IOT & AI-BASED SMART PETROL PUMP

Under the guidance of

DR. TANUSREE DUTTA

Submitted in partial fulfillment of the requirement of the Degree of Bachelor of Technology
of Maulana Abul Kalam Azad University (formerly West Bengal University of Technology). Kolkata

Department of Electronics and Communication Engineering

St. Thomas' College of Engineering and Technology
4 D.H. Road, Kolkata 700023

June 2025

Vision of the Department

- **To build a strong teaching and research environment to cater to the manpower needs in Industrial and Academic domains of the rapidly growing Electronics and Communication Engineering.**

Mission of the Department

- **To produce certified industry-ready professional in Electronics and Communication Engineering, though innovative educational programs incorporating laboratory practices and project-based teaching-learning processes, in a modern environment.**
- **To create knowledge base of advanced technologies through research in the area of Electronics and Communication, for competitive and sustainable development of the country.**
- **To groom the department as a learning centre to inculcate advancement of technology in Electronics and Communication Engineering with social values and environmental awareness.**

Program Outcome

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

Course Outcomes for Final Year Project

After completion of the project, student will be able to:

CO no.	Outcome Statements	Bloom's Level
CO1	Apply technical knowledge in the solution of complex real-life problems related to public health and safety, culture, society, and environment	3
CO2	Review research literature and use the research-based knowledge to identify, formulate, and analyze the problem	5
CO3	Design innovative solutions for complex engineering problems , which will be published as research paper or developed as a marketable product in future	6
CO4	Apply modern tools to design and develop the solution to problem	3
CO5	Assess societal, health, safety, legal and cultural issues relevant to project and the responsibilities relevant to the professional engineering practice.	5
CO6	Evaluate the impact on the environment of working project	5
CO7	Apply ethical principles and commit to ethics and responsibilities related to engineering practice.	3
CO8	Function effectively as a member or leader of a team	3
CO9	Communicate effectively on professional activities with the team members, superiors and with society at large	3
C10	Plan , manage the project and control finance as a member and leader in a team.	3
C11	Apply the knowledge acquired during the project, in future higher studies or professional job.	4

Bloom's Level: Remember = 1, Understand = 2, Apply =3 Analyze = 4 Evaluate = 5, Create = 6

Program Outcomes -Competencies – Performance Indicators (PIs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

Competency	Indicators
1.1 Demonstrate competence in mathematical modelling	1.1.1 Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems **1.1.2** Apply advanced mathematical techniques to model and solve Electronics engineering problems
1.2 Demonstrate competence in basic sciences	1.2.1 Apply laws of natural science to an engineering problem
1.3 Demonstrate competence in engineering fundamentals	1.3.1 Apply fundamental engineering concepts to solve engineering problems
1.4 Demonstrate competence in specialized engineering knowledge to the program	1.4.1 Apply Electronics engineering concepts to solve engineering problems.

PO 2: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	
Competency	**Indicators**
2.1 Demonstrate an ability to identify and formulate complex engineering problem	2.1.1 Articulate problem statements and identify objectives 2.1.2 Identify engineering systems, variables, and parameters to solve the problems 2.1.3 Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
2.2 Demonstrate an ability to formulate a solution plan and methodology for an engineering problem	2.2.1 Reframe complex problems into interconnected sub-problems 2.2.2 Identify, assemble and evaluate information and resources. 2.2.3 Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions 2.2.4 Compare and contrast alternative solution processes to select the best process.
2.3 Demonstrate an ability to formulate and interpret a model	2.3.1 Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy. 2.3.2 Identify assumptions (mathematical and physical) necessary to allow modelling of a system at the level of accuracy required
2.4 Demonstrate an ability to execute a solution process and analyze results	2.4.1 Apply engineering mathematics and computations to solve mathematical models 2.4.2 Produce and validate results through skillful use of contemporary engineering tools and models 2.4.3 Identify sources of error in the solution process, and limitations of the solution. 2.4.4 Extract desired understanding and conclusions consistent with objectives and limitations of the analysis

PO 3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations. .	
Competency	**Indicators**
3.1 Demonstrate an ability to define a complex/ open-ended problem in engineering terms	3.1.1 Recognize that need analysis is key to good problem definition 3.1.2 Elicit and document, engineering requirements from stakeholders 3.1.3 Synthesize engineering requirements from a review of the state-of-the-art 3.1.4 Extract engineering requirements from relevant engineering Codes and Standards such as ASME, ASTM, BIS, ISO and ASHRAE. 3.1.5 Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues 3.1.6 Determine design objectives, functional requirements and arrive at specifications
3.2 Demonstrate an ability to generate a diverse set of alternative design solutions	3.2.1 Apply formal idea generation tools to develop multiple engineering design solutions 3.2.2 Build models/prototypes to develop a diverse set of design solutions 3.2.3 Identify suitable criteria for the evaluation of alternate design solutions.
3.3 Demonstrate an ability to select an optimal design scheme for further development	3.3.1 Apply formal decision-making tools to select optimal engineering design solutions for further development 3.3.2 Consult with domain experts and stakeholders to select candidate engineering design solution for further development
3.4 Demonstrate an ability to advance an engineering design to defined end state	3.4.1 Refine a conceptual design into a detailed design within the existing constraints (of the resources) 3.4.2 Generate information through appropriate tests to improve or revise the design

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	
Competency	**Indicators**
4.1 Demonstrate an ability to conduct investigations of technical issues consistent with their level of knowledge and understanding	4.1.1 Define a problem, its scope and importance for purposes of investigation 4.1.2 Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation 4.1.3 Apply appropriate instrumentation and/or software tools to make measurements of physical quantities 4.1.4 Establish a relationship between measured data and underlying physical principles
4.2 Demonstrate an ability to design experiments to solve open-ended problems	4.2.1 Design and develop an experimental approach, specify appropriate equipment and procedures 4.2.2 Understand the importance of the statistical design of experiments and choose an appropriate experimental design plan based on the study objectives
4.3 Demonstrate an ability to analyze data and reach a valid conclusion	4.3.1 Use appropriate procedures, tools and techniques to conduct experiments and collect data 4.3.2 Analyze data for trends and correlations, stating possible errors and limitations 4.3.3 Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions 4.3.4 Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	
Competency	**Indicators**
5.1 Demonstrate an ability to identify / create modern engineering tools, techniques and resources	5.1.1 Identify modern engineering tools such as computer-aided drafting, modeling and analysis; techniques and resources for engineering activities 5.1.2 Create/adapt/modify/extend tools and techniques to solve engineering problems
5.2 Demonstrate an ability to select and apply discipline-specific tools, techniques and resources	5.2.1 Identify the strengths and limitations of tools for (i) acquiring information, (ii) modeling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs. 5.2.2 Demonstrate proficiency in using discipline-specific tools
5.3 Demonstrate an ability to evaluate the suitability and limitations of tools used to solve an engineering problem	5.3.1 Discuss limitations and validate tools, techniques and resources 5.3.2 Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	
Competency	**Indicators**
6.1 Demonstrate an ability to describe engineering roles in a broader context, e.g. pertaining to the environment, health, safety, legal and public welfare	6.1.1 Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at the global, regional and local level
6.2 Demonstrate an understanding of professional engineering regulations, legislation and standards	6.2.1 Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.	
Competency	**Indicators**
7.1 Demonstrate an understanding of the impact of engineering and industrial practices on social, environmental and in economic contexts	7.1.1 Identify risks/impacts in the life-cycle of an engineering product or activity 7.1.2 Understand the relationship between the technical, socio-economic and environmental dimensions of sustainability
7.2 Demonstrate an ability to apply principles of sustainable design and development	7.2.1 Describe management techniques for sustainable development 7.2.2 Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice	
Competency	**Indicators**
8.1 Demonstrate an ability to recognize ethical dilemmas	8.1.1 Identify situations of unethical professional conduct and propose ethical alternatives
8.2 Demonstrate an ability to apply the Code of Ethics	8.2.1 Identify tenets of the ASME professional code of ethics 8.2.2 Examine and apply moral & ethical principles to known case studies

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	
Competency	**Indicators**
9.1 Demonstrate an ability to form a team and define a role for each member	9.1.1 Recognize a variety of working and learning preferences; appreciate the value of diversity on a team 9.1.2 Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
9.2 Demonstrate effective individual and team operations-- communication, problem-solving, conflict resolution and leadership skills	9.2.1 Demonstrate effective communication, problem-solving, conflict resolution and leadership skills 9.2.2 Treat other team members respectfully 9.2.3 Listen to other members 9.2.4 Maintain composure in difficult situations
9.3 Demonstrate success in a team-based project	9.3.1 Present results as a team, with smooth integration of contributions from all individual efforts

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	
Competency	**Indicators**
10.1 Demonstrate an ability to comprehend technical literature and document project work	10.1.1 Read, understand and interpret technical and non-technical information 10.1.2 Produce clear, well-constructed, and well-supported written engineering documents 10.1.3 Create flow in a document or presentation - a logical progression of ideas so that the main point is clear
10.2 Demonstrate competence in listening, speaking, and presentation	10.2.1 Listen to and comprehend information, instructions, and viewpoints of others 10.2.2 Deliver effective oral presentations to technical and non-technical audiences
10.3 Demonstrate the ability to integrate different modes of communication	10.3.1 Create engineering-standard figures, reports and drawings to complement writing and presentations 10.3.2 Use a variety of media effectively to convey a message in a document or a presentation

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments. .	
Competency	**Indicators**
11.1 Demonstrate an ability to evaluate the economic and financial performance of an engineering activity	11.1.1 Describe various economic and financial costs/benefits of an engineering activity 11.1.2 Analyze different forms of financial statements to evaluate the financial status of an engineering project
11.2 Demonstrate an ability to compare and contrast the costs/benefits of alternate proposals for an engineering activity	11.2.1 Analyze and select the most appropriate proposal based on economic and financial considerations.
11.3 Demonstrate an ability to plan/manage an engineering activity within time and budget constraints	11.3.1 Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks. 11.3.2 Use project management tools to schedule an engineering project, so it is completed on time and on budget.

