Smart Charging System Using RFID For Secure and Controlled Power Access

Mr. N. Thiyagarajan
Assistant Professor, Dept. Of ECE
KGiSL Institute of Technology Coimbatore, TN, India
thiyaguec@gmail.com

Rajesh G
UG Student, Dept. Of ECE,
KGiSL Institute of Technology Coimbatore, TN, India
gopalrajesh959@gmail.com

Sabarish B
UG Student, Dept. Of ECE,
KGiSL Institute of Technology Coimbatore, TN, India
Sabarijaddu1135@gmail.com

Sanjay B
UG Student, Dept. Of ECE, KGiSL Institute of Technology Coimbatore, TN, India
san12sanjay@gmail.com

Rohith G
UG student, Dept of ECE,
KGiSL institute of technology,
Coimbatore, TN, India
rohithganesh059@gmail.com

Abstract—*In an age where electronic device usage is ubiquitous, public and shared charging stations have become essential infrastructure. However, uncontrolled access to these resources often leads to misuse, energy wastage, and maintenance issues. This project responds to these societal needs by developing an RFID-based secure charging system that allows only authorized users to access wired charging ports. The system employs an RFID reader integrated with a microcontroller to authenticate users before activating power supply to the charging outlet. Upon successful verification of an RFID tag, the circuit enables current flow to the device, ensuring a safe, regulated, and user-specific charging experience. This design enhances the utility of wired charging setups in environments like libraries, offices, schools, and public kiosks, where energy control and user accountability are increasingly important. The system emphasizes security, cost-effectiveness, and practical implementation, making it a strong candidate for real-time deployment in modern infrastructure.*

***Keywords*—RFID (Radio Frequency Identification), Wired Charging, Microcontroller, Authentication, Relay Control, Power Management, Security System, Access Control,, Embedded System**

I. Introduction

In today's technology-driven world, mobile devices have become essential for communication, productivity, and navigation. With the increasing reliance on smartphones, there is a growing demand for secure, efficient, and user-specific charging systems, particularly in shared or public environments. Traditional charging setups in such locations often suffer from unrestricted access, leading to unauthorized usage, energy wastage, and security concerns.

To address these issues, this project implements an **RFID-based smart mobile charging system using Arduino**, designed to provide controlled and authenticated access to a power supply. The core components of the system include an **Arduino Uno microcontroller**, an **MFRC522 RFID reader module**, a **5V relay module**, and an **LCD display**. The system operates by continuously monitoring for RFID input. When a card is scanned, the Arduino checks the unique RFID tag ID against a pre-authorized list. If the tag is valid, the Arduino activates the relay to switch on the charging port and provides user feedback through the LCD.

The relay ensures that power is only supplied to the charging circuit when valid credentials are presented, thereby preventing unauthorized use. The RFID reader enables wireless, contactless identification, making the process seamless and tamper-resistant. The LCD module serves as a user interface to confirm authorization status and guide the user during operation.

This system is ideal for deployment in semi-public spaces like hostels, libraries, and offices, where secure and trackable access to power is essential. The project demonstrates the practical integration of embedded systems, RFID technology, and automation to solve real-world challenges in access control and energy management.

II. LITERATURE SURVEY

The increasing demand for renewable energy solutions and efficient charging infrastructure has led to significant research in piezoelectric energy harvesting, solar-powered systems, and RFID-based authentication for both mobile devices and electric vehicles (EVs). Kulkarni et al. [1] developed a **footstep-based piezoelectric energy harvesting system** capable of generating **2.4V and 3.6mW per step**, integrated with RFID technology for secure device charging. Similarly, Kadam et al. [2] proposed a **solar-powered public charging station** using RFID authentication, offering a portable solution for areas with unreliable grid access. Alam et al. [3] and [5] introduced an **IoT-based secured charging station** with RFID and coin-based authentication, ensuring only authorized users can access charging ports. Riduvarshini et al. [4] expanded this concept with a **solar-powered, token-operated kiosk** supporting both RFID and coin payments, featuring real-time monitoring and safety mechanisms.

