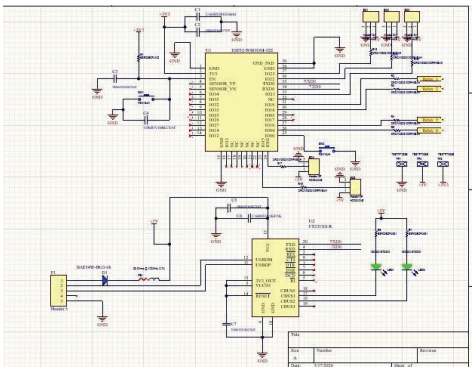

Fig. 3. Circuit Diagram Of ESP 32 Microcontroller

external loads. These relay circuits are interfaced through appropriate driver components to handle higher current requirements safely. Additionally, indicator LEDs and resistors are used to provide visual status of operation. The overall design ensures proper power management, reliable communication, and efficient control of external devices, making it suitable for automation and embedded system applications.

The working of the circuit begins with the application of an external power supply, which is regulated and filtered to provide a stable 3.3V required by the ESP32-WROOM32. Once powered, the ESP32 initializes and executes the programmed instructions.

For programming and communication, the FT231XS converts USB signals from a computer into UART signals, enabling data exchange through the TXD and RXD pins. During code uploading, the RTS and DTR control lines automatically toggle the EN and IO0 pins of the ESP32, placing it into programming mode without manual intervention. In normal operation, the ESP32 reads inputs or executes logic based on its firmware and generates output signals through its GPIO pins. These signals drive the relay circuits via driver components, energizing the relay coils and switching connected external loads such as electrical appliances. The flyback protection in the relay section prevents voltage spikes during switching, ensuring circuit safety. Additionally, LEDs provide visual indication of system status and operation. Overall, the system performs automated control by processing inputs, making decisions in the ESP32, and controlling external devices through relays.

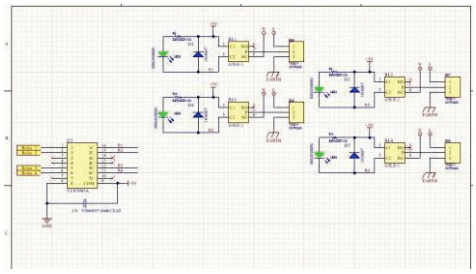

Fig. 4. Relay Driver

A. HARDWARE DESIGN

- Power Supply Unit : The power supply unit converts 230V AC from the mains into low-voltage DC required by electronic components. Components Used Step-down transformer / SMPS module Bridge rectifier Filter capacitor Voltage regulator (7805 / AMS1117) Output +5V for relay module +3.3V for ESP32 Function: Provides stable DC voltage for system operation.
- PIR Motion Sensor : The PIR (Passive Infrared) Sensor detects human movement by sensing infrared radiation. Working Human enters detection area PIR detects motion Sends signal to ESP32 Features Adjustable sensitivity Adjustable delay time Low power consumption Function: Detects motion and sends signal to controller.
- ESP32 Microcontroller : ESP32 is the main controller of the system. Functions Receives signal from PIR sensor Processes data Sends control signal to relay Features WiFi And Bluetooth support Low power consumption High processing speed Function: Controls complete system operation.
- Relay Driver (ULN2003 / Transistor) : The relay driver is used because ESP32 cannot directly drive relay. Components Used ULN2003 IC / Transistor Protection diode Function: Amplifies signal from ESP32 and drives relay.
- Relay Module : Relay acts as an automatic switch. Working Motion detected → Relay ON No motion → Relay OFF Controls Light Fan Appliances Function: Switches AC appliances automatically.
- Load (Appliances) : These are output devices controlled by system. Examples Light bulb Fan AC TV

B. SOFTWARE DESIGN

a) Software Overview : The software design controls automation based on motion detection. The ESP32 microcontroller reads input from a motion sensor (PIR sensor) and automatically controls devices like lights, fans, or appliances. When motion is detected: ESP32 receives signal ESP32 processes signal ESP32 turns ON device After no motion →
ESP32 turns OFF device

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b) Software Component: 1.ESP32 Firmware The firmware is programmed using: Arduino IDE / PlatformIO Embedded C / Arduino Programming Main tasks: Read
sensor data Process logic control output devices

