IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 20, April 2026
Impact Factor: 8.2

Solar Powered Railway Gate System

Prof. A. Maurya[1], Mr. Arman Ayub Kha[2], Mr. Roshan R. Bopale[3], Mr. Deepak P. Chopade[4], Mr. Chaitanya B. Patil[5] Mr. Vivek C. Bauskar[6], Mr. Chetan Patil[7]

Professor, Department of Mechanical Engg[1]

Students, Department of Mechanical Engg[2,3,4,5,6,7]

Dr. V. B. Kolte College of Engineering, Malkapur, India

Abstract: *The Solar Powered Automatic Railway Gate System is an advanced safety solution designed to minimize human error and improve efficiency at railway crossings. Traditional railway gates often rely on manual operation, which can lead to delays, accidents, and operational inefficiencies. This project proposes an automated system powered by solar energy, ensuring reliable and eco-friendly operation even in remote or power-deficient areas. The system uses sensors such as infrared (IR) or track-based detection mechanisms to identify the presence and movement of trains. Once a train is detected at a predefined distance, the system automatically triggers the closing of the gate using a motor-driven mechanism controlled by a microcontroller (such as Arduino or ATmega series). After the train passes safely, the gate reopens automatically, restoring normal road traffic flow. Solar panels are integrated to provide a renewable energy source, with battery storage ensuring uninterrupted operation during nighttime or low sunlight conditions. This system enhances safety by reducing the chances of accidents caused by human negligence or miscommunication. It also reduces manpower requirements and operational costs. Additionally, the use of solar energy makes the system environmentally sustainable and suitable for rural or unmanned railway crossings. Overall, the Solar Powered Automatic Railway Gate System represents a reliable, cost-effective, and intelligent solution for modern railway infrastructure.*

Keywords: Solar Energy, Automatic Railway Gate, Microcontroller, IR Sensors, Renewable Energy, Railway Safety, Automation System, Smart Transportation etc

I. INTRODUCTION

Railway transportation is one of the most widely used and efficient modes of transport, especially in countries like India where a vast railway network connects urban and rural regions. However, railway crossings remain critical points of concern due to frequent accidents caused by manual gate operation, human negligence, and lack of proper coordination between railway authorities and road users. Many unmanned or semi-automated railway crossings still depend on human intervention, which increases the risk of delays and mishandling, leading to serious safety hazards. To overcome these challenges, automation in railway crossing systems has become essential. The Solar Powered Automatic Railway Gate System is designed to enhance safety, reliability, and efficiency by eliminating the need for manual operation. This system uses advanced sensing technologies such as infrared (IR) sensors or proximity detectors to detect the arrival and departure of trains. Based on the signals received from these sensors, a microcontroller processes the data and controls the opening and closing of the railway gate automatically. One of the key features of this project is the use of solar energy as the primary power source. In many remote or rural areas, consistent electricity supply is not always available. By integrating solar panels along with rechargeable battery storage, the system ensures uninterrupted operation even during power outages or in off-grid locations. This makes the system not only reliable but also environmentally friendly and cost-effective in the long run.

The system also incorporates warning mechanisms such as visual signals (LED indicators) and audible alarms (buzzers) to alert road users before the gate closes. This provides sufficient time for vehicles and pedestrians to clear the crossing safely. The automation reduces human dependency, minimizes errors, and ensures timely gate operation, thereby

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 20, April 2026 Impact Factor: 8.2

significantly reducing the chances of accidents. In addition, the implementation of such smart systems aligns with the growing trend of intelligent transportation and smart infrastructure. It contributes to improving traffic management, reducing congestion near railway crossings, and enhancing overall public safety. The project demonstrates how renewable energy and embedded systems can be effectively combined to solve real-world problems. In conclusion, the Solar Powered Automatic Railway Gate System is a practical and innovative approach to modernizing railway crossing operations. It offers a sustainable, efficient, and safer alternative to conventional systems, making it highly suitable for future railway infrastructure development.

II. LITERATURE REVIEW

Atul Kumar Dewangan et al. (2012) This study proposed a microcontroller-based railway gate control system that automates gate operation using sensors to detect train movement. The system reduces human intervention and enhances safety at level crossings.

Saifuddin Mahmud et al. (2015) The authors developed an automated railway gate controlling system using ultrasonic sensors and control modules. Their work focused on detecting trains and obstacles, ensuring safe gate operation with alarm and signal mechanisms.

