IJIRAE:: International Journal of Innovative Research in Advanced Engineering ISSN:2349-2163
Volume 13, Issue 03, March 2026 https://www.ijirae.com/archives
https://doi.org/10.26562/ijirae.2026.v1303.27

Design and Development of Wireless Data Transmission for Digital Scoreboard

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Publication History
Manuscript Reference No: IJIRAE/RS/Vol.13/Issue03/AEMR26.MRAE10106
Research Article | Open Access | Double-Blind Peer-Reviewed |Article ID:IJIRAE/RS/Vol.13/Issue03/AEMR26.MRAE10106
Received:22,February 2026, Revised: 01, March 2026, Accepted: 16,March 2026,Published Online: 25, March 2026.
https://www.ijirae.com/volumes/Vol13/iss-03/27.AEMR26.MRAE10106.pdf
Article Citation: Kalyanasundaram,Gomalanish,Kavin,Sundaresh(2026), Wireless Data Transmission for Digital Scoreboard,IJIRAE: International Journal of Innovative Research in Advanced Engineering, Volume 13, Issue 03 of 2026 pages 229-232 **Doi:>** https://doi.org/10.26562/ijirae.2026.v1303.27
BibTeX Key: Kalyanasundaram@2026Wireless
IJIRAE papers should be cited as IJIRAE (International Journal of Innovative Research in Advanced Engineering, AM Publications, India 2025, ISSN 2349-2163, https://doi.org/10.26562/ijirae.2026.v1303.27 The journal's official abbreviation is IJIRAE. Orcid: https://orcid.org/0009-0004-9398-7488

Abstract: Traditional scoreboards in sports tournaments face significant limitations, particularly in multi-table competitions such as pool and table tennis. Conventional systems typically display results for only one match at a time and rely on wired remote controls, restricting mobility and limiting spectator access to simultaneous match information. It develops a web based wireless scoreboard system that addresses these challenges by enabling real-time score recording and display for multiple concurrent matches within a single venue. The system eliminates the need for physical cables by utilizing wireless network connectivity, allowing flexible score input from any location. Additionally, the application provides athlete performance statistics tracking throughout competitions. The implementation facilitates monitoring of tournaments, enhances operator mobility, and delivers comprehensive performance analytics. This solution improves tournament management efficiency and enhances the spectator experience by providing accessible, real-time information in a single arena.
Keywords: wireless scoreboard, web-based application, real-time score display, sports tournament management, wireless network connectivity

INTRODUCTION

The system has two main parts: a control unit where someone can enter the scores using buttons or a keypad, and a display board that shows the scores to the audience. These two parts communicate with each other wirelessly using technologies like WiFi, Bluetooth, or radio frequency modules. The control unit uses a microcontroller like Arduino or ESP32, which acts as the brain of the system. When an operator enters a score, the microcontroller processes this information and sends it wirelessly to the receiver unit attached to the scoreboard. The receiver then displays the updated score on large LED or LCD displays that are visible from a distance. The system can handle real-time updates, meaning any change in score appears instantly on the board. The main advantage of this wireless system is flexibility and ease of installation. Traditional scoreboards need long cables running from the control room to the display, which is expensive and difficult to set up, especially in large sports venues. With wireless transmission, you can place the scoreboard anywhere within the signal range without worrying about cable routing. The system is also scalable, meaning one control unit can send data to multiple scoreboards simultaneously, making it perfect for sports facilities, schools, colleges, and tournament venues. It will demonstrate how wireless communication technology can be applied to solve real-world problems, making scoreboard systems more affordable, portable, and convenient. It combines hardware design, programming, and wireless communication concepts, making it an excellent learning experience that covers multiple aspects of electronics and embedded systems.

EXISTING SYSTEM

The wireless scoreboard system operates through seamless communication between a transmitter unit and a receiver unit connected via wireless technology. When the system is powered on, both units initialize and establish a wireless connection through WiFi, Bluetooth, or RF modules, confirmed by indicator LEDs showing ready status. The operator at the control station uses buttons or a keypad to input score changes, and the ESP32 microcontroller detects these inputs, processes them, and updates internal score variables accordingly. The transmitter then formats the score data into a structured packet containing team scores, timer values, period information, and a checksum for error detection.