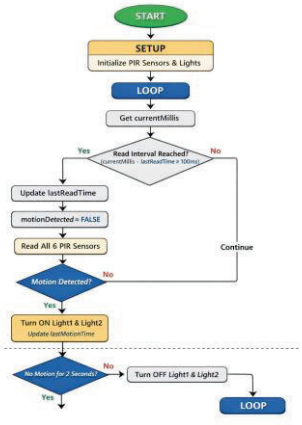

Fig. 5. Flow Chart Of The System

c) Input Handling (Motion Sensor): PIR sensor connected to ESP32 GPIO pin ESP32 reads HIGH/LOW signal
HIGH = Motion detected LOW = No motion

d) Control Logic: Software follows this logic:

- Initialize system
- Read motion sensor
- If motion detected
- Turn ON output device
- Wait for delay time
- If no motion detected
- Turn OFF device

V. LIMITATIONS AND FUTURE SCOPE

Motion-based home automation, which uses sensors to detect movement to control lighting, security, and climate, offers convenience and energy efficiency, but faces significant limitations in accuracy and reliability. The future of this technology lies in AI-driven predictive analytics, advanced presence detection, and 5G integration to create proactive living spaces.

1) : Limitations of Motion-Based Home Automation -

- Positives/Negatives: Motion sensors (like PIR) often struggle to distinguish between people, pets, or inanimate moving objects (e.g., curtains), leading to lights turning on when not needed or off when a person is still.
- Lack of True ”Presence” Detection: Traditional motion sensors detect movement, not occupancy. If a user sits still, the system may assume the room is empty and turn off lights or HVAC.
- High Initial Cost and Complexity: Installing a comprehensive sensor network, especially in existing homes, can be costly and requires technical expertise for setup and configuration.
- Privacy Concerns: Motion sensors, especially when integrated with cameras or tracking systems, collect data on daily habits and routines, raising concerns about data security and privacy.
- Interoperability Issues: Many devices from different manufacturers do not communicate well together, leading to fragmented systems that require multiple apps.
- Internet/Power Dependency: Many smart sensors rely on Wi-Fi and power; power outages or network disruptions can disable the automation system.

2) : Future Scope and Trends -

- AI and Machine Learning: Future systems will use AI to learn user routines and habits, making them more predictive rather than just reactive, adjusting environments before commands are given.
- Advanced Presence Detection: Technologies like mmWave radar and 3D vision will replace simple PIR sensors, allowing systems to detect breathing or slight movements, accurately identifying occupancy even if the person is still.
- Energy Efficiency And Smart Grids: Systems will become more sophisticated, managing energy consumption by interacting with smart grids to reduce power usage during peak times.
- 5G Integration: The rollout of 5G will provide instantaneous, low-latency control of devices, supporting higher densities of sensors and more complex automation routines.
- Healthcare Integration: Motion sensors will be used for elderly care, monitoring for ”unusual lack of movement” to trigger emergency alerts for falls or medical incidents.
- Context-Aware Automation: Systems will adapt to environmental factors, such as automatically adjusting lighting based on natural light levels or changing climate settings based on weather forecasts.

VI. CONCLUSION

In the Smart Home Automation system, the motion detection and capturing system have been proposed as an effective solution for monitoring and surveillance and property crimes. In this paper, the improvised and integrated approach is introduced using advanced technology, ESP32 cam, and PIR sensor, which will notify the user directly if motion is detected on the Telegram application. Besides, the project produced a reliable motion capturing detection system at a relatively low cost. And this same as Temperature Based Fan Speed Control is implemented. Thus, here fan speed has been controlled by using Arduino. Modulation and Arduino board according to the temperature sensed with the help of Temperature Sensor (LM35). The idea of the project is to change the fan temperature automatically. The fan’s speed depends on the weather, and there is no need to regulate the fan speed manually again and again. In conclusion, the project successfully demonstrates a simple yet powerful home automation model. By

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using motion and tap sensors together, it achieves a balance between intelligence and ease of use. This approach can be further expanded into advanced smart home systems in the future. This project demonstrates an innovative approach to home automation by integrating motion sensing with tap-based manual control, creating a system that is both intelligent and user-centric. It not only automates routine tasks to improve energy efficiency and security but also ensures flexibility through direct user interaction. The design reflects a practical balance between automation and human control, making it reliable in real-world situations. Furthermore, this system lays a strong foundation for future advancements in smart home technology, where more intelligent, adaptive, and interconnected solutions can be developed to enhance modern lifestyles. Overall, the project highlights the importance of smart technologies in improving lifestyle. The combination of motion and tap sensors makes the system practical and userfriendly. In the future, such systems can be expanded to create fully intelligent and connected living environments."

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