Md Jalal Uddin et al. (2017) This research emphasized a radio communication-based automatic railway gate controller. The system enables gates to operate automatically based on train signals, eliminating human error and improving operational reliability.

M. Abinaya et al. (2018) The study introduced an IoT-based railway gate automation system that integrates sensors and internet connectivity for real-time monitoring. It enhances smart control and remote supervision of railway crossings.

S. Suresh et al. (2019) This paper focused on the fabrication of an automatic railway gate controller, highlighting practical implementation using sensors and motorized gates. The system aimed to improve safety and reduce accidents at unmanned crossings.

Hay Man Oo et al. (2019) The authors proposed a four IR sensor-based railway gate control system using a microcontroller. The system improves detection accuracy and ensures proper opening and closing of gates based on train movement.

Harshitha D et al. (2020) This research presented an automatic railway gate control system using ultrasonic sensors for train and obstacle detection. It includes alarm and signal modules to prevent accidents and enhance safety.

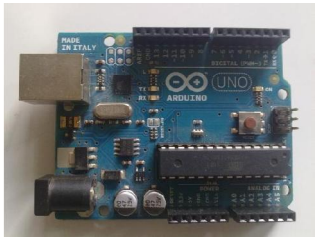
Dinesh C. Birajdar et al. (2021) The study proposed an automatic unmanned railway gate system using IR sensors. It focuses on reducing accidents and improving response time at crossings without human supervision.

III. HARDWARE COMPONENTS

ARDUINO

Arduino is an open-source physical computing platform designed to sense and controls the physical world using a simple microcontroller board and an easy-to-use development environment. It allows users to create interactive projects by reading inputs from sensors or switches and controlling outputs such as motors, lights, and other devices. Arduino boards can operate independently or communicate with a computer, and both the hardware designs and software tools are freely available. The Arduino Uno, based on the ATmega328 microcontroller, is widely used in educational and professional applications. It operates at 5 V with a 16 MHz clock speed and features 14 digital input/output pins (including PWM outputs), 6 analog input pins, 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM. The board includes a USB interface, external power supply support, and easy-to-use headers for hardware connections. Programs written in a simplified C/C++ language can be uploaded via USB and run autonomously without a computer. Unlike earlier boards, the Arduino Uno uses an ATmega16U2 as a USB-to-serial converter, making it a complete and reliable platform for embedded system development.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 20, April 2026
Impact Factor: 8.2



LCD (Liquid Crystal Display)

LCD (Liquid Crystal Display) is an electronic display device widely used in applications such as mobile phones, calculators, computers, televisions, and embedded systems. LCDs are preferred over multi-segment LEDs and seven-segment displays due to their low cost, ease of programming, ability to display custom characters, and support for simple animations. Compared to CRT displays, LCDs are thinner, lighter, and consume significantly less power. A 16×2 LCD operates by blocking light rather than emitting it, making it energy efficient and suitable for compact electronic devices.

LDR (Light Dependent Resistor)

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light. It is often used as a light sensor, light meter, Automatic street light, and in areas where we need to have light sensitivity. LDR is also known as a Light Sensor. LDR are usually available in 5mm, 8mm, 12mm, and 25mm dimensions. It works on the principle of photoconductivity whenever the light falls on its photoconductive material.

ULTRASONIC SENOR

An ultrasonic sensor transmits ultrasonic waves into the air and detects reflected waves from an object. There are many applications for ultrasonic sensors, such as in intrusion alarm systems, automatic door openers and backup sensors for automobiles. Accompanied by the rapid development of information processing technology, new fields of application, such as factory automation equipment and car electronics, are increasing and should continue to do so.

LM2596S DC-DC Buck Conveter

The LM2596S DC-DC Buck Converter is a widely used step-down voltage regulator that efficiently converts a higher DC input voltage into a lower, stable output voltage. It is based on switching regulator technology, which makes it much more efficient (typically up to 80–90%) compared to linear regulators, especially in applications with large voltage differences. This converter can accept an input voltage range of approximately 4V to 40V and provides an

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 20, April 2026
Impact Factor: 8.2

adjustable output voltage from 1.25V to 37V, depending on the module design. It is capable of delivering output currents up to 3A, making it suitable for powering microcontrollers, sensors, motors, and other electronic components. The LM2596S module usually includes essential components such as an inductor, diode, capacitors, and a potentiometer for adjusting the output voltage. It also features built-in protection mechanisms like thermal shutdown and current limiting, ensuring safe and reliable operation. Due to its compact size, high efficiency, and ease of use, the LM2596S buck converter is commonly used in projects like solar-powered systems, battery-powered devices, embedded systems, and automation projects, including the Solar Powered Automatic Railway Gate System.