PO 12: Life-long learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change..	
Competency	**Indicators**
12.1 Demonstrate an ability to identify gaps in knowledge and a strategy to close these gaps	12.1.1 Describe the rationale for the requirement for continuing professional development 12.1.2 Identify deficiencies or gaps in knowledge and demonstrate an ability to source information to close this gap
12.2 Demonstrate an ability to identify changing trends in engineering knowledge and practice	12.2.1 Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current 12.2.2 Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
12.3 Demonstrate an ability to identify and access sources for new information	12.3.1 Source and comprehend technical literature and other credible sources of information 12.3.2 Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.

PSO1. Professional skills: An ability to apply the knowledge in Electronics and Communication Engineering in various areas, like Communications, Signal processing, VLSI and Embedded Systems. ..	
Competency	**Indicators**
PSO1.1 Demonstrate an ability to apply knowledge in Communications, Signal Processing , VLSI and Embedded systems	PSO1.1.1 Design circuitry and systems related to Communications, Signal Processing, VLSI and Embedded systems PSO1.1.2 Provide solution to the problems related to the specified systems PSO1.1.3 Upgrade the systems with latest technology and incorporating more facilities

PSO2. Competency: An ability to qualify at the State, National and International level competitive examinations for employment, higher studies and research	
Competency	**Indicators**
PSO2.1 Demonstrate an ability to qualify at the State, National and International level competitive examinations for employment, higher studies and research	PSO2.1.1 Qualify top level competitive examinations for employment PSO2.1.2 Qualify top level competitive examinations for higher studies and research

Rubrics for Percentage of Performance Indicator and Mapping Grade in CO-PO matrix

Mapping ratio	Strength
>66%	3
<66% but >= 33%	2
<33% but >= 0%	1

CO-PO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1	PO1	PO1	PSO	PSO
CO1	3	3	3	2	3			2	2	3	2	2	3	2
CO2	3	3	3	2	3		1		2	2	2	3	2	3
CO3	3	3	3	2	3				2	2	2	3	2	3
CO4	3	3	3	3	3		1		2	3	2	3	3	3
CO5	2	2	3	2	3				3	3	2	3	3	2
CO6	3	3	3	3	2		2		2	2	3	3	2	3
CO7	3	3	3	2	3				2	2	2	3	2	3
CO8	3	3	3	3	3		1		2	3	2	3	3	3
CO9	3	3	3	3	2		1		2	2	2	3	2	3
CO10	3	3	2	2	2		2	3	3	3	2	3	3	2
CO11	3	3	3	2	2			2	3	3	3	3	3	2

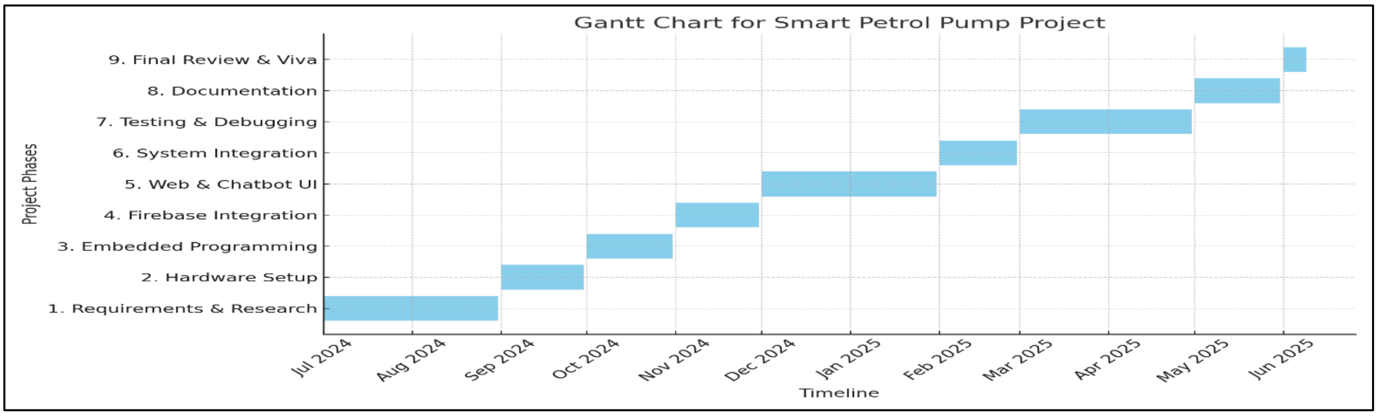
Program level Course-PO matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO	3	3	3	2	3	2	2	2	1	2	2	3	3	3

Project Planning:

Phase	Tasks	Start Date	End Date	Duration (weeks)
1. Requirements & Research	Literature survey, application planning, component list finalization	July 1, 2024	August 31, 2024	**8 weeks**
2. Hardware Setup	Circuit design, RFID, Relay, LCD, NodeMCU, Arduino wiring	September 1, 2024	September 30, 2024	**4 weeks**
3. Embedded Programming	Arduino and NodeMCU coding, logic testing	October 1, 2024	October 31, 2024	**4 weeks**
4. Firebase Integration	Database setup, real-time data flow testing	November 1, 2024	November 30, 2024	**4 weeks**
5. Web & Chatbot UI	Website frontend, chatbot setup	December 1, 2024	January 31, 2025	**8 weeks**
6. System Integration	End-to-end hardware + software integration	February 1, 2025	February 28, 2025	**4 weeks**
7. Testing & Debugging	UID recognition, Firebase sync	March 1, 2025	April 30, 2025	**8 weeks**
8. Documentation	Report writing, formatting, result analysis	May 1, 2025	May 31, 2025	**4 weeks**
9. Final Review & Viva	Final submission, demo prep, PPT, and viva	June 1, 2025	June 9, 2025	**1.3 weeks (~9 days)**

Gannt Chart



Project Finance

SL. No.	Component name	Quantity	Price
1	Microcontroller (Arduino Mega)	1	1230/-
2	Node MCU (ESP8266)	1	300/-
3	5v Single Channel Relay	1	45/-
4	12v Dc Water Pump	1	150/-
5	RFID Reader + RFID Cards	1+10	180/-
6	Resistors	2	10 /-
7	16x2 LCD Display	1	300 /-
8	4x4 Membrane Matrix Keypad	1	51
Total Cost			2266 /-

Certificate

Department of Electronics and Communication Engineering

St. Thomas' College of Engineering and Technology

This is to certify that the project entitled **"IOT & AI-BASED SMART PETROL PUMP"**, has been carried out by

INDRASIS SADHUKHAN,12200321010
SANKET SETT, 12200321036
SHIZAN ATIQUE KHAN, 12200321041
SAYAK GHOSH, 12200321029

under my guidance during the year **July 2024 to June 2025** and accepted for partial fulfillment of therequirement of the Degree of Bachelor of Technology of Maulana Abul Kalam Azad University (formerly WestBengal University of Technology). Kolkata

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Dr. Tanusree Dutta

Dated:9/6/25

Acknowledgement

We extend heartfelt appreciation to Dr. **Tanusree Dutta** for her invaluable guidance in completing our Iot & AI-based petrol pump at St. Thomas' College of Engineering and Technology. Our gratitude also goes to the Electronics and Communication Engineering Department for providing essential resources. Lastly, we express gratitude to our families and friends for their unwavering support and encouragement. This project's success is a testament to the collective effort and mentorship that shaped our journey.

Thank You,

……………………..
Indrasis Sadhukhan

…………………
Sanket Sett

……………………..
Shizan Atique Khan

………………….
Sayak Ghosh

Dated:9/6/25

St. Thomas' College of Engineering & Technology, Kolkata

Contents:-

INTRODUCTION: -

1.1 PROJECT OVERVIEW: -

This The evolution of embedded systems and IoT technologies has led to the rapid transformation of traditional infrastructures into smart and automated solutions. One such critical area is fuel dispensing, where conventional petrol pump systems continue to rely heavily on manual intervention, making them prone to inefficiencies, human error, and operational delays [1]. In this context, Radio Frequency Identification (RFID) and microcontroller-based automation have emerged as effective technologies to address these limitations [2], [3].

