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# Advanced 2-Step Level Crossing

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**ABSTRACT:** In India, certain level crossings are still manually operated, and due to inadequate lighting, lack of light source in some areas and due to over congestion of vehicles also, vehicles often approach these crossings at high speeds, leading to numerous accidents. At some level crossings, people try to cross while the gates are closing to avoid wasting time. This can lead to serious accidents if they get trapped between the gates.

From 2001 to 2017, a total of 1,078 accidents were registered at level crossings in India, while in Britain, the number was only 274. In terms of collisions, India had only 146 cases between 2001 and 2017, whereas Britain had 6,973. Similarly, there were 104 fire incidents reported in India compared to 2,019 in Britain. Despite the overall safety of railways, India lags behind Britain in terms of level crossing safety.

Although there has been a significant decrease in level crossing accidents since 1960, India still has a long way to go to achieve zero level crossing accidents. To address this issue, we have proposed an advanced two-step level crossing system. This system includes not only gates but also red, yellow and green signals positioned few meters before the crossing. This way, approaching vehicles can slow down if the signal is red, and a few seconds before the gates close, the signal will turn red. The yellow signal indicates one must be cautious about train. Otherwise, when the gate is open, the signal will be green. This entire device will operate on solar power.

**KEYWORDS:** Level crossings, Safety system, LED signals, 555 IC timer, Simulation.

## I. INTRODUCTION

In India, level crossings are still manually operated in some areas, and due to inadequate lighting and lack of electricity, vehicles often approach these crossings at high speeds, leading to numerous accidents. From 2001 to 2017, a total of 1,078 accidents were registered at level crossings in India, while in Britain, the number was only 274. In terms of collisions, India had only 146 cases between 2001 and 2017, whereas Britain had 6,973. Similarly, there were 104 fire incidents reported in India compared to 2,019 in Britain. Despite the overall safety of railways, India lags behind Britain in terms of level crossing safety.[1]

In this project, we aim to enhance the safety of level crossings in India by implementing a system with red, yellow and green lights. The red light will turn on just before the gate closes, indicating that a train is approaching and will soon cross the level crossing. This advanced warning will alert pedestrians and vehicle drivers nearby, ensuring they stay cautious. The yellow light will activate a few moments before the gate starts to close. This provides a clear signal to everyone in the vicinity that a train is imminent. When the red light turns on, drivers should stop their vehicles near the crossing gate, and pedestrians should stay clear of the tracks. Once the gate is fully closed, the train will pass, after which the gate will open, and the red and yellow light will turn off, allowing normal traffic to resume. The green light will indicate that the gate is open and it is safe for vehicles and pedestrians to cross without any hindrance. When the green light is on, there will be no obstruction to the flow of traffic, ensuring smooth movement.

Presently, some level crossings have visibility issues due to inadequate lighting, especially at night. The new system will ensure that the lights are visible from a distance, allowing vehicles to slow down in time. Clear signals will prevent accidents caused by vehicles accidentally driving onto the tracks or colliding with the closing gates. Often, vehicles approach level crossings at high speeds and fail to stop in time when the gates start closing. The early activation of the yellow light will give ample warning to drivers, encouraging them to slow down and stop safely. This will prevent last-minute attempts to cross, reducing the risk of collisions and accidents. People sometimes rush to cross the tracks before the gate closes to save time, leading to accidents. The yellow light will serve as a clear indicator that the gate is about to close, discouraging such risky behaviour.

To demonstrate this project, we will create a replica in which a servo motor will be used in place of the gate. We will use a 555 IC timer to control the system and LEDs to indicate the red, green, and yellow signals and a few gates for simulation.[2] The simulation will be done on the Tinkercad website.[3] This project is not entirely independent. It will require integration with the existing railway level crossing systems, such as the track circuit, to be fully operational.[4] In this paper, we will discuss the materials required to build this project, the methodology, the techniques used, and finally, how we will achieve the results. We will also address the limitations and potential improvements of this system.