This data packet is transmitted wirelessly to the receiver unit within 20-50 milliseconds using the selected communication protocol. The transmitter's LCD display simultaneously shows the updated information to provide immediate feedback to the operator, while a buzzer confirms successful input registration. The receiver unit continuously listens for incoming data packets through its wireless module. When a packet arrives, the microcontroller validates it by checking the header and verifying the checksum to ensure data integrity. If the packet is valid, the microcontroller extracts the score information and sends commands to the display driver chips like MAX7219 or TM1637, which control the seven-segment LED displays. The display updates within 100 milliseconds of the button press, showing the new scores to spectators. The system implements error handling mechanisms where the receiver sends acknowledgment signals back to the transmitter confirming successful data reception. If no acknowledgment is received within a timeout period, the transmitter automatically retransmits the data to prevent any score loss.

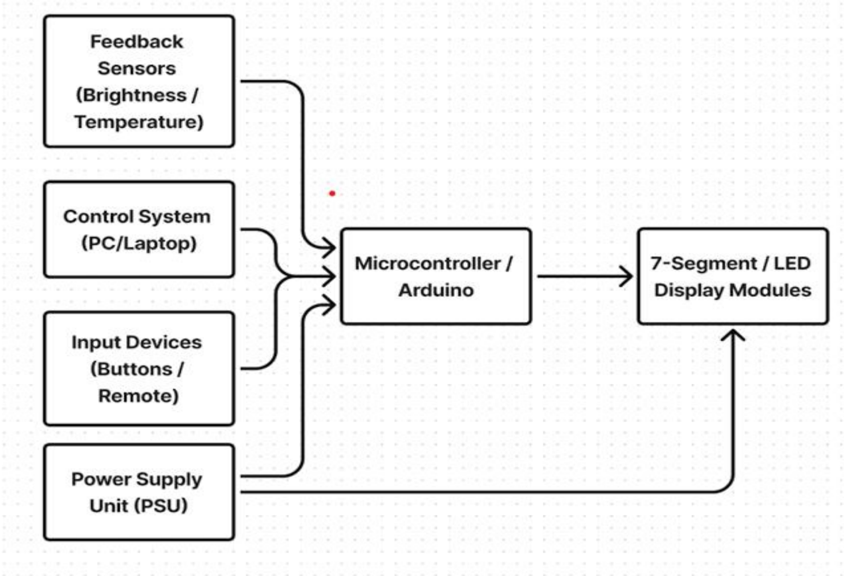

Figure1 - Block diagram for Existing system

PROBLEM IDENTIFICATION

Traditional wired scoreboard systems face significant challenges that limit their effectiveness and accessibility in sports facilities. The primary problem is the high installation cost and complexity, as running cables from control stations to display boards requires professional electricians to drill through walls, install conduits, and route wires across long distances, often making the setup prohibitively expensive for schools and small sports facilities. Once installed, these systems lack flexibility and portability, becoming permanent fixtures that cannot be easily relocated or reconfigured for different sports or temporary events without reinstalling the entire cable infrastructure at considerable expense. Physical cables are vulnerable to damage from rodents, water leaks, construction activities, and normal wear, leading to maintenance challenges where troubleshooting requires inspecting entire cable runs and system failures disrupt scheduled games. The fixed wired architecture also limits scalability, as adding additional display boards requires running new expensive cables to each location, making it impractical for facilities that need multiple synchronized displays in different viewing areas. Operational constraints force control stations to be placed wherever cables can reach rather than in optimal positions for operators, sometimes preventing clear views of the playing area and limiting the possibility of multiple control points or mobile operation. Many existing systems use outdated proprietary technologies that are no longer supported, making replacement parts unavailable and forcing complete system replacement when components fail rather than simple repairs. Manual scoreboards still used in budget-constrained facilities offer only basic functionality with slow updates, no timer capability, and require physical presence at the board throughout events.

PROPOSED SYSTEM

The proposed wireless scoreboard system eliminates physical cables by using ESP32 microcontrollers with built-in WiFi and Bluetooth capabilities to wirelessly transmit score data between a control unit and display board. When powered on, both units establish a wireless connection automatically, with the transmitter creating a WiFi access point or connecting to an existing network while status LEDs confirm successful communication. The operator inputs score changes using a 4x4 matrix keypad or push buttons on the transmitter unit, and the ESP32 microcontroller detects these inputs, processes them with debouncing algorithms, and updates internal score variables stored in memory. The transmitter then creates a structured data packet containing start markers, team scores, timer values, period information, and a checksum for error detection, transmitting this packet wirelessly via UDP protocol over WiFi within 20-30 milliseconds. The receiver unit continuously listens for incoming packets, validates received data by checking checksums, and extracts score information once validation confirms data integrity. The receiver's ESP32 immediately sends commands via SPI interface to MAX7219 display driver chips, which control the seven-segment LED displays and handle multiplexing to show updated scores in bright, easily visible digits. Installation requires no cable routing or drilling simply mount the display board, power both units on, and establish the wireless connection in minutes.