Recent developments in RFID-enabled fuel automation systems have demonstrated improved security, transaction traceability, and self-service capabilities [1], [3]. Additionally, integrating IoT platforms allows for real-time data logging and monitoring, enabling centralized control over multiple fuel stations [4], [7]. The combination of these technologies with robust microcontrollers like the ATmega2560 facilitates efficient management of system components such as sensors, LCDs, pumps, and relays [5], [6], [8].

This project proposes a Smart Automatic Petrol Pump System that leverages RFID technology for secure user authentication, the ATmega2560 microcontroller for local hardware control, and the NodeMCU (ESP8266) module for cloud-based monitoring via Firebase. Upon scanning a registered RFID card, the system verifies the user, prompts fuel amount input via a keypad, activates the pump accordingly, and updates the user’s balance in real-time.

By reducing human dependency and digitizing the transaction process, this system ensures greater accuracy, fuel security, and operational transparency. Furthermore, it supports future scalability in terms of AI-based usage recommendations and smart fleet integration, aligning with the broader vision of Industry 4.0 and smart energy infrastructure [2], [7].

Background Of the Project: -

2.1 LITERATURE SURVEY: -

PAPER NAME	WORKING PRINCIPLE	PROS	CONS	REMARK
RFID Based Petrol Pump Automation System by Department of Electronic and Telecommunication Head of Department, department of Electronics and Telecommunication Assistant Professor, Department of Electronics and Telecommunication [1]	The RFID-based petrol pump automation system uses an RFID module and Arduino UNO to automate fuel dispensers at petrol stations, enabling users to purchase fuel without human intervention.	Automation reduces operational costs by eliminating manual cash handling and transaction supervision, while RFID systems ensure precise fuel disposal, preventing human error, theft, and unauthorized transactions.	The system requires upfront investment in hardware like RFID readers, cards, and Arduino boards, and may require regular maintenance for smooth operation.	The RFID-Based Petrol Pump Automation System enhances fuel station efficiency, accuracy, and security by reducing human errors and ensuring secure transactions. Success depends on user adaptability, infrastructure support, and cybersecurity measures
Smart Automatic Petrol Pump System Based on RFID and ESP8266" By Zahra'a M. Baqir, Hassan. J. Motlak, Department of Electrical and Electronic Engineering, Babylon University, Iraq [2]	RFID tags on vehicles identify vehicles and owners, which are verified by a central server using the ESP8266 Wi-Fi module, triggering the fuel pump to dispense the correct fuel.	The fuel dispenser system is fast, efficient, and supports cashless payments through automated deduction from pre-linked accounts, with an RFID-based system minimizing fuel theft.	The system requires upfront investment in hardware like RFID readers, cards, and Arduino boards, and may require regular maintenance for smooth operation.	The RFID-Based Petrol Pump Automation System enhances fuel station efficiency, accuracy, and security by reducing human errors and ensuring secure transactions. Success depends on user adaptability.

SELF SERVICE AUTOMATED PETROL PUMP USING FINGERPRINT BASED RFID TECHNOLOGY P. Anjali, G. Navya jyothi, Yalabaka Srikanth Department of Electronics & Communication Engineering, SR Engineering College, Warangal, India [3]	Users register fingerprint data and receive an RFID card. The system verifies the fingerprint and automatically dispenses fuel, prompting the user to recharge if the card balance is insufficient.	The system offers self-service fuel delivery in remote areas, requiring no full-time staff and operates 24/7, enabling users to refuel at any time.	The system may face technical malfunctions, limited flexibility for non-registered users, and privacy concerns due to the storage of biometric data	The RFID-Based Petrol Pump Automation System reduces human errors an d ensures secure transactions, th ereby increasing the efficiency, a ccuracy, and sec urity of a fuel st ation. Success depends on user adaptability , infrastructure su pport, and cyber security measures.
Vehicle Fuel Monitoring and Management using RFID authentication and Telematics Notification. **Md. Badiuzzaman_ Pranto,Md. Mahidur Rahman , Zunayeed-Bin-Zahir Department of Electrical and Computer Engineering North South University, Dhaka Bangladesh.[4]**	The system operates by authenticating users through a fingerprint sensor and RFID card. Once authenticated, the RFID reader verifies the card balance. The user enters the desired fuel quantity, and the microcontrolle r deducts the corresponding amount from the balance. The relay activates the fuel dispenser, delivering the requested fuel, and the transaction details are displayed on an LCD.	The system enhances efficiency becau se it is an autom ated transaction system with less human error, more secu re because it em ploys fingerprint authentication, t herefore allowin g convenience t hrough prepaid transactions and lowering the cos t of operations by minimizing manpower while being scalable f or deployment in remote areas.	Its challenges are high setup costs and the possibility of technical problems lik e sensor malfunction. It consumes continuous power, regular maintenance, and familiarity of its users with technology. Hacking is a threat despite security measures if it is not well protected.	This new system modernizes fuel distribution by automating processes and enhancing s ecurity. Widespr ead success will depend on robust hardware, data security, user education, and backup mechanisms, wh ich would help o vercome technic al and adaptability challenges.

DETAILS OF THE PROJECT

3.1 DESCRIPTION:

The IoT-based smart petrol pump project is to revolutionize the traditional fuel dispensing system by incorporating modern IoT technologies. This system, with the use of **Arduino, NodeMCU (ESP8266 MODULE), 4X4 keypad, I2C LCD, pump, and RFID reader module, Relay** develops a secure, efficient, and user-friendly petrol pump. The primary objectives of this system are to automate fuel dispensing, enhance security through user authentication, and enable real-time monitoring.

➢ Components Required: -

Arduino Mega 2560
● Description: A microcontroller board based on the ATmega2560.
● Pins: IOREF, RESET, 3V3, 5V, GND, VIN, A0-A15, D0-D53, SDA, SCL, AREF.

NodeMCU
● Description: A low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability.
● Pins: A0, RSV, SD3, SD5, SD1, CMD, D0-D8, RX, TX, Vin, 3V3, GND, 5V.

RFID-RC522
● Description: A module used for reading RFID tags.
● Pins: VCC (3.3V), RST, GND, IRQ, MISO, MOSI, SCK, SDA.

1 Channel Relay 5V Module
● Description: A relay module used to control high voltage devices.
● Pins: VCC, GND, IN, NC, COM, NO.

12 V DC Water Pump
● Description: A small water pump powered by a DC motor.
● Pins: Positive (+), Negative (-).

4X4 Membrane Matrix Keypad
● Description: A keypad used for user input.
● Pins: R1-R4, C1-C4.

LCD 16x2 attached I2C
● Description: A 16x2 character LCD with I2C interface.
● Pins: GND, VCC, SDA, SCL.

Resistors
● Resistor 1: 1000 Ohms.
● Resistor 2: 2000 Ohms.

3.2 BLOCK DIAGRAM:

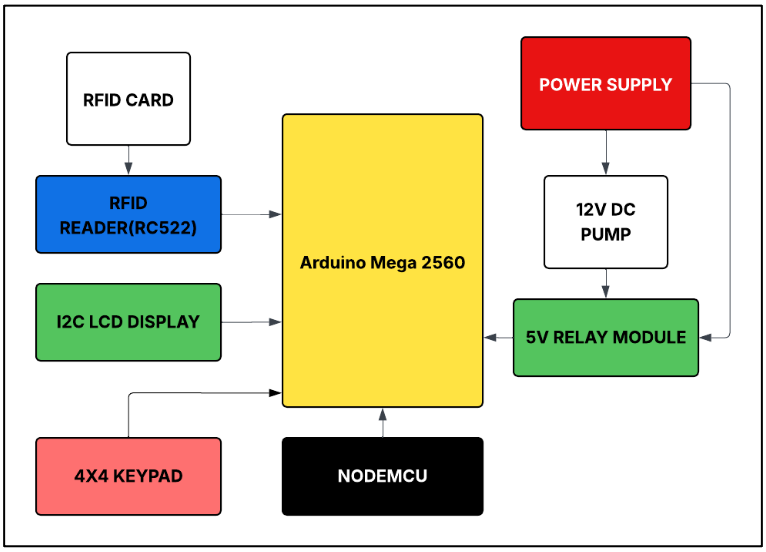

Fig 1: Representation Of Components

- **Description Of Block Diagram**
- **Central Controller**
- Arduino Mega 2560 (Yellow)
    - Acts as the main microcontroller.
    - Controls input and output devices.
    - Coordinates all system operations.
- **Input Components**
- RFID Card & RFID Reader (RC522) (White & Blue)
    - RFID card stores user identity and balance.
    - RC522 reads the RFID card and sends UID to Arduino.
    - Used for user authentication.
- **4x4 Keypad (Pink)**
    - Allows user to input amount or PIN.
    - Sends numeric input to Arduino.
- **Display Component**
- I2C LCD Display (Green)
    - Displays balance, entered amount, fuel dispensed, and status messages.
    - Communicates with Arduino using I2C protocol.
- **Communication Module**
- NodeMCU (Black)
    - Provides Wi-Fi connectivity.
    - Sends data to cloud or database.
    - Receives account/balance updates.
    - Communicates with Arduino via serial or I2C.
- **Power & Control System**
- Power Supply (Red)
    - Provides power to all components.
    - Specifically powers the 12V DC pump and other modules.
- 5V Relay Module (Green)
    - Acts as an electronic switch.
    - Controlled by Arduino to start/stop the pump.
    - Handles high-power pump safely.