## II. MATERIAL, METHODOLOGIES AND TECHNIQUES

The advanced two-step level crossing system integrates three distinct subsystems designed to enhance railway crossing safety and efficiency. These subsystems work together to manage traffic flow, activate crossing barriers, and provide information to individuals who are far from the crossing or have visual impairments, particularly at night. The system relies heavily on track circuits, which provide real-time data on train locations and timings. The first subsystem is the traffic light control system, which manages and reduces traffic flow as a train approaches the level crossing. Traffic lights are used to indicate whether the crossing is clear or if a train is nearing. The second subsystem is responsible for automatically lowering the crossing barriers as a train approaches, ensuring that barriers descend at the appropriate time to prevent accidents. The third subsystem focuses on alerting distant individuals and those with low vision, particularly at night, about the status of the level crossing and the approach of a train, thereby improving overall safety. To operate effectively, the system relies on track circuits, a standard technology used by Indian Railways. Track circuits provide crucial information about the position of trains, including their exact location on the track. The integration of track circuits with the subsystems is essential for the system's functionality.

Table 1 outlines the components used in this project, including the NE 555 Timer IC for pulse generation and control, LED Indicators for status display, Logic Gates and Inverters for signal processing, and Track Circuit Components such as DIP switches, current control lights, a micro servo motor (SG 90), and diode.[5] Figures 1 (a) and (b) illustrate the circuit diagram for traffic light system, the interaction of the NE 555 timer with the servo motor and light indicators, and the overall circuit design (The short forms used are stated in table 2). Figure 2 presents a schematic diagram of the project's implementation, showing how track circuits (TCSs) and traffic lights are integrated. The column A represents the traffic lights and column B depicts the led signals for different positions of train on track. Table 2 details the operational workflow and logic for the track circuit system. When no train is detected in any track circuit, the traffic lights are off, and only the green LED is illuminated, indicating that the level crossing is open. As a train approaches, the traffic lights change based on the train's proximity. For instance, if the train is detected in track circuits A or F, the green light turns off, and traffic lights start working making the flow the traffic and pedestrians lesser and controllable. When track circuits B or E detects the train the traffic lights get powered off and the yellow LED illuminates, signalling that the crossing might soon be closed. When the train reaches track circuits C or D, the red LED activates, signalling that the crossing is about to be closed, and vehicles must stop. At this point, the servo motor lowers the barriers from 0-degree to 120-degree, halting traffic flow completely and allowing the train to pass safely. The logic for gate implementation in Table 2 describes how traffic light states transition based on the presence of a train in track circuits, with green indicating safe passage, yellow signalling an approaching train, and red indicating that the crossing is closed. The use of high-speed CMOS circuitry, such as the 74HC family, ensures rapid processing and reliable operation, enhancing the overall performance of the system. [6]