RELAY

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram

Type-C 2S 8.4V Multi-Cell Step-Up Charger Module

The **Type-C 2S 8.4V Multi-Cell Step-Up Boost Lithium Battery Charger Module** is a small electronic device used to charge two lithium batteries connected in series (2S). It takes a 5V input from a USB Type-C port and increases (boosts) the voltage to 8.4V, which is required to fully charge the two batteries (each battery charges up to 4.2V). The module works using a boost converter that efficiently steps up the voltage while minimizing power loss.

Li-Ion Battery Pack

One of the key features of this battery pack is the inclusion of a Battery Management System (BMS). The BMS protects the battery from overcharging, over-discharging, and short circuits, thereby improving safety and battery life. The pack usually comes with connectors such as a DC jack or nylon connector, making it easy to integrate into circuits. The battery is compact, lightweight, and has high energy density compared to traditional batteries like lead-acid or nickel-cadmium.

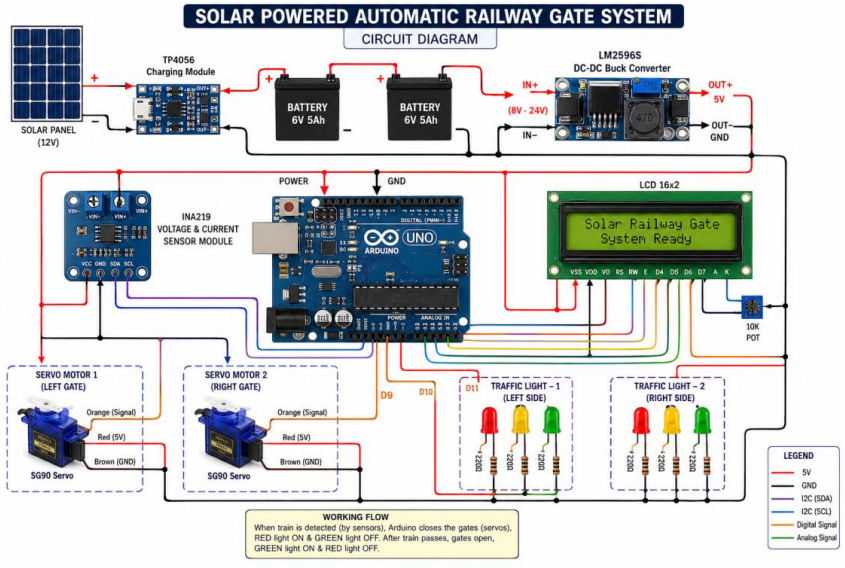
IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 6, Issue 20, April 2026 Impact Factor: 8.2

XL4015 5A DC-DC Buck Step-Down Supply Module

The XL4015 5A DC-DC Buck Step-Down Adjustable Power Supply Module is a widely used electronic component designed to convert a higher DC voltage into a lower adjustable output voltage efficiently. It works on the principle of a buck converter (step-down converter), where the input voltage must always be higher than the output voltage. This module typically accepts an input voltage in the range of about 4V to 38V and provides an adjustable output voltage from around 1.25V to 36V, making it suitable for a wide variety of electronic applications. The module is capable of delivering up to 5A output current with a maximum power of around 75W, depending on cooling conditions. It uses a high-frequency switching technique (around 180 kHz), which ensures high efficiency, often up to 96%, and reduces energy loss in the form of heat. This makes it more efficient than traditional linear voltage regulators.

IV. CONSTRUCTION OF PROJECT

The construction of the Solar Powered Automatic Railway Gate System is based on integrating a microcontroller-controlled automation unit with an efficient power management system and signaling components. The core of the system is the Arduino Uno, which acts as the central processing unit responsible for controlling all operations. The power supply is designed using two 6V, 5Ah batteries that provide sufficient backup and ensure continuous operation. These batteries are charged and protected using the TP4056, which offers overcharge and discharge protection, making the system safe and reliable. Since the voltage from the batteries may not be suitable directly for the microcontroller and other components, the LM2596S DC-DC Buck Converter is used to regulate and step down the voltage to a stable 5V output required for proper functioning. The automation of the railway gate is achieved using two SG90 Micro Servo Motor, which are connected to the PWM pins of the Arduino. These servo motors act as gate actuators and are programmed to rotate to specific angles to open and close the gates. When a train is detected (either through sensors or simulated input), the Arduino sends control signals to the servo motors, causing them to rotate and close the gate. Once the train passes, the motors rotate back to their original position, reopening the gate.



