

Low-Latency AP-Based Automation Interface

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ABSTRACT

This project presents a Low- Latency AP- Based Automation Interface using the Raspberry Pi Pico W microcontroller. The Pico W is configured as a standalone Wi-Fi access point (hotspot), allowing users to connect directly without requiring an external router or internet connection. A built-in web server hosted on the Pico W provides an interactive HTML webpage through which users can control multiple electrical appliances such as an AC motor, DC fan, and AC light. The control commands are sent from the web interface to the Pico W using HTTP requests. Based on the received commands, the Pico W activates or deactivates relays connected to the respective appliances. This system is simple, cost-effective, and suitable for smart home automation, industrial control, and educational IoT applications where local wireless control is required .

Keywords:-*Raspberry Pi Pico W, Python-Based Graphical User Interface, Wi-Fi-Enabled Communication, Electromechanical Relay Module, Local Area Network (LAN) Control, Industrial Automation Systems, Internet of Things (IoT), Remote Device Monitoring and Actuation, Embedded Control System, Secure Wireless Communication, micro python-Based Firmware, Smart Industrial Infrastructure, Automated Control System, Real-Time Operational Control, Cost-Effective Industrial Automation Solution.*

1. INTRODUCTION

With the rapid advancement of wireless communication and embedded systems, home and industrial automation has become an important area of technological development. Conventional appliance control systems require manual operation and physical presence, which can be inconvenient and inefficient. To overcome these limitations, this project introduces a Wi-Fi hotspot based appliance control system using the Raspberry Pi Pico W. The Pico W is capable of functioning as a standalone Wi-Fi access point and embedded web server, enabling direct wireless communication without the need for an external router or internet connection. By using a simple web-based interface, users can remotely control electrical appliances such as motors, fans, and lights within the local network. This project provides a low-cost, reliable, and user-friendly solution for local wireless automation and demonstrates the practical application of Internet of Things (IoT) concepts using the Raspberry Pi Pico W platform.

2. DESCRIPTION

This project is designed to control electrical appliances wirelessly using a Raspberry Pi Pico W. The Pico W is configured as a standalone Wi-Fi hotspot and hosts an embedded web server. Users can connect to this hotspot using a mobile phone or laptop and control appliances through a web-based interface. The system does not require an internet connection or external router. Control commands are sent as HTTP requests from the web page to the Pico W, which processes these commands and switches the connected devices ON or OFF using relay modules.

3. PROBLEM STATEMENT

“Design and implementation of a Low-Latency AP-Based Automation Interface, addressing the vulnerabilities of traditional wireless protocols and ensuring robust encryption, authentication, and data integrity in industrial IoT environments.”

4. DISCUSSION

Low-Latency AP-Based Automation Interface

The discussion points Low Latency AP-Based Automation Interface include the following key aspects:

- **Real-time Monitoring:** Ensuring continuous observation and response to industrial processes.
- **Remote Access:** Facilitating secure access to industrial facilities and systems.
- **Integration with IoT:** Seamless connectivity with Internet of Things devices for enhanced automation

and security.

- **Operational Efficiency:** Supporting scalable and decentralized networks for improved operational agility.
- **Security Protocols:** Implementing robust security measures to protect sensitive industrial data.
- **flexibility and cost-Effectiveness :** Reducing installation costs and enabling rapid reconfiguration of industrial operations. These points highlight the importance of secure wireless communication in enhancing the efficiency and safety of industrial operations while ensuring data integrity and operational safety.

5.COMPONENTS LIST

Sr. No	Component Name	Description
1.	Raspberry Pi Pico W	RP2040 MCU with built-in Wi-Fi
2.	Relay Module (3 Channel)	5V relay for AC/DC load control
3.	Transformer (Power supply unit)	Step down transformer
4.	AC Motor	Controlled via relay
5.	DC Fan	Controlled via relay
6.	AC Bulb	Controlled via relay
7.	Capacitor	DC supply
6.	Power Supply	USB for Pico W
7.	Connecting Wires	Jumper wires
8.	Rectifier Circuit	Convert AC to DC