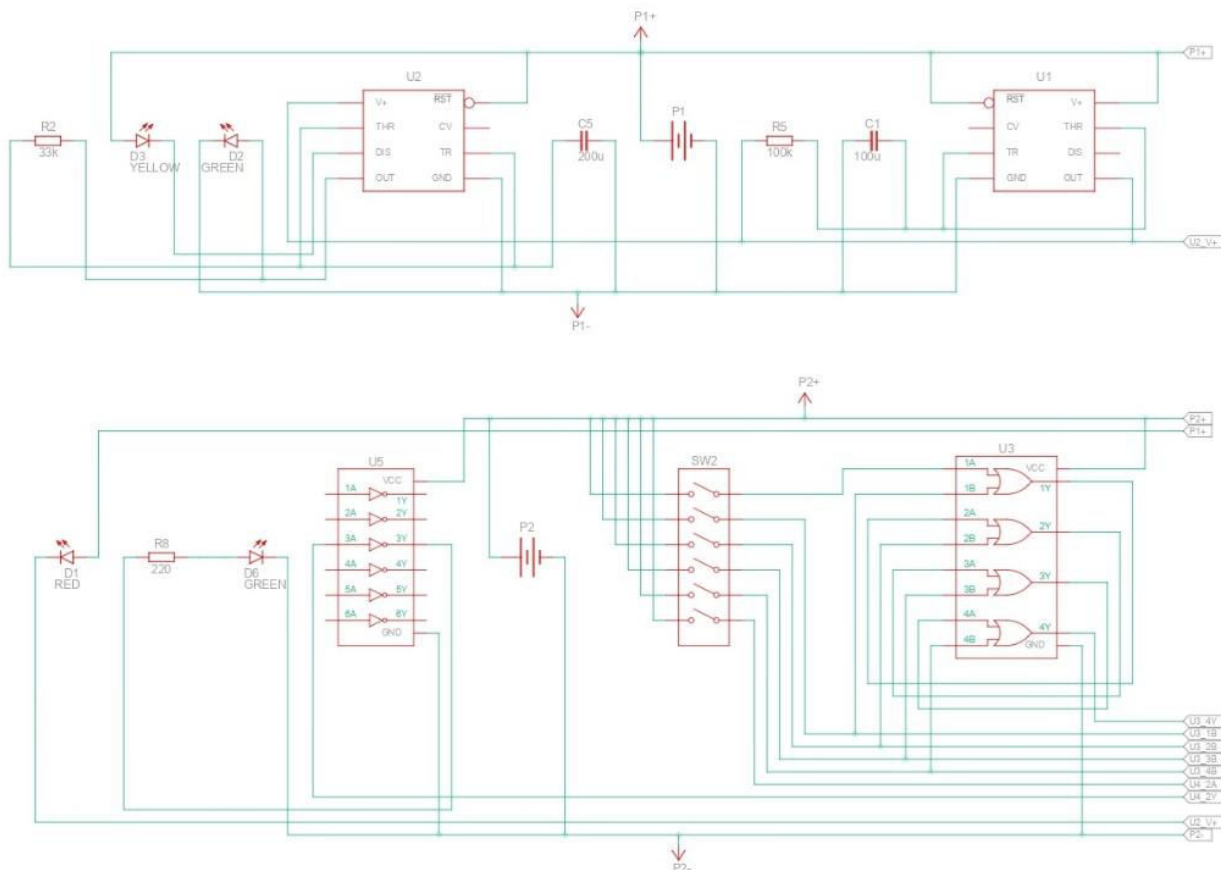
When all the switches in the DIP switch are set to zero, indicating no trains are present in any of the track circuits, all AND gate inputs are also zero, resulting in zero outputs. Consequently, the traffic lights receive a zero signal and do not function. Currently, the traffic lights are represented as a separate entity and have not been integrated with the system due to power distribution issues during implementation, which caused the traffic light system to cease functioning. This limitation will be discussed in detail later. When any DIP switch 1 or 6 becomes active or when at least one switch is on, the output signal transitions to high, turning off the green LED and activating the traffic signal. If further DIP switches 2 or 5 become active, the yellow LED will light up as current flows through it. Similarly, if switch 3 or 4 becomes high, the red LED will light up and servo will go from 120-degree to 0-degree, indicating that the crossing barriers are in operation. To avoid confusion and ensure clarity in traffic management, a principle was implemented where only one LED is high at any time while the others remain off. This setup helps prevent any issues or disruptions in traffic flow. The logical implementation for this was supported by OR gates and inverters, with the 74HCXX series ICs powered by a +5V supply. Each LED was paired with a 220  $\Omega$  resistor to limit the current flow, thereby extending LED life.



The operation of the servo motor and the NE 555 timer IC is contingent upon the red LED being high. This is because an LED acts as a diode; when it is high, it allows current to flow, completing the circuit for the NE 555 IC and the servo motor. The NE 555 IC generates small pulses controlled by an external RC circuit. Pulse width modulation (PWM) is used to control the amount of power delivered to the electronic load by varying the width of the pulses in a digital signal. This modulation adjusts the power delivered to the servo motor, which, through precise angle rotation, lowers the barricade. The duty cycle of PWM increases, raising the power supplied and causing the barricade to lift as needed. To control the servo with the NE 555 timer, external components include a 220 KΩ resistor, a 120 KΩ resistor, a 56 KΩ resistor, and a 100 nF capacitor to aid in charging and discharging. A diode is used to ensure current flows in a specific direction to prevent the capacitor from discharging unintentionally. This setup is also powered by a +5V supply. Two NE 555 timers and RC external circuits were used to complement the traffic lights, with external 2V supplies provided. The first NE 555 timer was paired with a 100 μF capacitor and a 100 KΩ resistor, while the second NE 555 timer used a 200 μF capacitor and a 33 KΩ resistor to control the red, yellow, and green LEDs in astable mode.