For EVs, wireless and dynamic charging solutions are gaining prominence. Fu et al. [6] optimized **RFID-based wireless charging** for sensor networks by minimizing charging delays through mobile reader movement. Zhai et al. [7] explored **ultra-wideband retro-reflective beamforming** for efficient long-distance wireless power transfer. Fabroyir et al. [8] compared **QR code and RFID authentication** in battery swapping stations, finding RFID faster but noting mixed user preferences. Fodorean et al. [9] designed a **hybrid mobile charging station** combining grid power, batteries, and ultracapacitors for urban and resort areas. N et al. [10] enhanced **EV charging stations** with solar energy and smart parking sensors for improved efficiency. Chaganti et al. [11] implemented an **RFID-based wireless charging system** for EVs using inductive coupling, eliminating manual intervention. Carbo et al. [12] analyzed **fast-charging station placement** in Ecuador, emphasizing grid impact and harmonic distortion. Prasad et al. [13] introduced a **Dynamic Wireless Charging System (DWCS)** enabling EVs to charge while in motion, reducing range anxiety. Tang [14] studied **congestion in fast-charging stations** due to rising EV adoption, highlighting grid-traffic interdependencies. Finally, Shanmugam et al. [15] provided a **systematic review of dynamic wireless charging**, covering couplers, compensation networks, and renewable integration.

III. PROPOSED WORKFLOW

The proposed workflow of the RFID-based smart mobile charging system is designed to offer a secure and user-friendly way to charge mobile devices in shared or public spaces. In many such places, charging ports are either freely accessible or poorly managed, which often leads to misuse, overuse, or unnecessary power consumption. This system provides a solution by ensuring that only authorized users can access the charging facility through the use of an RFID card.

The entire process begins when a user brings their RFID card close to the charging station. The system automatically detects the card and checks whether it is registered and allowed to use the charger. If the card is recognized as valid, the system turns on the power supply to the charging port and allows the user to charge their device. A screen on the system shows a message confirming that charging has started. On the other hand, if the card is not valid or is not recognized, the system keeps the charging port turned off and shows a message denying access. This helps ensure that only users who are supposed to use the system can do so.

The process is fully automatic and doesn't require any manual supervision, making it easy to manage and reliable for everyday use. The display helps users understand the status of their access, so they know whether they've been approved or denied. The system continues to monitor for new cards while managing power supply to prevent waste.

This kind of smart charging setup is especially useful in places like hostels, libraries, offices, or bus stands where many people may want to charge their phones but need a system that can control and limit access. It helps to reduce energy waste and makes sure that only authorized users benefit from the service.

In simple terms, this workflow allows for a smooth and secure charging experience by using RFID cards to control who can use the charger. It combines ease of use with better control and efficiency, making it ideal for use in both public and semi-private locations.

Fig 1.1 shows the flowchart that explains the working flow the proposed sytem that strats from detecting the RFID card to charging decision taken by the microcontroller.