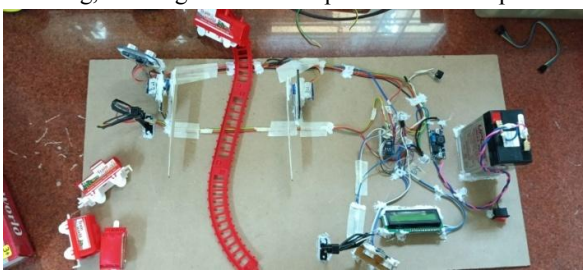
IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 20, April 2026
Impact Factor: 8.2

This mechanism ensures precise and smooth movement, which is essential for safe gate operation. To monitor the system's electrical performance, the INA219 Current Sensor Module is integrated into the circuit. This module measures both voltage and current consumption of the system and sends the data to the Arduino. This allows real-time monitoring of battery status and power usage, which is particularly useful in solar-powered systems where energy management is critical.

The data obtained can also help in maintaining system efficiency and detecting faults early. A 16x2 LCD display is interfaced with the Arduino to provide a user-friendly interface. It displays important system information such as gate status (open or closed), train detection alerts, and power parameters like voltage and current. This enhances the usability of the system by providing clear and immediate feedback to users or operators. Additionally, two sets of traffic light systems are installed on either side of the railway crossing. Each set typically includes red and green LEDs, which are controlled by the Arduino. When the gate is about to close, the red light is activated to signal vehicles and pedestrians to stop. After the train has passed and the gate opens, the green light turns on, allowing traffic to resume. All components are properly mounted and interconnected on a base platform to form a compact and organized system. Proper wiring, grounding, and insulation techniques are followed to ensure safety and durability. Overall, this construction demonstrates an effective combination of embedded systems, power electronics, and automation technology to create a reliable and energy-efficient railway gate control system.

V. WORKING OF PROJECT

The working of the Solar Powered Automatic Railway Gate System is based on the coordination between sensing, control, actuation, and power management units to ensure safe and efficient railway crossing operation. The system is powered by two 6V, 5Ah batteries, which provide the necessary energy for continuous functioning. These batteries are charged using a charging module and regulated through the LM2596S DC-DC Buck Converter to supply a constant 5V output required by the electronic components. The regulated power is then distributed to the Arduino Uno, sensors, display unit, and other modules, ensuring stable and reliable operation. At the core of the system, the Arduino Uno continuously monitors input signals that indicate the arrival of a train. In a practical implementation, this detection can be achieved using IR sensors or track-based detection methods, while in a prototype model, it may be simulated using switches or programmed inputs. When a train is detected at a certain distance from the crossing, the Arduino processes this signal and initiates a sequence of operations. First, it activates the traffic signaling system by turning on the red LED lights on both sides of the crossing, warning vehicles and pedestrians to stop.



This early warning mechanism helps prevent accidents and ensures that the crossing is cleared before the gate closes. Following the warning signal, the Arduino sends control signals to the two SG90 Micro Servo Motor, which are mechanically connected to the railway gates. These servo motors rotate to a predefined angle, causing the gates to close smoothly and block road traffic. The use of servo motors allows precise control over the movement and position of the gates, ensuring reliable operation without abrupt motion. During this process, the system also updates the 16x2 LCD display, showing messages such as "Gate Closing" or "Train Approaching," which provides clear information to nearby users or operators.

While the train is passing, the gates remain closed, and the red traffic signal stays active. At the same time, the INA219 Current Sensor Module continuously measures the voltage and current levels of the system. This monitoring helps in

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 20, April 2026
Impact Factor: 8.2

assessing battery condition, detecting any abnormal power consumption, and ensuring efficient energy usage, which is especially important in a solar-powered setup. Once the train has completely passed the crossing point, the system detects its departure through sensors or programmed delay logic. After confirming that the track is clear, the Arduino initiates the gate opening sequence. It turns off the red signal and activates the green LED lights, indicating that it is safe for vehicles and pedestrians to cross. Simultaneously, the servo motors rotate back to their original position, opening the gates smoothly. The LCD display updates the status to "Gate Open" or "Safe to Cross," providing visual confirmation of normal operation. This entire process is carried out automatically without any human intervention, significantly reducing the risk of human error. Overall, the working of this project demonstrates a seamless integration of automation, embedded control, and renewable energy utilization. The system ensures timely gate operation, efficient power management, and enhanced safety at railway crossings, making it a reliable and practical solution for modern transportation infrastructure.