In our circuit design, we utilized the astable mode of the 555 timer IC. The astable multivibrator, also known as a free-running multivibrator, alternates between two different output voltage levels continuously. This mode generates continuous square or rectangular waveforms, with the output switching between high and low voltage levels at regular intervals. The 555 timer operates in this mode without needing any external input, relying solely on the internal configuration of resistors and capacitors to produce the oscillating output.

Astable multivibrators have several advantages, including no need for external triggering, simplicity in circuit design, low cost, and continuous operation. However, they also have limitations such as higher energy absorption within the circuit, low output signal energy, and the inability to achieve a duty cycle greater than 50%. They are widely used in applications such as amateur radio equipment, Morse code generators, timer circuits, analog circuits, and television systems.



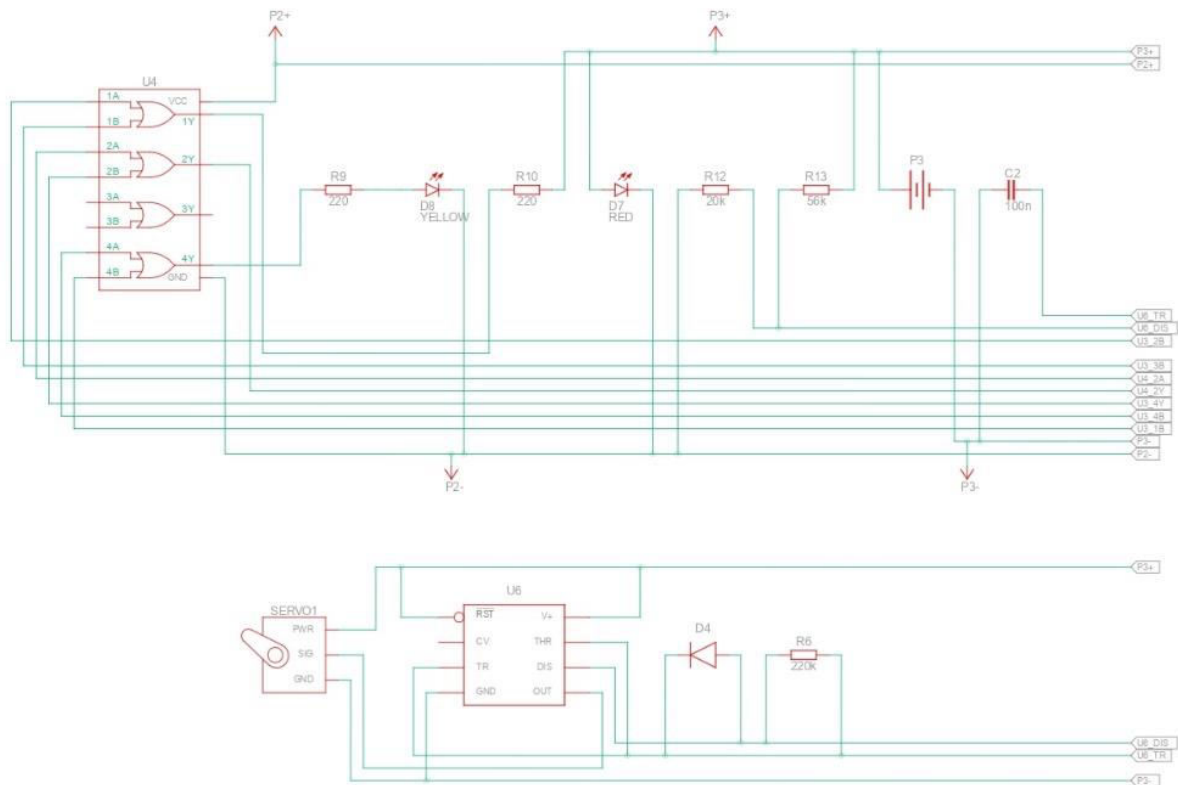


Fig. 1. Circuit Schematic of: (a)Traffic lights and DIP switch with gates IC, (b)continuation of DIP switch diagram and servo with NE555 IC.