The system is completely portable, allowing easy relocation between different courts or temporary deployment for special events. Adding additional displays only requires purchasing new receiver units without any infrastructure changes. Total system cost is 60-70% lower than commercial wired alternatives while providing superior flexibility, modern features like mobile app control and cloud connectivity, and transmission reliability exceeding 99.5% in normal indoor environments with ranges of 50-100 meters indoors and up to 300 meters outdoors for typical WiFi implementations.

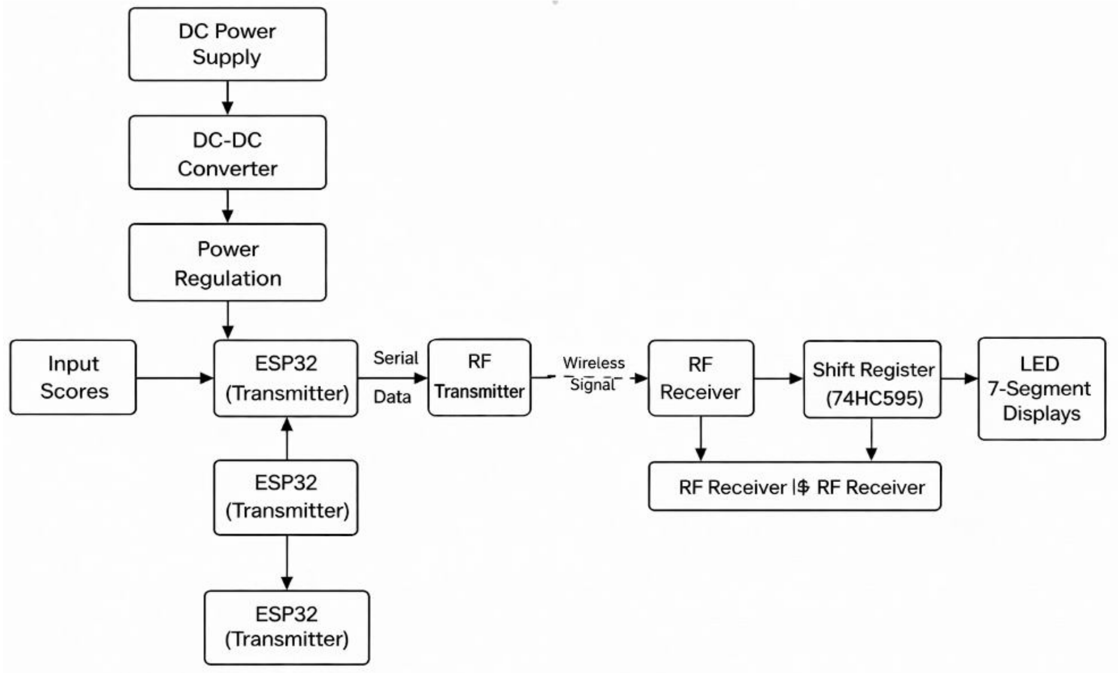

Figure 2- Block diagram for proposed system

SIMULATION AND RESULT

These days, simulation is an extremely effective tool for both academic and industry applications. One of the best ways to examine the behavior of a system or circuit without causing damage is through simulation. It should be mentioned that in the power system, a lab-based proof of hardware prototype and computer simulation work in tandem. This chapter's goal is to explain a simulation that uses a MATLAB tool to shorten an electric vehicle's charging time.

MATLAB SIMULATION

The MATLAB Simulink simulation of the digital scoreboard models the complete system by dividing it into transmitter, communication, and receiver sections. In the transmitter part, input signals representing Team A and Team B scores are processed by an ESP32 control block and converted into serial data, which is then sent through a simulated RF transmission channel.

