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Optical Sensor Based Contact-less Automotive Lever Combination Switch

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Abstract*— In this paper, we have discussed the Automotive Lever Combination switch, its mechanism, which is used in vehicles to control the electrical functions of the car - turn signals, headlight control, and wiper control; its common failures; and the contact-less systems. Previous research on contact-less technology on automotive lever combination switches was based on Hall-effect sensors. At the same time, we have explored the possibility of using an Optical Sensor to operate the Lever Light Switch. The experiment used an ESP32 board as the Main controller, TEMT6000 light sensors, LEDs, and an Automotive Lever Light Switch. The LED located bottom of the lever will be used by the optical sensor, which is incorporated inside the switch, to detect changes. It will convert the LED light into an electrical pulse, which the ESP32 will process. Once the signal interpretation has been completed in accordance with the logic defined in the ESP32 controller software, the results will be shown in the Verification Box.

Keywords — Automotive Lever combination switch, Contactless, ESP32, Light switch, Optical sensor, TEMT6000, Wiper switch.

I. INTRODUCTION

A lever combination switch, also known as a turn signal switch, is a mechanism used in vehicles to control the various electrical functions of the car. The switch typically consists of a lever operated by the driver and a series of electrical contacts that activate different functions when the lever is moved in various positions. [1]

The lever combination switch is typically located near the driver's seat on the steering column. It controls the car's turn signals, headlights, and other electrical functions. It is an essential component of a vehicle's electrical system, allowing the driver to safely control the car's lighting as signaling systems and windshield wipers.

The lever combination switch activates a series of electrical contacts when the lever is moved. When the lever is moved to the left, it activates the left turn signal and deactivates the right turn signal. Similarly, when the lever is moved to the right, it starts the right turn signal and deactivates the left turn signal.

The lever combination switch also typically has additional positions for activating the vehicle's headlights, high beams, and other electrical functions. These positions generally are labelled on the switch, making it easy for the driver to locate and operate the various functions.

In modern vehicles, the lever combination switch is often integrated with other electrical components, such as the wiper, washer controls, and cruise control system. This allows the driver to easily access and control the car's electrical functions from a single location on the steering column.

Overall, the lever combination switch is essential to a vehicle's electrical system and ensures the car's safe and efficient operation.

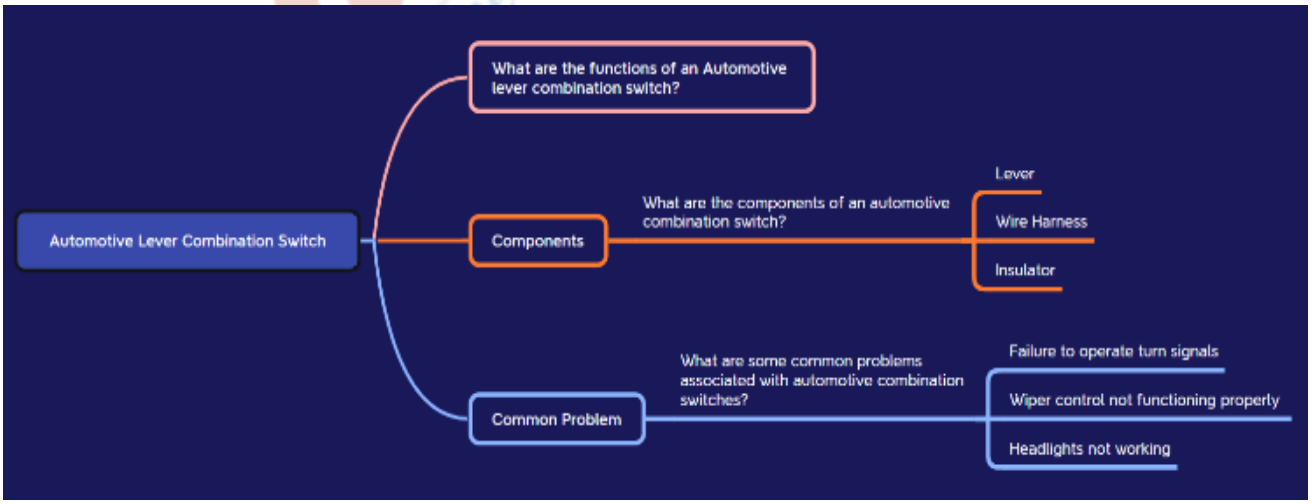

Figure 1: Automotive Combination Switch

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A. Overview of Lever Combination Switch