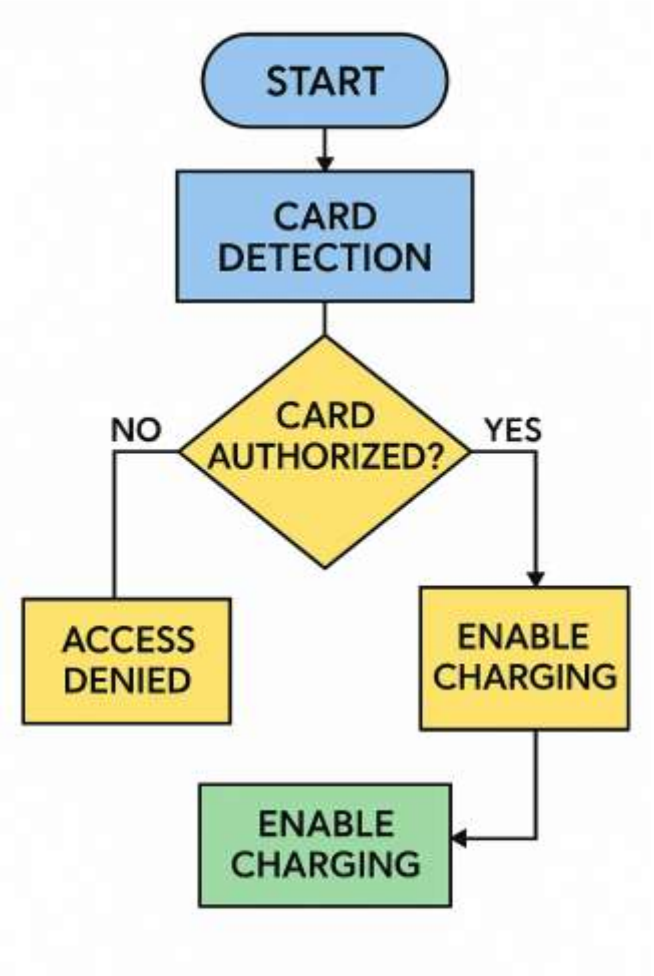

Fig 1.1 Shows the flowchart of the proposed system

The block diagram of the proposed workflow illustrates the secure, RFID-enabled charging solution designed for public and semi-public spaces such as hostels, libraries, and transport hubs. The system ensures only authorized users can access the charging port, optimizing energy use while preventing misuse.

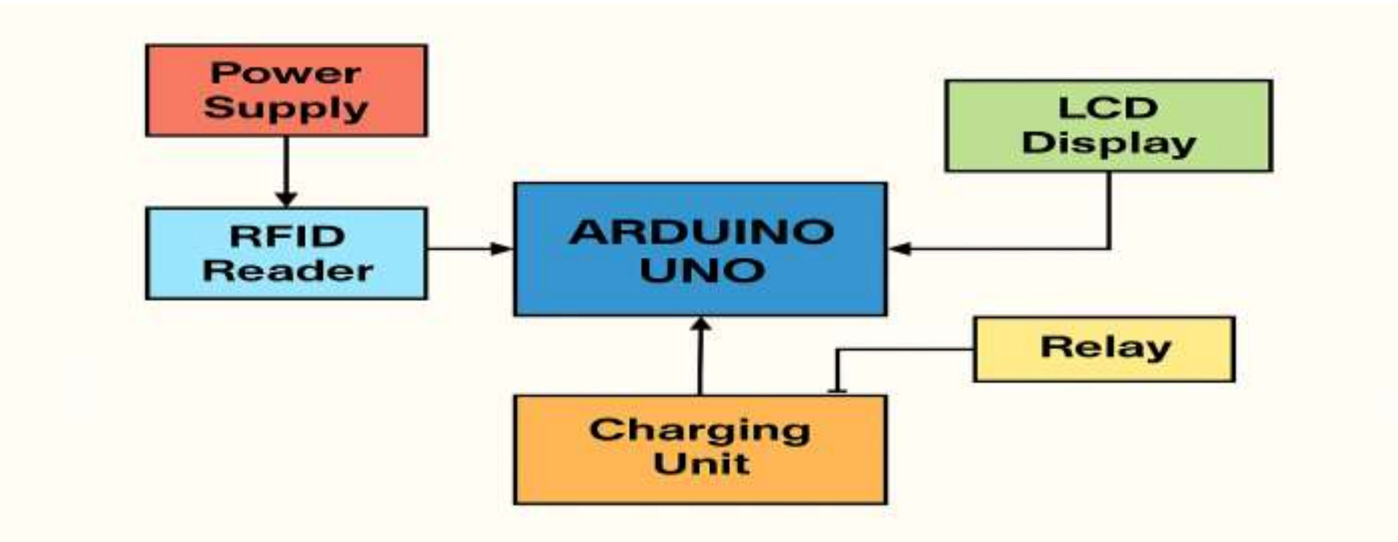

Fig 1.2 Block diagram of the proposed workflow

1. User Authentication and Access Control

The system begins with the identification and authentication of users through an RFID reader (MFRC522). When a user presents an RFID card or tag near the reader, the RFID module reads the unique identifier embedded in the tag. This identifier is then transmitted to the Arduino Uno microcontroller via the SPI communication protocol. The microcontroller compares the incoming RFID data against a preloaded list of authorized IDs stored in its EEPROM or flash memory. If a match is found, the system proceeds to activate the charging port; otherwise, access is denied. This mechanism ensures that only registered users can initiate the charging process, thereby enhancing security and user control.

2. Charging Activation and Control

Upon successful authentication, the microcontroller triggers a relay module connected to the charging port. The relay acts as a digital switch, physically connecting or disconnecting the power supply to the mobile charging socket. When activated, it allows electricity to flow from the main power source to the connected device. The relay remains active for a fixed or configurable duration, after which it automatically turns off to avoid unnecessary power consumption. This time-based control prevents overcharging and ensures fair usage in shared environments. The relay is typically a 5V module, directly controlled by one of the Arduino's digital output pins.

