

# Wireless Universal Remote Controller for Haptic Interfaces Using Lora Technology

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**Abstract:** *The rapid advancement in wireless communication and human-machine interaction has led to the development of efficient remote control systems for haptic interfaces. This project presents the design and implementation of a wireless universal remote controller using LoRa technology for controlling haptic devices over long distances. The system integrates joystick-based input modules with ESP32 microcontrollers to capture user commands and transmit them wirelessly using low-power, long-range LoRa communication. On the receiver side, the transmitted signals are decoded and used to drive haptic actuators, enabling real-time tactile feedback. The use of LoRa ensures reliable communication even in environments where conventional wireless technologies such as Wi-Fi or Bluetooth are limited by range or interference. The proposed system is energy-efficient, cost-effective, and capable of supporting applications in robotics, virtual reality, assistive devices, and remote operation systems. The overall design emphasizes portability, scalability, and improved user interaction through precise haptic feedback..*

**Keywords:** *LoRa Technology, Wireless Communication, Haptic Interface, ESP32 Microcontroller, Remote Controller, Joystick Control, Long-Range Communication Internet of Things (IoT), Low Power Systems, Tactile Feedback*

## 1. INTRODUCTION

In recent years, advancements in wireless communication and human-machine interaction have significantly enhanced the development of haptic systems, which enable users to experience tactile feedback in virtual or remote environments. Haptic interfaces are widely used in applications such as robotics, medical simulation, gaming, and assistive technologies, where precise control and feedback are essential [1]. Traditional wired control systems limit mobility and flexibility, creating the need for efficient wireless solutions that can operate reliably over long distances [2].

Conventional wireless technologies such as Wi-Fi and Bluetooth provide high data rates but suffer from limited range and higher power consumption, making them less suitable for long-distance remote control applications [3]. To address these challenges, LoRa (Long Range) technology has emerged as a promising solution due to its low power consumption, extended communication range, and robustness in noisy environments [4]. LoRa enables communication over several kilometers, making it ideal for remote haptic control systems [5].

The integration of microcontrollers such as ESP32 with LoRa modules allows efficient data acquisition, processing, and transmission in real time [6]. Joystick-based input devices are commonly used to capture user commands and translate them into control signals for actuators [7]. At the receiving end, haptic actuators such as vibration motors convert electrical signals into physical feedback, enhancing user interaction and system responsiveness [8].

This project focuses on designing a wireless universal remote controller using LoRa technology to control haptic interfaces efficiently. The system aims to provide a reliable, low-power, and long-range communication solution while



maintaining real-time performance and accurate feedback [9]. Such systems have the potential to improve remote operation capabilities in fields like telemedicine, industrial automation, and virtual reality environments [10].

## II. PROBLEM STATEMENT

Existing haptic control systems are largely dependent on wired connections or short-range wireless technologies, which restrict user mobility and limit their effectiveness in remote applications. Technologies such as Wi-Fi and Bluetooth, although widely used, are not suitable for long-distance communication due to range limitations, higher power consumption, and susceptibility to interference. This creates challenges in applications where reliable, real-time control and feedback are required over extended distances.

Additionally, many current systems lack portability and energy efficiency, making them unsuitable for continuous or field-based operations. The absence of a universal, low-cost solution that can provide stable long-range communication while maintaining accurate haptic feedback further highlights the need for improvement.

Therefore, there is a need to develop a wireless remote controller that can overcome these limitations by offering long-range connectivity, low power consumption, reliable data transmission, and real-time control of haptic interfaces.

## III. OBJECTIVES

- To design and develop a wireless remote controller for haptic interfaces using LoRa technology.
- To implement joystick-based input for generating precise control signals.
- To establish long-range and low-power communication between transmitter and receiver units.
- To control haptic actuators effectively based on transmitted signals for real-time feedback.
- To create a reliable and cost-efficient system suitable for applications in robotics and remote operation.

## IV. LITERATURE SURVEY

The paper titled “**Haptic Servos: Self-Contained Vibrotactile Rendering Devices**” (2023) by N. Sabnis et al., published in ACM Digital Library, presents a compact and self-contained haptic system capable of generating precise vibrotactile feedback. The study focuses on integrating sensing, actuation, and control within a single unit to improve response time and portability. The proposed system enhances user interaction by delivering accurate tactile signals without requiring complex external hardware. The results demonstrate improved efficiency and responsiveness in haptic rendering, making it suitable for wearable and remote interaction applications

The paper titled “**Ubi Edge: Authoring Edge-Based Tangible User Interfaces in Augmented Reality**” (2023) by F. He et al., presented at the CHI Conference, introduces a system that uses physical edges of everyday objects to provide haptic feedback in augmented reality environments. The system allows users to interact with digital content through tactile cues by mapping real-world surfaces to virtual controls. The study highlights improved usability and intuitive interaction, showing that tangible interfaces can enhance user experience in AR-based control systems