6.BLOCK DIAGRAM

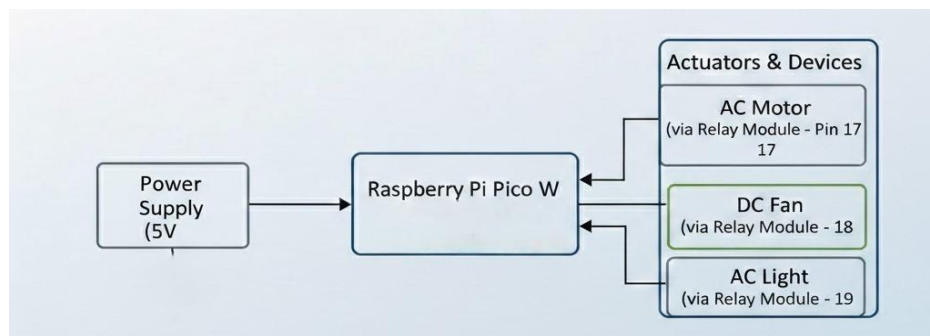


Fig-5.1: block diagram (a)

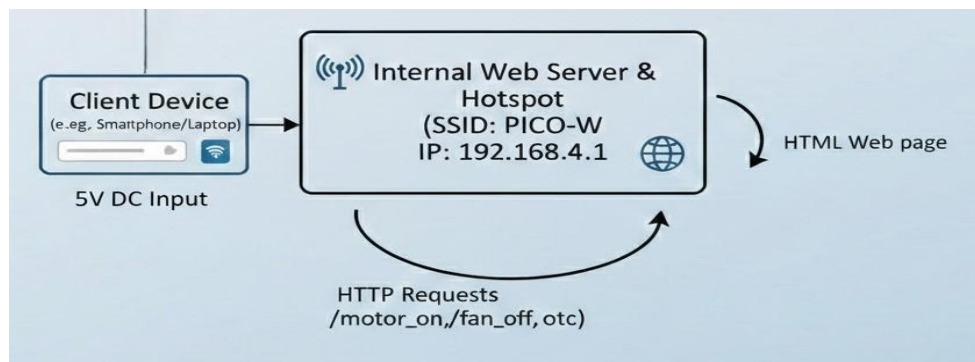


Fig-5.2: block diagram (b)

7.WORKING METHODOLOGY

The working of the proposed system is based on local Wi-Fi communication between the user device and the Raspberry Pi Pico W. Initially, the Pico W is powered ON and configured as a Wi Fi access point, creating its own hotspot. When a user connects a mobile phone or laptop to this hotspot and opens the assigned IP address in a web browser, the Pico W serves an embedded control webpage. This webpage contains ON and OFF buttons for each connected appliance. Upon pressing any button, an HTTP request is sent to the Pico W web server. The microcontroller continuously listens for incoming requests, identifies the specific command, and accordingly changes the state of the respective GPIO pin. These GPIO pins are connected to relay modules, which act as electronic switches to control the connected AC motor, DC fan, and AC light. The relays provide electrical isolation, ensuring safe operation while switching high-voltage loads. The appliance remains in the selected

state until a new command is received, enabling reliable and real time wireless control without requiring an internet connection.

8.RESULT OR OUTPUT



9.CONCLUSION

This project successfully demonstrates a Wi-Fi hotspot based appliance control system using Raspberry Pi Pico W. The system is simple, efficient, cost-effective, and does not rely on internet connectivity. It provides a practical solution for local wireless automation and serves as a strong foundation for advanced IoT applications.

The key findings of this development include:

- **Network Autonomy:** The system successfully establishes a localized "PICO-W" hotspot, ensuring operational continuity in remote or network-restricted industrial environments.
- **Hardware Efficiency:** Utilizing GPIO pins 17, 18, and 19, the controller achieves near-zero latency in switching operations for the AC Motor, DC Fan, and AC Light.
- **Interface Accessibility:** The embedded HTML/JavaScript GUI enables cross-platform compatibility, allowing any client device with a browser to manage the hardware layer seamlessly.
- **Safety & Scalability:** The use of opto-isolated relays provides necessary electrical isolation between the logic and power circuits, while the modular code allows for the addition of further actuators or sensors.

Future Work

- Implementing SSL/TLS encryption for the local web server to enhance security.
- Integrating real-time sensor feedback (e.g. temperature or current monitoring) into the HTML dashboard.
- Developing a PWA (Progressive Web App) for better mobile user experience.

10.REFERENCES

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