3. User Feedback and Display Interface

To enhance user interaction, the system integrates a 16x2 or 20x4 character LCD module. This display provides clear, real-time feedback during each stage of the process. At standby, the LCD shows messages such as “Scan your card.” Once an RFID card is scanned, it updates to indicate whether access is granted or denied. If successful, the LCD may display “Charging Started” and optionally include a countdown timer for the remaining charging time. This immediate feedback helps users understand the system's status and reinforces trust and transparency in its operation.

4. Energy Supply and Regulation System

The system operates on a 5V regulated DC power supply, which can be derived from a 12V adapter or battery through a buck converter or linear voltage regulator such as the 7805 or AMS1117. These regulators step down and stabilize the voltage for the Arduino, RFID reader, and relay module. Proper voltage regulation is crucial to ensure the reliable operation of all components and to protect against power fluctuations. In future implementations, this power system can be made solar-compatible by integrating a solar charge controller and a rechargeable battery, allowing the unit to function sustainably in off-grid areas.

5. Security, Safety, and Future Scalability

The system includes built-in safety features such as electrical isolation through the relay and the option for fuse protection or circuit breakers. These protect users and devices from overcurrent or short-circuit conditions. The design also supports scalability: multiple units can be deployed across different locations, each with a shared or centralized RFID database. For extended features, the system can be upgraded to support Wi-Fi modules, enabling remote usage logs, alerts, or control commands. Such modularity ensures that the project remains adaptable for future enhancements, such as mobile app control or cloud-based usage analytics.

The steps to be followed in the proposed workflow is given below

Idle State

i. The system powers on and initializes all modules, displaying “Scan your card” on the LCD screen.
ii. It remains in standby mode, continuously checking for RFID card presence near the reader.

RFID Card Detection

i. When a user presents an RFID card, the MFRC522 module reads the card’s unique identifier (UID).
ii. This UID is then sent to the Arduino for processing and verification.

Authentication

i. The Arduino compares the scanned UID against a list of pre-stored, authorized UIDs in memory.
ii. If the UID is found, access is granted; otherwise, the system displays “Access Denied.”

Access Decision

i. For valid cards, the Arduino sends a signal to activate the relay module, starting the charging session.
ii. An LCD message “Charging Started” and the name of the user confirms the relay is closed and power is flowing.

Charging Phase

i. The relay remains activated, allowing power to flow to the charging socket for a fixed time duration.
ii. During this time, the LCD may display a countdown or charging progress status.

Session End

i. Once the timer expires, the Arduino deactivates the relay to stop power to the charger.
ii. A message that includes the name of the user and the time consumed for charging is displayed to notify the user.

Ready for Next User

i. The system resets to its original idle state, ready to scan a new RFID card.