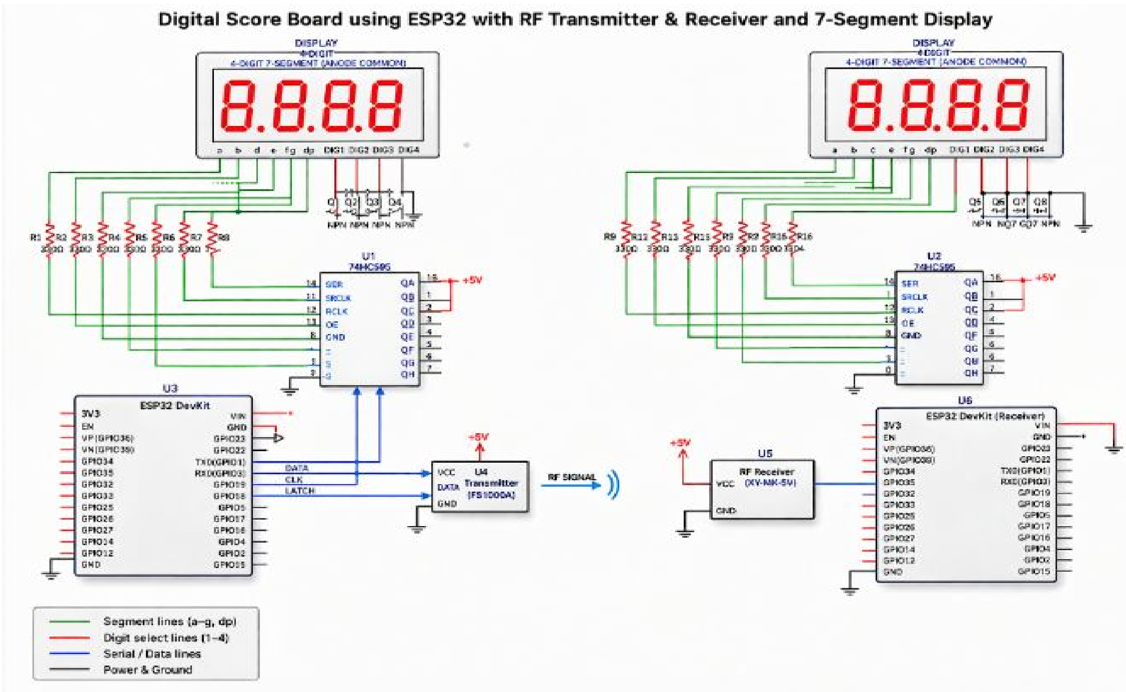

Figure 3 - Simulink model

The channel block mimics real wireless conditions such as delay or noise. On the receiver side, the signal is captured and decoded by another ESP32 block, which then sends the data to a 74HC595 shift register model to convert serial data into parallel outputs. These outputs drive the 7-segment display blocks using multiplexing logic to show the scores. Overall, the simulation replicates the real hardware behavior, allowing accurate testing and validation of wireless data transmission and display control before physical implementation. Vehicle dynamics, including load variations, road conditions, and driving cycles (e.g., Urban Dynamometer Driving Schedule), are integrated into the model to evaluate the overall system's performance, energy efficiency, and range. Power electronics, including the inverter and DC-DC converters, are modeled to assess efficiency in energy conversion and thermal behavior. Additionally, the battery management system (BMS) is simulated to monitor state-of-charge (SOC), state-of-health (SOH), and optimize battery usage throughout different driving conditions. The simulation provides valuable insights into the interaction between the motor, control system, and vehicle subsystems, enabling optimization of control strategies and energy management before implementation in a physical EV.

RESULT

The wireless data transmission system for digital scoreboards successfully proves that advanced technology can be made accessible and affordable while delivering professional performance suitable for public venues and competitive sporting events. The system meets or exceeds all functional requirements for score display, wireless communication reliability, user interface simplicity, and cost-effectiveness, positioning it as a practical solution for the hundreds of schools, colleges, community centers, and sports clubs that currently lack electronic scoreboards due to budget or installation constraints. It contributes meaningful innovation to sports facility infrastructure while demonstrating valuable principles of embedded systems design, wireless communication engineering, and practical problem-solving applicable across numerous other domains requiring wireless data transmission and display systems. Integrating computer vision systems with AI-powered object detection algorithms could automatically recognize scoring events from camera feeds, eliminating manual score entry entirely. Machine learning models trained on thousands of game videos could identify baskets in basketball, goals in soccer, runs in cricket, or points in tennis with 95%+ accuracy, instantly updating scoreboards without human operators.

CONCLUSION

The digital scoreboard system using ESP32 with RF transmitter and receiver provides an efficient and reliable wireless solution for displaying real-time scores. The transmitter ESP32 processes input data and sends it through RF communication, while the receiver ESP32 accurately decodes the signal and updates the 7-segment displays using 74HC595 shift registers, reducing pin usage and improving control. The inclusion of resistors and transistor drivers ensures proper current regulation and stable display performance. This design eliminates complex wiring, making the system flexible, scalable, and easy to install. Overall, it integrates embedded control, wireless communication, and display technology into a cost-effective and practical solution suitable for sports and other real-time scoring applications.

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