Advantages of Proposed System

- Improved Safety: Automatically controls gate operation, reducing accidents at railway crossings.
- Eliminates Human Error: No dependency on manual operation or gatekeepers.
- Automatic Operation: Gates open and close based on real-time train detection.
- Energy Efficient: Uses solar energy, reducing electricity consumption.
- Works in Remote Areas: Suitable for rural locations with limited power supply.
- Low Operating Cost: Minimal maintenance and no continuous manpower required.
- Reliable Performance: Operates even during power cuts due to battery backup.
- Quick Response Time: Sensors provide fast and accurate detection of trains.
- Eco-Friendly: Uses renewable energy, reducing environmental impact.
- Better Traffic Management: Reduces unnecessary waiting time for vehicles.
- Warning System: Provides alerts through buzzer and LED indicators for road users.

VI. CONCLUSION

The Solar Powered Automatic Railway Gate System provides an effective and modern solution to improve safety and efficiency at railway crossings. By using a microcontroller-based control unit like the Arduino Uno, the system eliminates the need for manual gate operation and significantly reduces the chances of human error. The integration of automation ensures that the gates open and close at the correct time, preventing accidents and improving traffic management. One of the major advantages of this project is the use of renewable energy. The incorporation of solar power along with battery storage makes the system suitable for remote and rural areas where continuous electricity supply may not be available. The use of the LM2596S DC-DC Buck Converter ensures a stable power supply, while components like servo motors and traffic signals enable smooth and reliable operation. Additionally, monitoring through the INA219 Current Sensor Module enhances system efficiency and maintenance.

The project also demonstrates the practical application of embedded systems and power electronics in real-life safety systems. It is cost-effective, energy-efficient, and easy to implement, making it a viable alternative to traditional railway gate systems. Furthermore, it can be expanded in the future by integrating advanced technologies such as IoT, GSM alerts, or AI-based train detection for even better performance. In conclusion, this system not only improves railway crossing safety but also promotes the use of sustainable energy and smart automation. It represents a reliable, innovative, and scalable solution for modern railway infrastructure development.

REFERENCES

[1]. Kalaivani M, "Automatic unmanned railway gate control using solar and object sensor", Proceedings of International Conference on Recent Trends in Computing, pp.18-19 October 2019.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 20, April 2026
Impact Factor: 8.2

[2]. Prof. Meena Chavan1,Sai Mohak Mishra, Saurabh Kumar, Udit Dhurve4, "Automated Railway Crossing", International journal of innovative research in technology, Vol. 6 Issue 1, June 2019

[3]. Pawar Laxman, Patil Rima, Sonde Sukhda, Prof. K. P. Gaikwad, "Solar Operated Automatic Railway Gate control", Proceedings of International Research Journal of Engineering and Technology (IRJET), Vol. 6 Issue: 02 ,Feb 2019

[4]. Chowdhury, K. B. Q., Khan, M. R., & Razzak, M. A(2020), "Automation of Rail Gate Control with Obstacle Detection and Real Time Tracking in the Development of Bangladesh Railway", 2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC).

[5]. E Amarnatha Reddy, Ilaiah Kavati, K Srinivas Rao, G Kiran Kumar "A Secure Railway Crossing System Using Iot", Volume 5 Issue 9 (IEEE-2017).

[6]. Dr.Velayutham.R, Sangeethavani.T, undaralakshmi.K,"Controlling Railway Gates Using Smart Phones By Tracking Trains With Gps",), ISSN:2348-9510,Volume 8 Issue No.10, (IEEE-2018).

[7]. Miss. Sandhya Sharma, (Prof.) Dr. Neetesh Kumar Gupta"A GENETIC APPROACH TO SEGMENT AND DETECT CRACK IN RAIL TRACK", ISSN: 2319-8753, Volume 7, Issue 5 (IEEE-2019).

[8]. Afsana Ahmed, Kazi Rifah Noor, Tanveer Rahman "Unmanned Multiple Railway Gates Controlling And Bi-Directional Train Tracking With Alarming System Using Principles Of Iot", (IEEE-2019

[9]. Marwa M. Eid(Prof.), M. I. Fath Allah "Automated Railway Security System" Volume 3 Issue 4, (IEEE-2019).