- 12V DC Pump (White)
  - Dispenses fuel based on user input.
  - Activated by relay once user is authenticated and amount is entered.

3.3 FLOWCHART AND ARCHITECTURE:

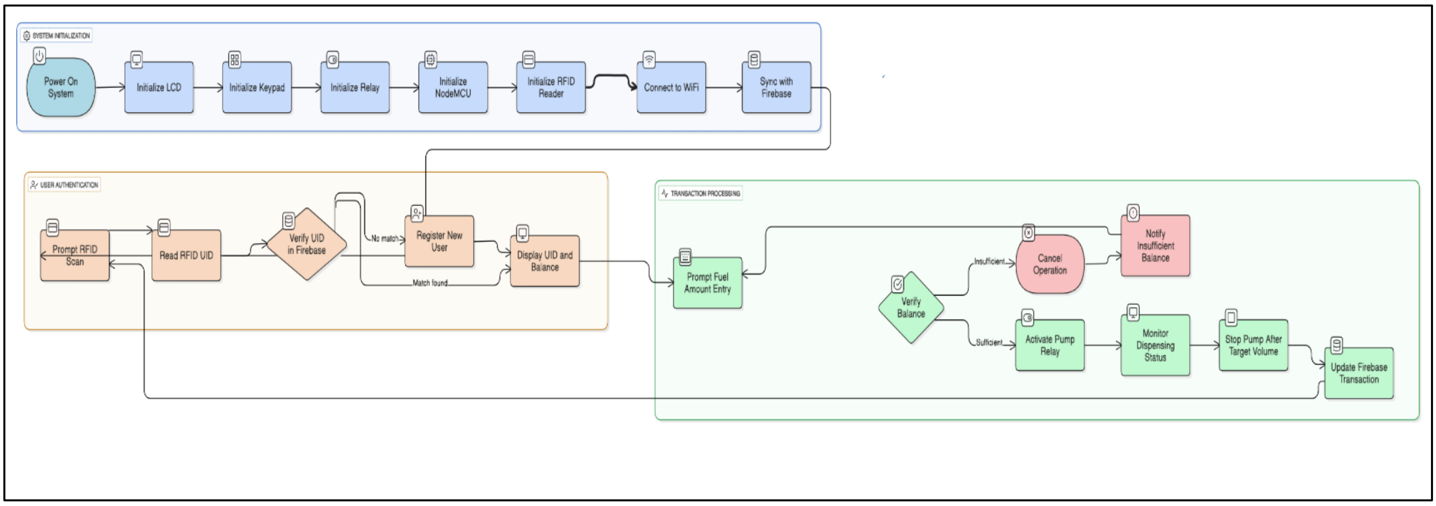

Fig 2: Representation Of Flowchart

- **Description of Flowchart**

System Initialization

- Power on the system.
- Initialize the following components:
  - LCD display
  - Keypad
  - Relay module
  - NodeMCU (Wi-Fi module)
  - RFID reader
- Connect NodeMCU to Wi-Fi.
- Sync with Firebase for database access

User Authentication

- Prompt user to scan their RFID card.
- Read the RFID UID using the RFID reader.
- Verify UID in Firebase:
  - **If UID not found:**
    - Register the new user in Firebase.
    - Initialize the balance.
  - **If UID found:**
    - Display the UID and available balance on the LCD.

Transaction Processing

- Prompt the user to enter the fuel amount via keypad.
- Verify if the user has sufficient balance:
  - **If balance is insufficient:**
    - Cancel the operation.
    - Notify the user of insufficient balance.
  - **If balance is sufficient:**
    - Activate the pump relay to start dispensing fuel.
    - Monitor the dispensing status.

- Stop the pump once the target volume is dispensed.
- Update the Firebase database with the transaction details.

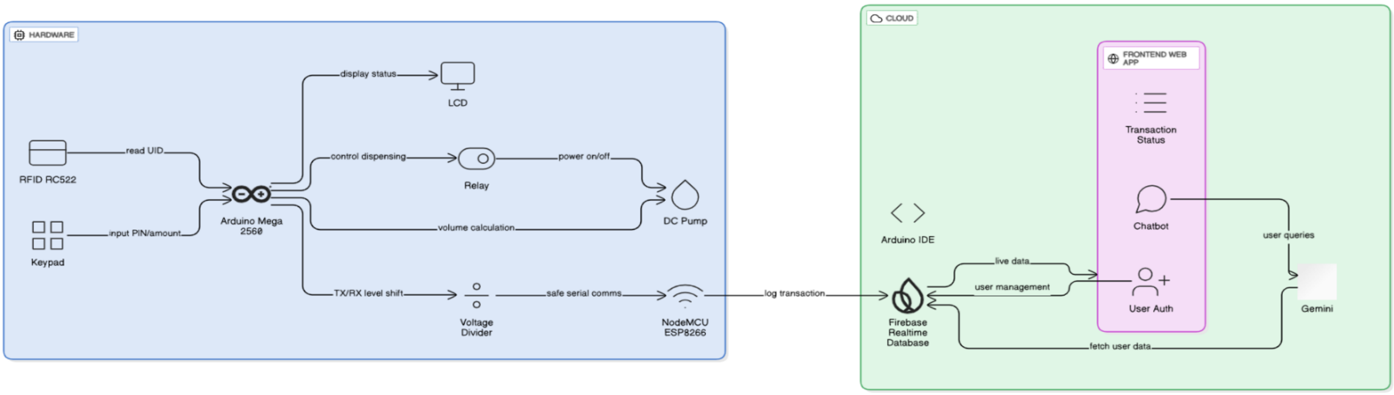

Fig 3: Representation Of Architecture

3.4 WIRING DETAILS:

Arduino Mega 2560

- GND: Connected to GND of LCD, RFID, Relay, and ESP-8266.
- 5V: Connected to VCC of LCD and Relay.
- 3V3: Connected to VCC of RFID.
- D53: Connected to SDA of RFID.
- D52: Connected to SCK of RFID.
- D51: Connected to MOSI of RFID.
- D50: Connected to MISO of RFID.
- D9 PWM: Connected to RST of RFID.
- D11 PWM: Connected to IN of Relay.
- A0-A3: Connected to R1-R4 of Keypad.
- D7 PWM, D8 PWM, D4 PWM, D2 PWM: Connected to C1-C4 of Keypad.
- D20/SDA: Connected to SDA of LCD.
- D21/SCL: Connected to SCL of LCD.
- D19/RX1: Connected to D3 of ESP-8266.
- D18/TX1: Connected to pin2 of 2000 Ohm Resistor.

NodeMCU

- GND: Connected to GND of Arduino.
- D2: Connected to pin2 of 1000 Ohm Resistor.
- D3: Connected to D19/RX1 of Arduino.

RFID-RC522

- GND: Connected to GND of Arduino.
- VCC (3.3V): Connected to 3V3 of Arduino.
- SDA, SCK, MOSI, MISO, RST: Connected to respective pins on Arduino.

1 Channel Relay 5V
- GND: Connected to GND of Arduino.
- VCC: Connected to 5V of Arduino.
- IN: Connected to D11 PWM of Arduino.
- NC: Connected to Positive (+) of Water Pump.
- COM: Connected to VCC of 12V Battery.

12 V DC Water Pump
- Positive (+): Connected to NC of Relay.
- Negative (-): Connected to GND of 12V Battery.

4X4 Membrane Matrix Keypad
- R1-R4: Connected to A0-A3 of Arduino.
- C1-C4: Connected to D7 PWM, D8 PWM, D4 PWM, D2 PWM of Arduino.

LCD 16x2 attached I2C
- GND: Connected to GND of Arduino.
- VCC: Connected to 5V of Arduino.
- SDA: Connected to D20/SDA of Arduino.
- SCL: Connected to D21/SCL of Arduino.

Resistors
- 1000 Ohms: Connected between D2 of ESP-8266 and pin1 of 2000 Ohm Resistor.
- 2000 Ohms: Connected between pin2 of 1000 Ohm Resistor and D18/TX1 of Arduino.