ii. It continuously loops through this cycle for each user interaction

Fig 1.3 shows the software simulation of the proposed system

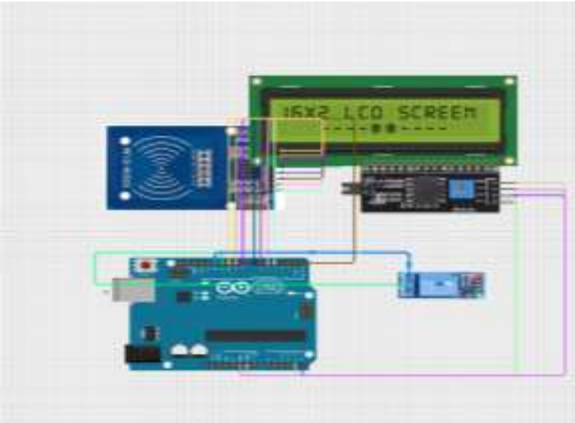

Fig 1.3 arduino IDE simulation of the proposed system

Fig 1.4 shows the hardware module of the proposed system

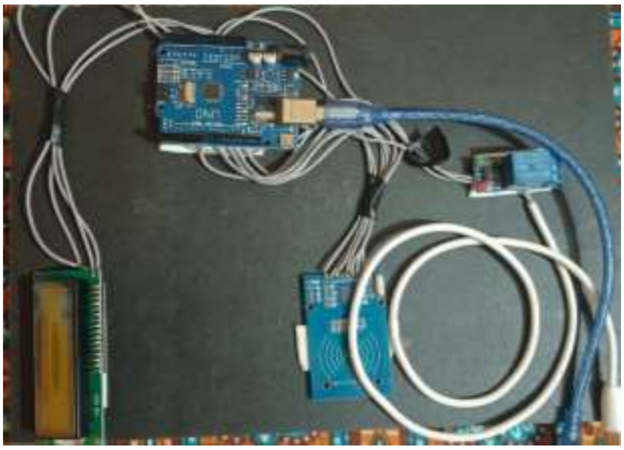

Fig 1.4 hardware module of the proposed system

Fig 1.5 shows the scanning of the RFID card in the hardware module

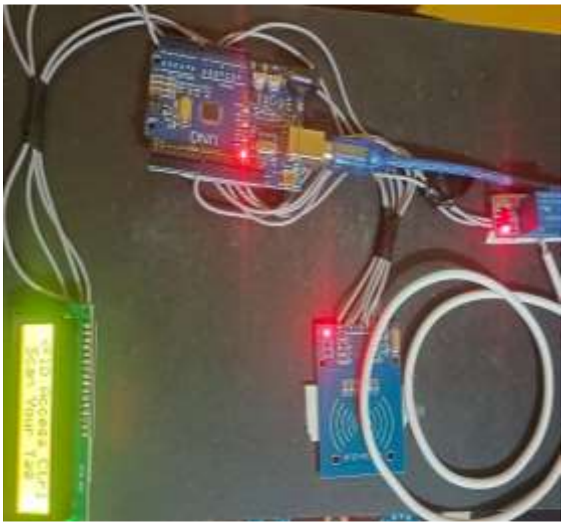

Fig 1.5 scanning of RFID in hardware module of the proposed system

ANALYSIS AND RESULTS

The RFID-based wired charging system was implemented and tested to evaluate its functionality, efficiency, and reliability in real-time conditions. During testing, the RFID module successfully detected authorized tags within a 2–5 cm range and activated the charging circuit via relay control in less than one second. Unauthorized tags were consistently rejected, confirming the effectiveness of the access control logic. The system operated continuously under typical load conditions without overheating or signal failure, demonstrating its stability. Power consumption of the control circuit remained low, making it suitable for energy-conscious environments. The results validate the proposed system's goal of providing secure, user-specific access to wired charging, with potential deployment in the places and charging stations where controlled energy use is necessary

Fig 1.6 LCD display to indicate the scanning process

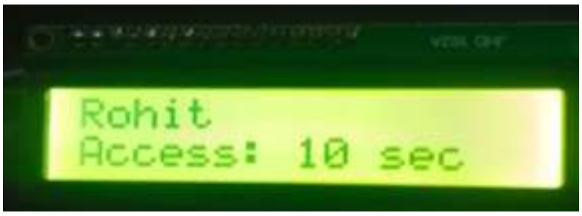

Fig 1.7 charging time consumed by user 1

Fig 1.8 charging time consumed by user 2

Fig 1.9 charging time consumed by user 3

Fig 1.10 charging time consumed by user 4

IV. CONCLUSION

The proposed RFID-based wired charging system offers a secure, efficient, and user-specific solution for controlling access to power in shared environments. By integrating RFID authentication with a microcontroller-controlled relay, the system ensures that only authorized users can activate the charging circuit, thereby minimizing energy misuse and enhancing accountability. This approach is especially valuable in settings such as libraries, offices, educational institutions, and public facilities where regulated power access is essential. Looking ahead, the system can be enhanced by integrating real-time usage tracking, mobile app connectivity for remote access and monitoring, and the use of cloud-based databases to manage user credentials dynamically. Additional features such as charging duration limits, payment integration, and support for multiple user profiles could also broaden the scope and utility of the system in smart infrastructure and IoT-based

V. REFERENCES

1. P. Kulkarni, S. A. Hoskote, S. S and R. R. C, "Sustainable Piezoelectric Energy Harvesting for Device Charging with RFID Authorization," 2024 2nd International Conference on Networking, Embedded and Wireless Systems (ICNEWS), Bangalore, India, 2024, pp. 1-6, doi: 10.1109/ICNEWS60873.2024.