The Automotive Combination Switch is a complex device with several components that make it function the way it does. Its key features include the control arm, which adjusts the settings, and the wiper and signal levers. Electrical connectors, wiring harnesses, and relays connect the switch to the car's electrical system. Additionally, the internal circuits process the signals received from the controls and send them to the appropriate components of the vehicle. These components work harmoniously to allow drivers to perform several car functions with one.

An automotive combination switch is a crucial component of modern-day cars. It controls multiple functions like headlights, turn signals, and windshield wipers. A multifunctional switch integrates several electrical and electronic switches into one assembly. The critical components of this switch include the wiper switch, turn signal switch, headlight switch, and hazard switch. In addition, internal components, printed circuit boards, resistors, capacitors, and diodes help regulate the switch's electrical flow. All these components together ensure that the driver can easily control the various functions of their vehicle, providing a safer and more comfortable driving experience.

i. Lever: The lever is a critical component of the automotive combination switch. It is a small arm or handle that allows the driver to control various functions in the vehicle, such as turning on the headlights, a turn, or adjusting the windshield wipers. Commonly made of durable plastic or metal, the lever is to withstand frequent use and wear and tear. Depending on the vehicle's make, the lever may be in the steering column, dashboard or elsewhere on the car's interior. Its function is essential to safe and efficient driving, as it allows the driver to operate multiple functions without their hands off the wheel or eyes off the road.

ii. Wire Harness: The wire harness is a crucial component of an automotive combination switch. It is a bundle that connects various electrical components throughout the vehicle. The harness is an organized and efficient means of transmitting electrical signals and power to the various components of the switch. W wires within the harness are often colour-coded to connect correctly and may also have various connectors for easy installation and removal. In short, the harness ensures that the switch functions properly and reliably, providing a safe and efficient means of multiple functions within the vehicle.

iii. Insulator/ PCB: These are vital to any automotive combination switch. They are simple devices that control the current flow in an electrical circuit. When the switch is turned, the contacts close, allowing electricity to go through the circuit. When the switch is turned off, the contacts open, breaking the circuit and stopping the flow of electricity. Some switches have multiple positions, allowing for distinct functions to be controlled by a single switch. Switches come in many shapes and sizes, from simple toggles to complex, programmable, and adaptive electronic switches. They can be found in car parts, from the steering column to the dashboard to the engine compartment. The switches in a combination switch are engineered to withstand harsh environments and demanding conditions every day.