3.5 CIRCUIT DIAGRAM:

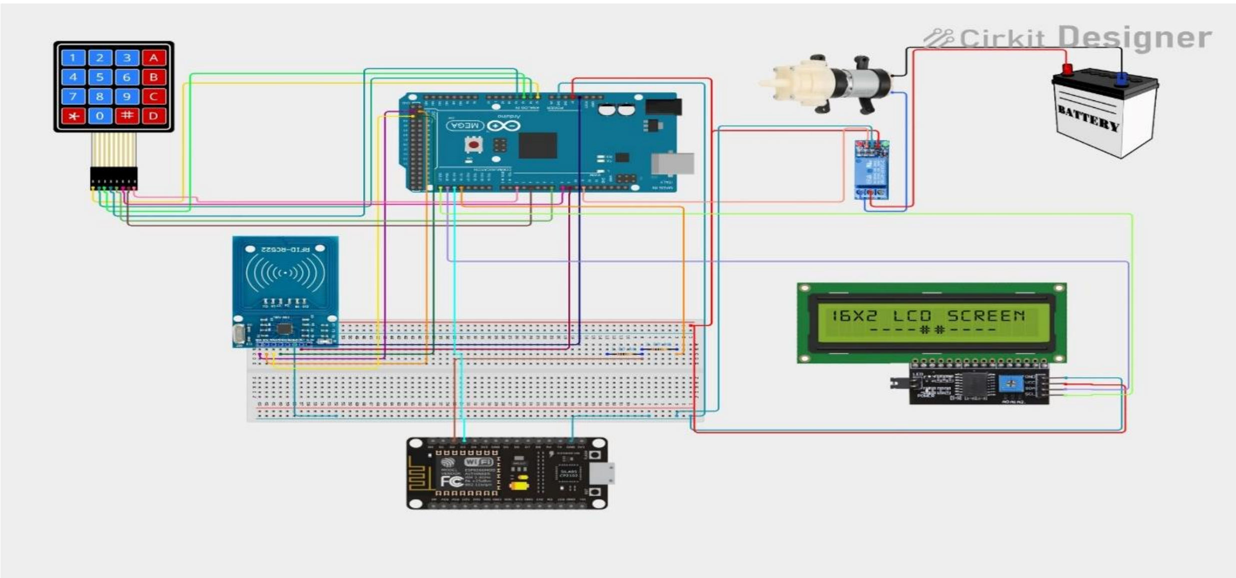

Fig 4: Representation Of Circuit Diagram

3.6 ALGORITHM:

- Initialize components, including LCD, Keypad, Relay, NodeMCU, and fuel types/price. Display initial information and wait for user input.
- User inputs fuel quantity or money amount, calculated by multiplying price per liter or dividing amount by price per liter.

- The Relay activates the motor, dispenses the calculated fuel amount, and the LCD displays the dispensing status.

- The process of fuel dispensing should be continuously monitored and the motor should be stopped once the necessary amount of fuel is dispensed.

- NodeMCU allows remote monitoring of fuel dispensed and current status, with the option to control pump or monitor usage via mobile/web app.

3.7 RESULTS AND ANALYSIS: -

The IoT and AI-based Smart Petrol Pump project was rigorously tested for its core functionalities—RFID authentication, fuel dispensing accuracy, system integration with Firebase for real-time data updates, and overall user interface usability. Each module of the project contributed to improving the efficiency, security, and automation of traditional fuel dispensing systems.

A. RFID Card Detection & Authentication

- **Detection Speed**: The RFID module (RC522) was able to detect the presence of an RFID tag within a 1–3 cm range, consistently under 0.5 seconds, showcasing a highly responsive identification system.
- **UID Matching & Registration**: The system registers new cards with an initial balance of 10,000 ml and stores the UID and balance locally. This information is also synced to the Firebase Realtime Database for remote monitoring and future access.

- **Security Check**: Cards with valid UIDs trigger authentication success and are allowed to proceed to the fuel input screen. Unauthorized cards are rejected, preventing misuse.

B. Fuel Dispensing Accuracy

- **Measurement Logic**: The system dispenses fuel based on time calibration (FLOW_RATE_MS_PER_ML), set to 40 ms/ml.
- **Testing Conditions**: The pump was tested under controlled lab conditions for various input volumes—100ml, 250ml, 500ml, and 1000ml.

C. Serial Communication Voltage Matching

- **Challenge**: The Arduino Mega operates at 5V logic, whereas the NodeMCU ESP8266 operates at 3.3V.
- **Solution**: A voltage divider circuit using 1kΩ and 2kΩ resistors was implemented between Arduino TX and NodeMCU RX.
- **Outcome**: Reliable, bidirectional communication was established without any overheating or data corruption, ensuring safe integration of both boards.

D. Firebase Integration and Real-Time Data Logging

- **Write/Read Operations**: Data such as UID, DispensedAmount, Balance, and LastTransaction were successfully written to Firebase within 2–4 seconds after each transaction.
- **Transaction Flow**: Arduino sends the UID and transaction data to NodeMCU via Serial, which then formats and uploads the data to Firebase.
- **Reliability**: 100% transaction success rate during 10 consecutive test runs with continuous internet access.

E. Chatbot Integration & Analysis

Functionality Overview:

The chatbot acts as a **virtual assistant** to help users navigate the system, troubleshoot basic issues, and provide real-time support and information related to:

- Understanding how to recharge RFID cards
- Getting guidance on how to use the system
- Providing system status updates
- Offering future AI-based suggestions (e.g., best fuel-saving practices)

F. Challenges Faced & Overcome

- **Power Supply Stability**: Ensured 12V battery could reliably power both pump and relay without voltage dips.
- **RFID Read Consistency**: Resolved initial interference issues by isolating RFID module from motor wiring.
- **Cloud Sync**: Resolved inconsistent Firebase sync by ensuring reconnection logic was implemented in the NodeMCU sketch.