The paper titled “**Haptic Interface with Flexible Self-Sensing Actuators for Wireless Touch Communication**” (2023) by various researchers, published on ResearchGate, proposes a wireless haptic communication system that allows users to interact with remote objects through tactile feedback. The system uses flexible actuators capable of sensing and generating force feedback simultaneously. The results show that such systems enable realistic remote interaction and can be applied in teleoperation and virtual communication environments

The paper titled “**Long-Range Technology-Enabled Smart Communication using LoRa**” (2022) presents a study on LoRa-based communication systems for IoT applications. The paper explains how LoRa provides low-power, long-range wireless connectivity suitable for remote monitoring and control systems. It highlights the advantages of LoRa over traditional communication technologies, including extended range and reduced energy consumption, making it ideal for distributed and remote control applications

The paper titled “**Contactless Haptic Display Through Magnetic Field Control**” (2022) by X. Lu et al., proposes a novel haptic system that uses magnetic fields to create tactile sensations without physical contact. The system enables



users to interact with virtual objects in a free space environment. Experimental results show that the approach provides accurate force feedback and enhances user perception, offering new possibilities for touchless interaction systems. The paper titled “FlyHaptics: Flying Multi-Contact Haptic Interface” (2025) by L. Moreno et al., introduces a drone-based haptic system capable of delivering tactile feedback through multiple contact points. The system uses aerial platforms to provide force feedback in virtual and remote environments. The study demonstrates that users can accurately recognize tactile patterns, proving the feasibility of advanced haptic systems for immersive applications such as virtual reality and teleoperation.

### V. WORKING OF SYSTEM

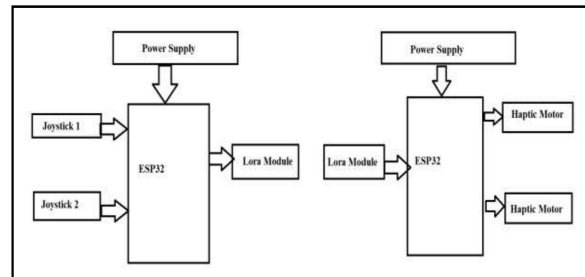


Fig 1: Design of the system

The block diagram represents a Wireless Universal Remote Controller for Haptic Interfaces using LoRa Technology, consisting of two main sections: the transmitter side and the receiver side.

#### Transmitter Section

The transmitter section is responsible for capturing user input and transmitting it wirelessly. It includes two joysticks (Joystick 1 and Joystick 2), which are used to generate control signals based on user movement. These joysticks provide analog inputs corresponding to different directions and positions.

The signals from the joysticks are fed into the ESP32 microcontroller, which acts as the main processing unit. The ESP32 reads the input signals, processes them, and converts them into digital data suitable for transmission.

A LoRa module is connected to the ESP32, which transmits the processed data over a long-range wireless communication channel. The transmitter section is powered by a power supply unit that ensures stable operation of all components.

#### Receiver Section

The receiver section is responsible for receiving the transmitted data and generating haptic feedback. It consists of a LoRa module that receives the wireless signals sent from the transmitter.

The received data is then passed to another ESP32 microcontroller, which decodes and processes the signals. Based on the received commands, the ESP32 controls the haptic motors connected to it.

The haptic motors convert electrical signals into physical vibrations, providing tactile feedback to the user. This allows the system to simulate touch or motion sensations. The receiver section also includes a power supply to provide the necessary energy for the ESP32 and motors.

#### Overall Working

When the user moves the joysticks, the input signals are processed by the ESP32 and transmitted via the LoRa module. The receiver LoRa module captures the signals and sends them to the ESP32, which controls the haptic motors accordingly. This enables real-time wireless control of haptic feedback over long distances.

### VI. SYSTEM DESIGN

The system design of the AI-Based Intelligent Traffic Signal System with Emergency Vehicle Detection is based on the integration of Artificial Intelligence (AI), Internet of Things (IoT), and embedded systems.



The proposed system is designed as a **wireless haptic control system** consisting of two main units: a transmitter unit and a receiver unit. The transmitter captures user input through a joystick and sends control signals wirelessly using LoRa communication. The receiver processes these signals and drives haptic actuators to produce physical feedback. The system emphasizes long-range communication, low power consumption, and real-time response.

**Components Description**

**ESP32 Development Board (2 Units)**

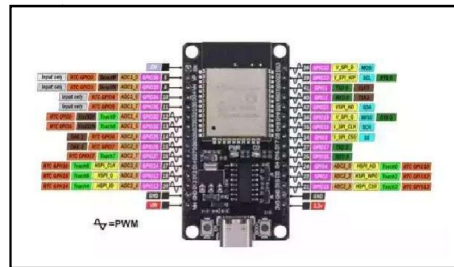


Fig.2.ESP 32

The ESP32 microcontroller serves as the central processing unit in both the transmitter and receiver sections. In the transmitter, it reads analog signals from the joystick and converts them into digital data for transmission. In the receiver, it decodes the incoming data and generates appropriate control signals for the actuators. It is chosen due to its high processing capability, built-in ADC, and efficient performance.