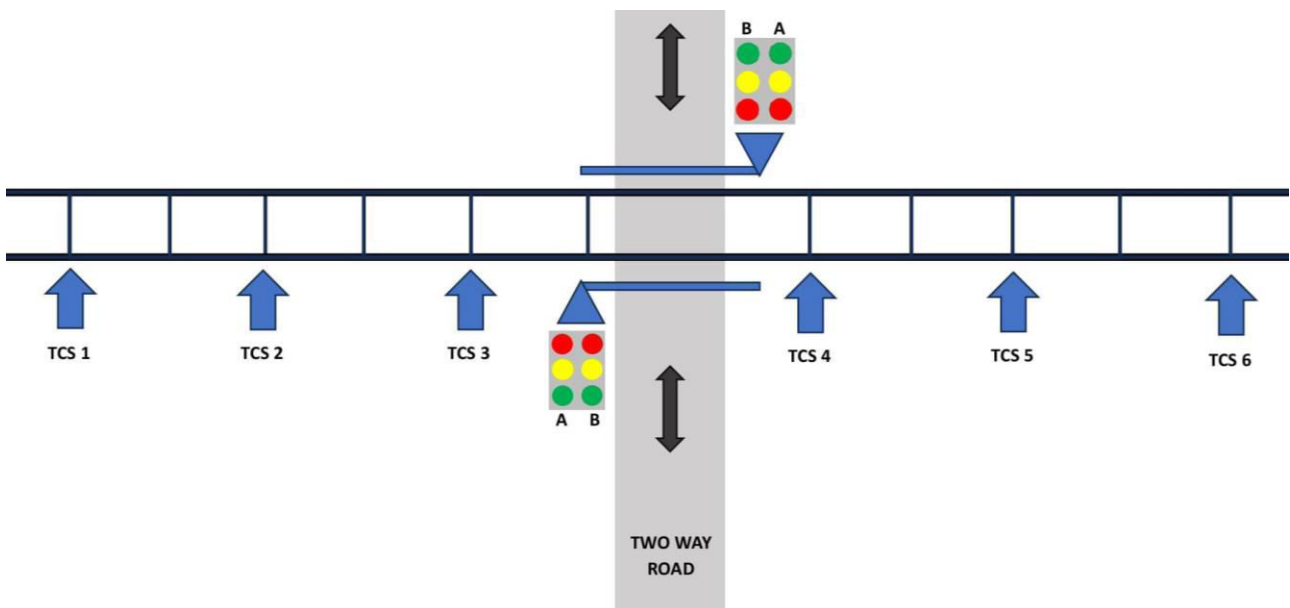


Figure 2. Design of proposed project's implementation.

Table I. Logical implementation of Track Circuit and Signals

Proposed logic	TRACK CIRCUIT SYSTEMS						SIGNALS			
	A	B	C	D	E	F	Traffic Lights	Green	Yellow	Red
All OR	0	0	0	0	0	0	0	1	0	0
A or F	1 or 0	0	0	0	0	1 or 0	1	0	0	0
B or E	-	1 or 0	0	0	1 or 0	-	0	0	1	0
C or D	-	-	1 or 0	1 or 0	-	-	0	0	0	1

Table II. Components used in the implementation of proposed project

Name	Quantity	Component
U1, U2, U6	3	NE555 Timer IC
D1, D7	2	Red LED
D2, D6	2	Green LED
D3, D8	2	Yellow LED
C1	1	100 uF Capacitor
C5	1	200 uF Capacitor
R2	1	33 kΩ Resistor
R5	1	100 kΩ Resistor
SW2	1	DIP Switch SPST x 6
U3, U4	2	Quad OR gate
P2	1	5V, Power supply
R8, R9, R10	3	220 Ω Resistor
U5	1	Inverter IC
SERVO1	1	Positional Micro Servo
R6	1	220 kΩ Resistor
C2	1	100 nF Capacitor
D4	1	Diode
R12	1	20 kΩ Resistor
R13	1	56 kΩ Resistor
P3	1	5V Power Supply
P1	1	2V, Power Supply

### III. RESULT AND DISCUSSION

In Figure 3, as you can see, when no train is approaching from either direction, all DIP switches are in the OFF position, indicating that the track circuits are inactive. Consequently, no lights are illuminated except for the green LED, which remains on indicating it is clear to go. When a train has approached either or both directions, all three LEDs red, green, and yellow are off. At this point, the traffic lights should be activated; otherwise, they should remain inactive in order to control flow of traffic. When the train gets closer to the level crossing, the yellow LED turns on. When the train is very close to or crossing the level crossing, the red LED is illuminated. At this stage, the servo motor has lowered the barricade, which was previously at 120 degrees in the earlier three cases, to 0 degrees in this case. The barricade was raised in the previous three cases and is now down.