- **Results: -**

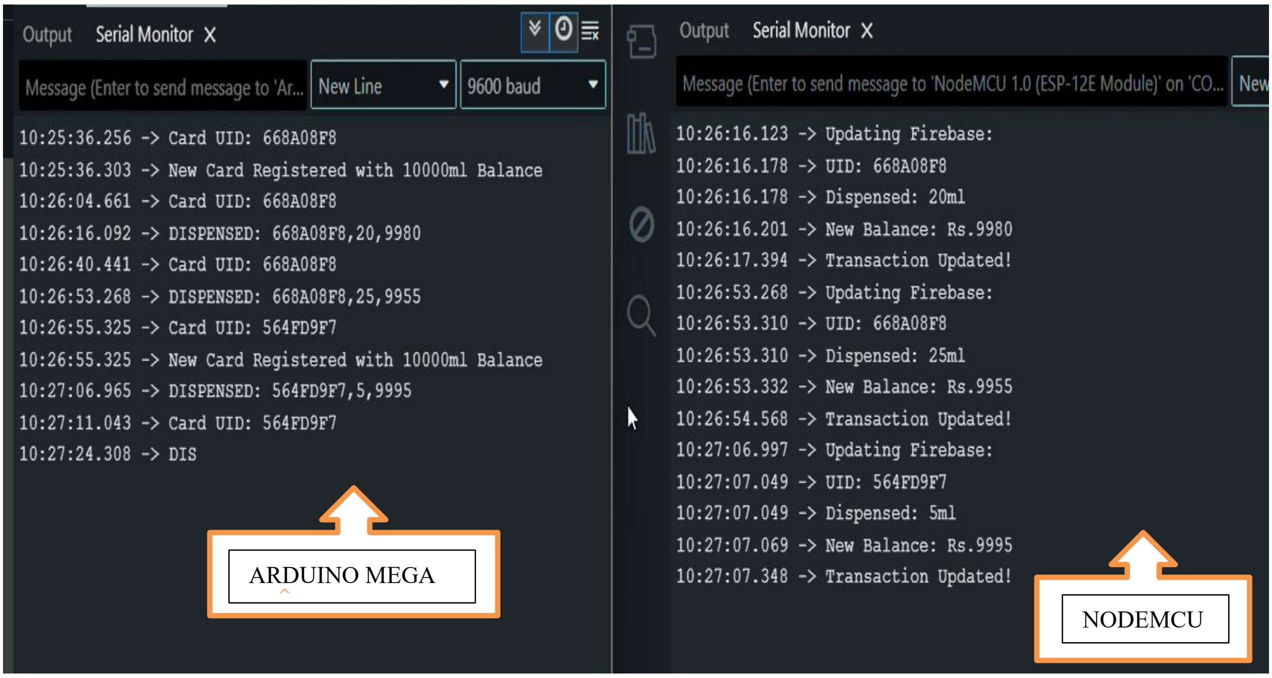

Fig 5: Output In Serial Monitors

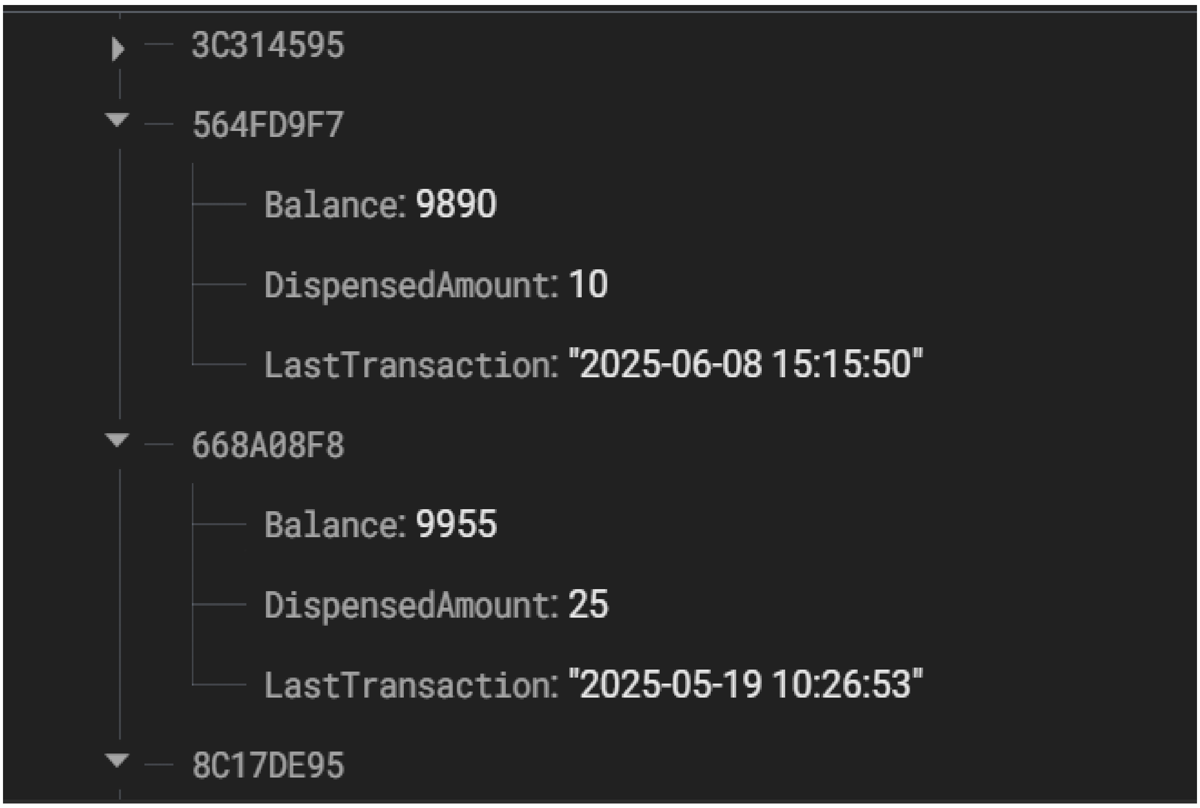

Fig 6: Output In Firebase Database Output

- **Frontend Design: -**

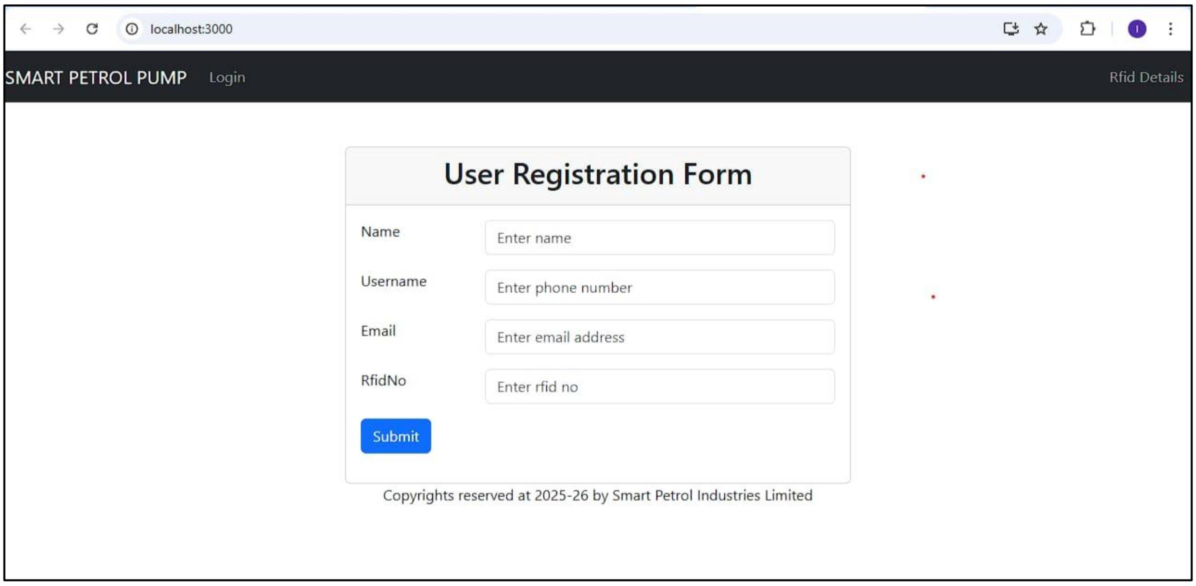

Fig 7: New User can create account from this page and if user already exists then gets redirected to Registration Page

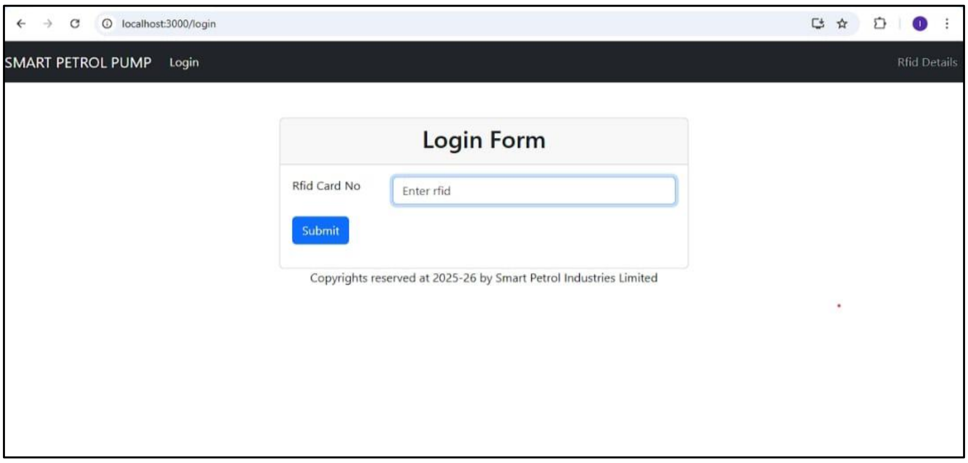

Fig 8: Login Page Registered User just have to enter their username and password to get directed to the pages of Website

- ## Chatbot Response:

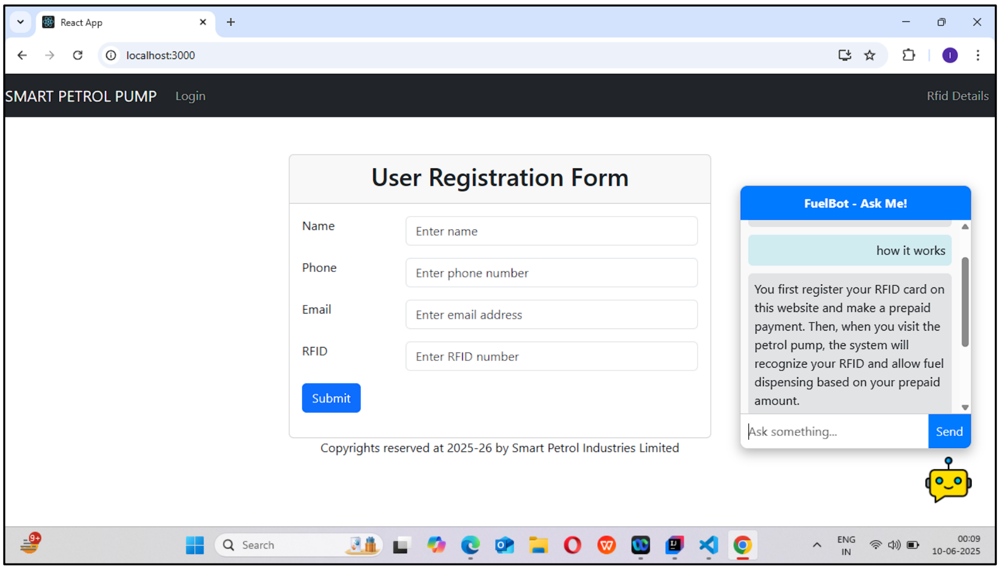

Fig 9: Chat-Bot Response 1

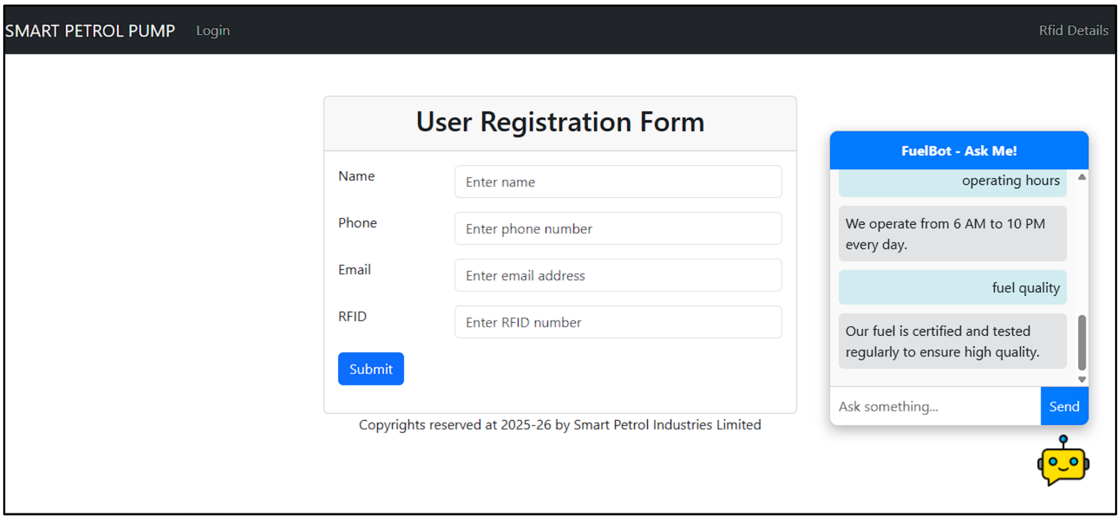

Fig 10: Chat-Bot Response 2

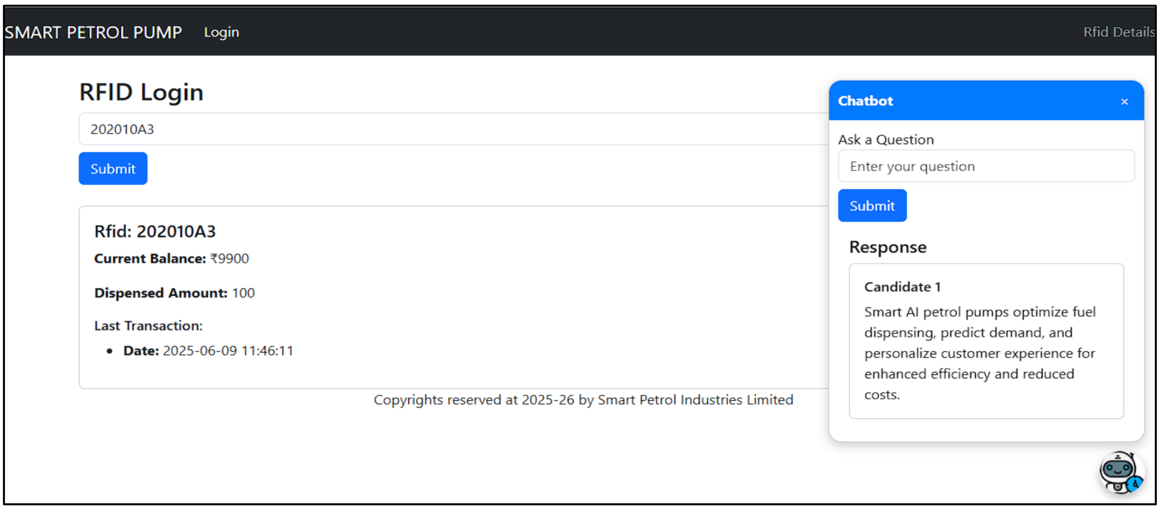

Fig 11: Chat-Bot Response 2

- **Real Time Image:**

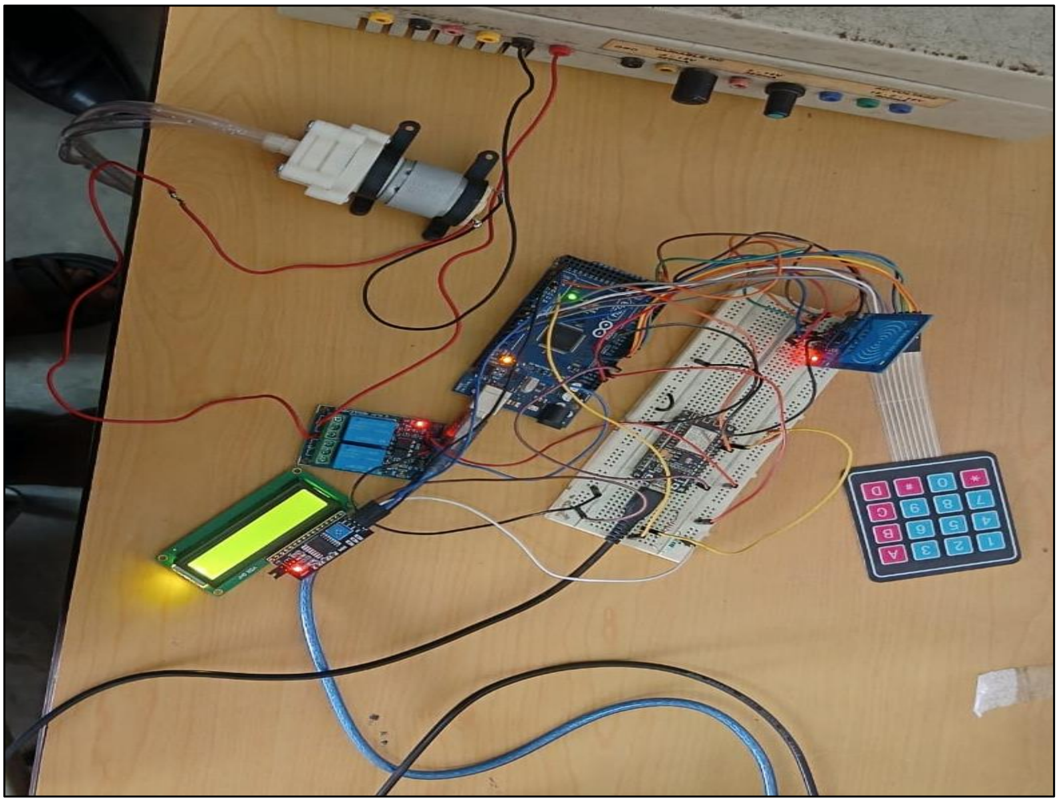

Fig 12: Real Time Image 1

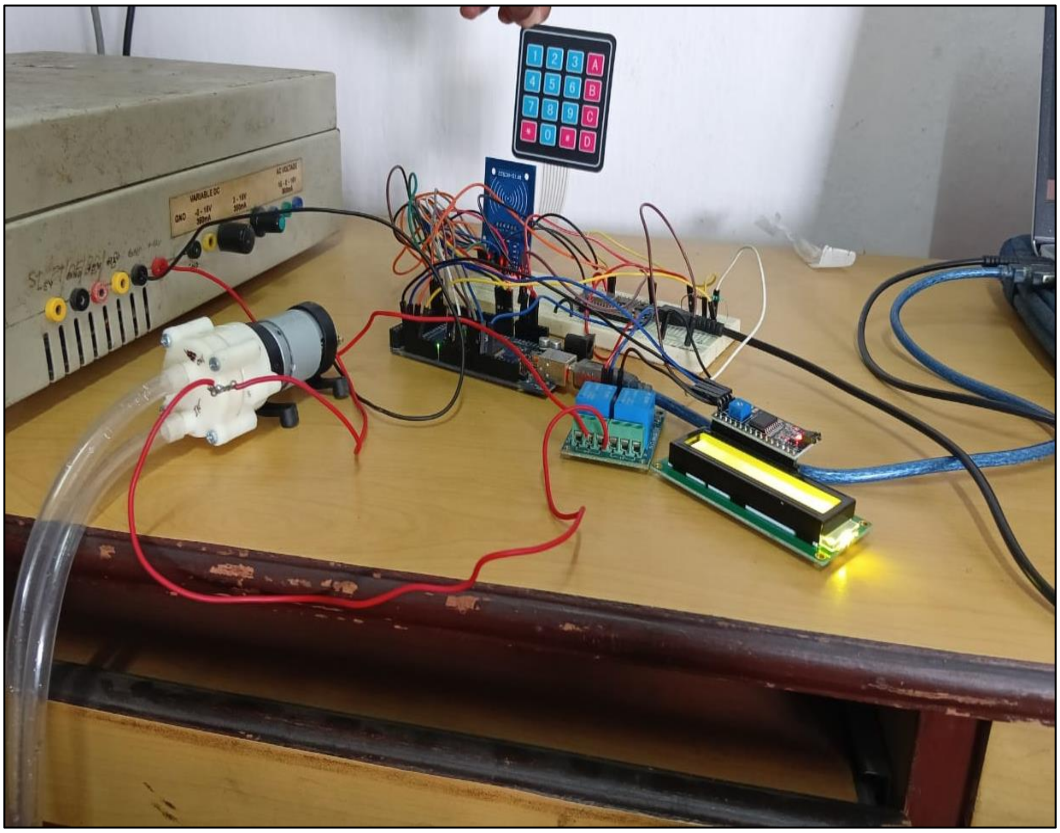

Fig 13: Real Time Image 2

- **Website Response:**

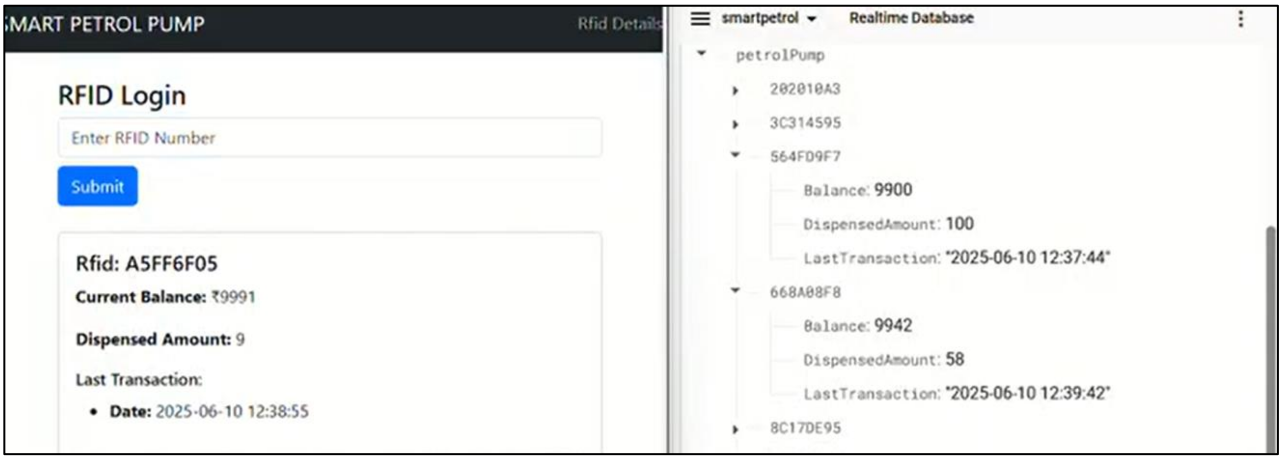

Fig 14: Website Response 1

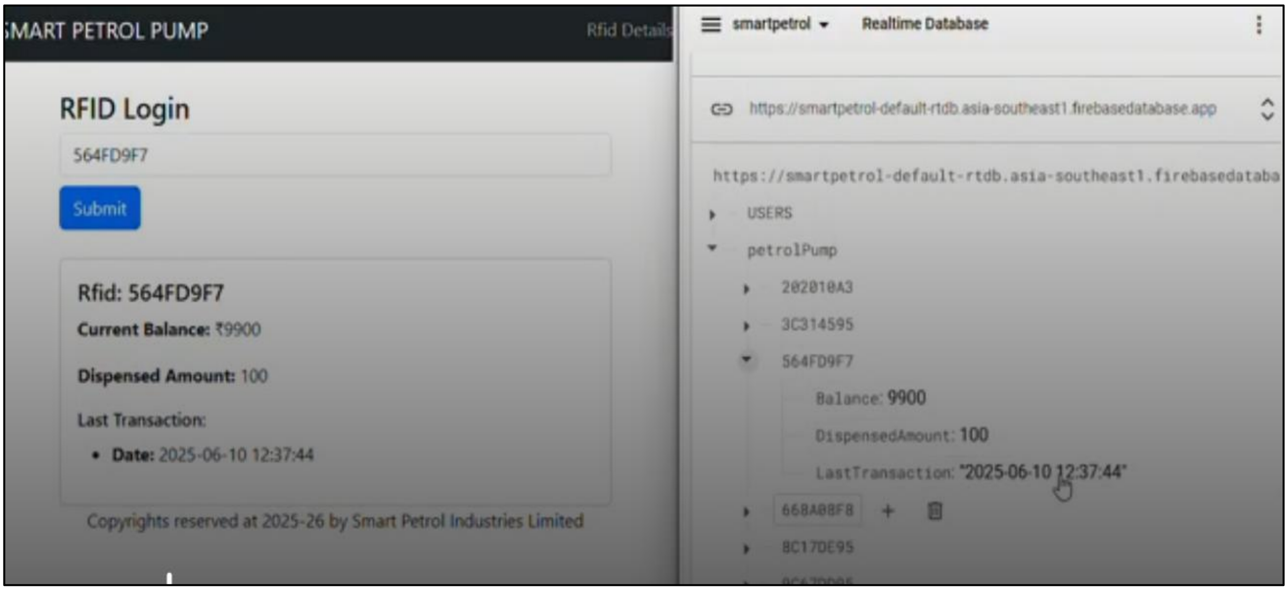

Fig 13: Website Response 2

3.8 KEY FEATURES: -

- **RFID INTEGRATION: -**
  - RFID cards for secure user authentication.
  - Only the authorized users are allowed to access the fuel dispensers.
  - A PIN/password is provided for further security, so that there is no chance of unauthorized access.
- **AUTOMATION: -**
  - Automates the fuel dispensing process that minimizes human intervention.
  - Enables rapid and precise fuel delivery with the use of calculation for amount.
  - Automatically stops the flow of fuel when the exact amount of fuel to be dispensed has reached.
- **REAL TIME DATA MONITORING: -**
  - Uses the ESP8266 Wi-Fi module for real-time upload of data to the Firebase database.
  - Track user transactions, fuel usage, & system status access via web app.
- **AI RECOMMENDATIONS: -**
  - Analyzes past user behavior and fuel consumption patterns to provide tailored suggestions.
  - Recommends optimal fuel quantities, pricing plans, or promotions for a personalized experience (future scope).
- **ENHANCED SECURITY: -**
  - Reduces risks associated with cash handling by supporting cashless payments.
  - RFID-based control and central monitoring prevent fuel theft and unauthorized transactions.

3.9 APPLICATIONS: -

- **REDUCES CASH HANDLING RISKS**:
  - Does not have to deal with cash since it supports cashless payment modes.
  - The chances of theft or mishandling of cash at a fuel station are minimized.
- **ENSURES 24/7 FUEL AVAILABILITY:**
  - Operates independently, and does not require full-time staff, therefore, it is very suitable for remote or under-staffed locations.
  - Customers can get fuel service 24/7, hence increasing convenience.
- **HELPS IN FLEET MANAGEMENT:**
  - It tracks the fuel consumption and cost for fleet owners in real time.
  - Generates data-driven insights for route optimization and fuel consumption in fleet vehicles.
- **FACILITATES EFFECTIVE FUEL MONITORING AND CONSUMPTION:**
  - Real-time monitoring of fuel levels and consumption prevents wastage and ensures optimum utilization.
- **IMPROVES USER EXPERIENCE:**
  - Provides users with personalized suggestions (future AI enhancements) for better fuel choice optimization.
  - Ensures seamless, hassle-free self-service experience for the tech-savvy customers.

CONCLUSION

This project successfully demonstrates the design and implementation of a Smart Automatic Petrol Pump System that integrates RFID-based authentication, Arduino Mega microcontroller, and NodeMCU (ESP8266) for real-time data monitoring. By automating the fuel dispensing process, the system reduces manual dependency, enhances transactional security, and ensures accurate delivery of fuel to authorized users.