2. P. Kadam, M. Sontakke, A. Narale, R. Agrawal and S. Sorte, "Design of Mobile Solar Powered Public Station Using RFID," 2022 International Conference on Electronics and Renewable Systems (ICEARS), Tuticorin, India, 2022, pp. 186-191, doi: 10.1109/ICEARS53579.2022.9752364.

3. M. E. Alam, M. A. Kader, M. Hossain, F. Noushin, M. S. Alam and S. Farid, "IoT Based Smart and Secured Mobile Charging Station in Public Place," 2021 3rd International Conference on Sustainable Technologies for Industry 4.0 (STI), Dhaka, Bangladesh, 2021, pp. 1-6, doi: 10.1109/STI53101.2021.9732560

4. M.Riduvarshini, S.Dharshin, B.Dharani and S. S. R. Senthil, "Solar Powered RFID Token Operated Mobile Charging System," 2025 International Conference on Electronics and Renewable Systems (ICEARS), Tuticorin, India, 2025, pp. 72-76, doi: 10.1109/ICEARS64219.2025.

5. L. Fu, P. Cheng, Y. Gu, J. Chen and T. He, "Optimal Charging in Wireless Rechargeable Sensor Networks," in IEEE Transactions on Vehicular Technology, vol. 65, no. 1, pp. 278-291, Jan. 2016, doi: 10.1109/TVT.2015.2391119.

6. H. Zhai, H. K. Pan and M. Lu, "A practical wireless charging system based on ultra-wideband retro-reflective beamforming," 2010 IEEE Antennas and Propagation Society International Symposium, Toronto, ON, Canada, 2010, pp. 1-4, doi: 10.1109/APS.2010.5561113

7. H. Fabroyir et al., "Auth at Battery Swapping Stations for Electric Scooters: QR Code vs. RFID Interaction Designs," 2023 14th International Conference on Information & Communication Technology and System (ICTS), Surabaya, Indonesia, 2023, pp. 46-51, doi: 10.1109/ICTS58770.2023.

8. D. Fodorean, F. Cirlea, M. S. Raboaca and C. Filote, "New Mobile Charging Station for Urban and Resort Areas," 2019 Electric Vehicles International Conference (EV), Bucharest, Romania, 2019, pp. 1-6, doi: 10.1109/EV.2019.8892866

9. P.K. L. N, A. S, H. P, A. P, K. B and G. C, "Advanced Power Management for Electric Vehicle Charging Station," 2023 International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS), Erode, India, 2023, pp. 1551-1556, doi: 10.1109/ICSSAS57918.2023.10331832

10. R. K. R. Chaganti, P. M. Amruth, V. R. Devarinti, B. V. J. Chandra and H. Victor Du John, "RFID Based Wireless Charging System for Electric Car," 2022 6th International Conference on Devices, Circuits and Systems (ICDCS), Coimbatore, India, 2022, pp. 403-406, doi: 10.1109/ICDCS54290.2022.

11. J. Carbo, S. Mendoza, I. Endara and J. Urquizo, "Design and location analysis of fast charging hybrid vehicle stations. A case study from Ecuador," 2019 FISE-IEEE/CIGRE Conference - Living the energy Transition (FISE/CIGRE), Medellin, Colombia, 2019, pp. 1-8, doi: 10.1109/FISECIGRE48012.2019.8984976

12. D. V. Prasad, V. S. Lande, A. P. Bornare, P. B. Waghmare and M. Sujith, "Dynamic Wireless Charging System for Electric Vehicles," 2024 8th International Conference on Inventive Systems and Control (ICISC), Coimbatore, India, 2024, pp. 608-612, doi: 10.1109/ICISC62624.2024.00106.

13. D. Tang, "Congestion Assessment in Electric Vehicle Fast Charging Stations for Coupled Traffic-Power Systems in Smart Cities," 2021 IEEE 5th Conference on Energy Internet and Energy System Integration (EI2), Taiyuan, China, 2021, pp. 1760-1764, doi: 10.1109/EI252483.2021.9713398

14. Y. Shanmugam et al., "A Systematic Review of Dynamic Wireless Charging System for Electric Transportation," in IEEE Access, vol. 10, pp. 133617-133642, 2022, doi: 10.1109/ACCESS.2022.3227217.