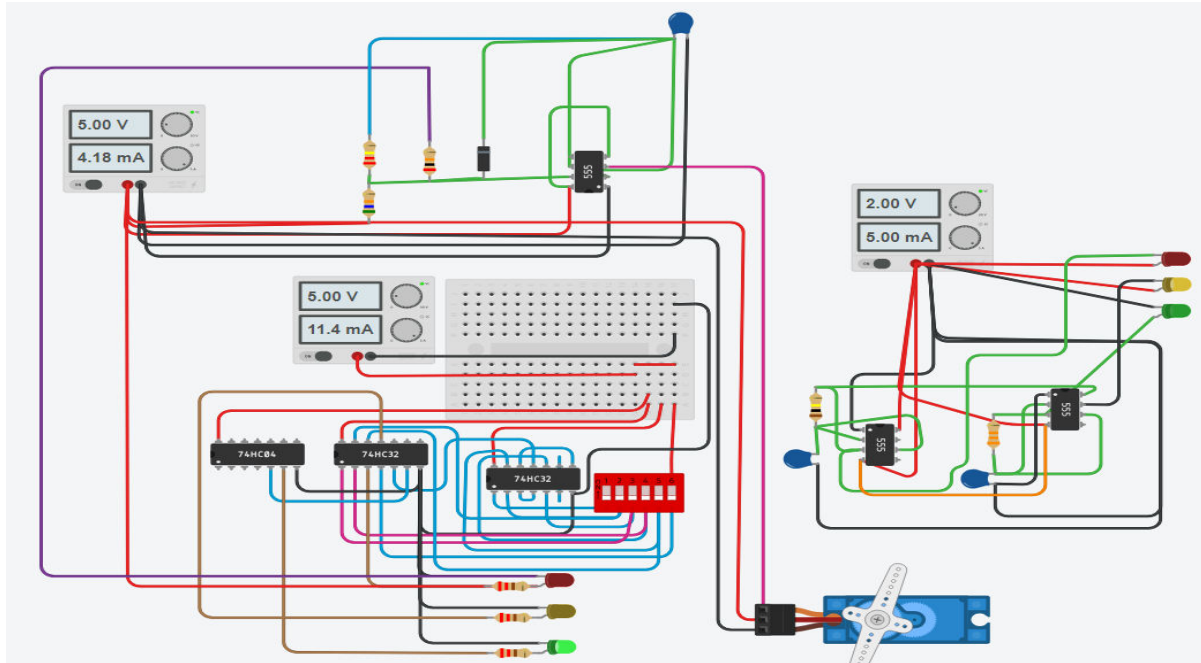


Fig. 3. Actual circuit schematic and working of project when train is not approaching or it is very far.

#### IV. CONCLUSION

The advanced two-step level crossing system proposed in this project represents a significant improvement in railway crossing safety, particularly in regions where manual operation and inadequate lighting increases serious risks. By incorporating red, yellow, and green signals that operate together with track circuits and a servo-controlled barricade, this system offers a more reliable and efficient method for managing vehicle and pedestrian traffic at railway crossings. Despite the success of the system in simulating the desired outcomes, the project faced limitations in the implementation, particularly with the continuous operation of traffic lights. The original design aimed to activate traffic signals only when trains were detected at specific track circuits (TCS 1 and TCS 6). However, due to issues related to power consumption and current draw, the system did not perform as intended. To address this, future improvements could involve the use of advanced semiconductor technology, such as Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs), to enhance power management and ensure that the traffic lights operate only when necessary. Overall, the project lays a strong foundation for improving level crossing safety and highlights key areas for further research and development. Implementing these improvements could make this system a viable solution for reducing accidents and enhancing the safety of railway crossings, particularly in regions with high vehicle congestion and inadequate infrastructure.

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