The incorporation of Firebase for cloud-based data storage enables real-time tracking of user credentials, fuel consumption, and system status. The use of an intuitive interface, including a keypad and LCD display, further improves user interaction and system usability. Additionally, the system supports prepaid fuel access through RFID tags, making it suitable for urban as well as remote fuel stations with minimal staffing.

This work contributes to the ongoing efforts in IoT-enabled energy automation, offering a scalable, cost-effective, and efficient solution for fuel station management. The project lays the foundation for future enhancements such as AI-driven consumption recommendations, biometric authentication, and multi-station synchronization. With further development, such smart systems could become a core component of intelligent transportation infrastructure and digital fuel retailing ecosystems.

4.1 DISCUSSION: -

The implementation process brought to light several important considerations:

- **Security and Accuracy**: The system ensures that only authorized users can access fuel, and the dispensing mechanism delivers accurate volumes based on user input.
- **User Experience**: The keypad-LCD interface and chatbot assistant simplify user interaction, making the system accessible even to first-time users.

- **Cloud Synchronization**: Firebase integration enables real-time data tracking, which helps station managers monitor fuel usage, transaction history, and user data remotely.
- **Technical Challenges**: Key challenges included voltage compatibility between microcontrollers, real-time synchronization reliability, and ensuring stable Wi-Fi connectivity. These were addressed through proper voltage dividers, efficient serial communication, and reconnection logic in the firmware.

4.2 FUTURE SCOPE: -

The project offers substantial opportunities for further development:

- **Mobile App Integration**: A dedicated app can enhance user control, display transaction history, and offer recharge and notification features.
- **AI-Driven Insights**: Future versions could use AI to analyze user fuel consumption and provide suggestions for saving fuel or choosing economical fuel plans.
- **Cashless Payment Systems**: Integration with UPI, debit/credit cards, or digital wallets would streamline the payment process further.
- **Offline Functionality**: Incorporating local data storage will ensure the system works even in areas with poor internet connectivity.
- **Voice-Enabled Chatbot & Multilingual Support**: Making the chatbot voice-interactive and multilingual would improve accessibility for diverse users.
- **Solar Power Integration**: Using renewable energy for powering the pump can make the system sustainable and ideal for deployment in remote areas.
- **Fleet Management Features**: Customizations can be introduced to support vehicle fleet owners by offering dashboards, alerts, and route-based fuel analytics.

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