**ALPS Analog Gaming Joystick Module**



Fig.3. Joystick

The joystick module acts as the primary input device. It provides analog outputs based on movement along the X and Y axes. These signals represent direction and intensity of motion, allowing precise control of the system. The joystick also includes a push-button function for additional control if required.

**Motor / Actuator Driver (L298N / Servo Driver / H-Bridge)**

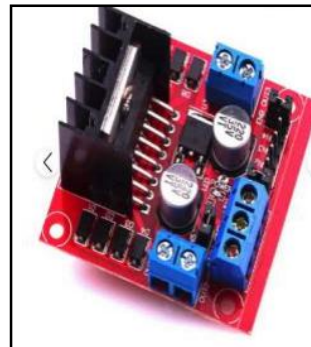


Fig.4. Joystick  
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The motor driver is used to control the operation of actuators. Since the ESP32 cannot directly drive high-power motors, the driver acts as an interface between the microcontroller and the actuators. It controls speed, direction, and power supplied to the motors based on signals received from the ESP32.

#### **Haptic Actuators / Motors**

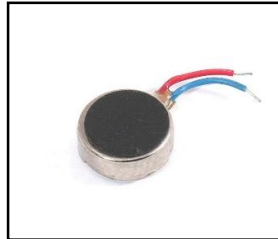


Fig.5.Haptic Actuators

These components generate physical feedback in the form of vibration or motion. Depending on the application, different types of actuators such as DC motors, servo motors, or vibration motors can be used. They convert electrical signals into tactile sensations, enabling the user to experience feedback.

#### **Power Supply / Battery Pack**



Fig.6.Power Supply

The system is powered using a battery pack or external power supply, typically providing 5V or 3.7V. This ensures portability and allows the system to function without a fixed power source. A stable power supply is essential for reliable operation of the ESP32 and other components.

#### **Voltage Regulator Module (AMS1117 / Buck Converter)**

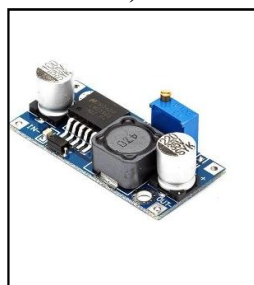


Fig.7.Voltage Regulator

The voltage regulator ensures a constant and stable output voltage to the system components. It protects sensitive electronics from voltage fluctuations and prevents damage due to overvoltage or unstable power conditions.



### Connecting Wires / Jumper Cables



Fig.7.Jumper Cables

These are used to establish electrical connections between various components in the system. They ensure proper signal transmission and power distribution within the circuit.

### PCB / Breadboard

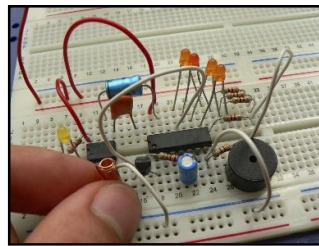


Fig.8.PCB

A PCB or breadboard is used for assembling and mounting the components. During the development phase, a breadboard is used for easy prototyping, while a PCB is used for final implementation to ensure durability and compact design.

## VII. RESULTS

The developed wireless haptic control system was successfully implemented and tested to evaluate its performance. The system demonstrated reliable communication between the transmitter and receiver using LoRa technology over a significant distance without noticeable data loss. The joystick inputs were accurately captured by the transmitter ESP32 and transmitted in real time, allowing smooth and responsive control at the receiver end.

On the receiver side, the ESP32 effectively decoded the incoming signals and controlled the haptic actuators as intended. The motors responded promptly to changes in joystick movement, producing consistent tactile feedback. The system maintained stable operation with minimal delay, ensuring a satisfactory real-time user experience.

Additionally, the power consumption of the system remained low, making it suitable for battery-operated applications. The overall setup proved to be cost-effective, portable, and efficient for long-range wireless control. These results confirm that the proposed system can be effectively used in applications such as remote operation, robotics, and interactive haptic systems.

## VIII. CONCLUSION

The project successfully demonstrates the design and implementation of a wireless universal remote controller for haptic interfaces using LoRa technology. The system effectively integrates joystick-based input, ESP32 microcontrollers, and long-range communication to enable reliable transmission of control signals. The use of LoRa ensures stable performance over extended distances while maintaining low power consumption.



The receiver unit accurately interprets the transmitted data and controls the haptic actuators to produce timely and consistent feedback. The overall system shows good responsiveness, minimal delay, and dependable operation, making it suitable for real-time applications.

This work highlights the potential of combining low-power wireless communication with haptic technology to improve remote interaction systems. The developed system is portable, cost-effective, and adaptable, making it useful for applications in robotics, simulation, and assistive technologies.

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