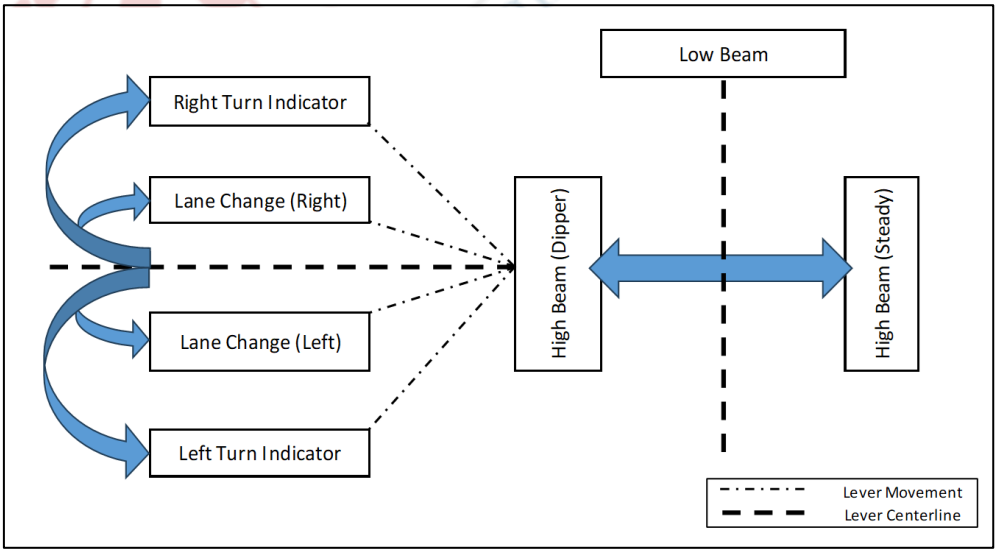

Figure 2: Light Lever Position & Function

B. The function of the Lever Combination Switch

An *automotive switch* is a multifunctional device that allows drivers to control multiple vehicle operations with one instrument. The lever combination of the switch serves as a vital interface for many vehicles and assemblies. It combines various levers that allow the driver to control multiple functions with one hand. An automotive lever combination

primarily includes turning on/off the headlights, controlling the wipers, activating the turn signals, and adjusting the steering wheel's position. The combination switch offers drivers enhanced safety, convenience, and comfort by streamlining the vehicle control functions. [3], [4]

i. Turn Signal Operation: Turn signal operation is essential in any automotive combination. It is responsible for indicating the direction of a turn or lane change and warns other drivers on the road. When the driver activates the turn signal lever, a circuit is completed that sends electrical to the respective bulb on the side of the activated turn signal. This causes the light to flash, indicating which direction the driver plans to turn. The system is designed to work only when the vehicle is moving and automatically switches off after a turn or lane change is made. This feature ensures that drivers are aware of each other's movements, enhancing road safety for all users.

ii. Wiper/Washer Control: The Wiper/Washer control is a feature of the Automotive Combination Switch that allows the driver to control the speed and frequency of the windshield wipers. This control consists of a lever or switch readily accessible to the driver. The primary function of this control is to turn the wipers on and off, as well as the speed of the wiper blades to match the level of rain or snowfall. In addition, modern vehicles now include a Washer control feature as part of this system. This control allows the driver to spray cleaning solution onto the windshield. At the same time, the wipers are in motion, making it easier to remove dirt, grime, or any other foreign substances from the windshield.

iii. Headlight Operation: The operation headlights are critical to driving during nighttime or in inclement weather conditions. An automotive combination switch typically functions for low and high beam output that the driver can activate to adjust the intensity of the light. When the low beam function is selected, the vehicle's headlights illuminate the road, allowing the driver to navigate dimly lit environments. When the high beam function is turned on, the headlights have a stronger, more concentrated light, providing enhanced visibility. Switching between these two functions enables drivers to adapt to different lighting conditions and ensure the safety of themselves and other passengers on the road.

C. What are some common problems associated with automotive combination switches?

Common problems with automotive combinations are primarily related to wear and tear, electrical issues, and damage due to accidents or mishandling. They may become loose or insensitive due to wear and tear, making operating the functions they regulate challenging or impossible. Issues can lead to intermittent complete failure of the switch, affecting the operation of the corresponding features. Damage due to accidents or mishandling causes physical damage to the or its internal components, leading to malfunction. Proper maintenance and repairs can help prevent these common problems, ensuring vehicle combination switches' safe and reliable operation.

Automotive combination switches are known for their durability and longevity. However, like any electronic device, they are prone to specific issues arising over time. Some common associated with automotive combination switches include malfunctioning wipers, failing turn signals, and the inability to engage the high beams or beams on the vehicle's headlights. Another common issue is when the switch fails to activate the horn or controls the cruise control feature. Many factors, such as wear and tear, a faulty connection, or a malfunctioning relay, can cause these problems. The good news is that these are usually fixed by a mechanic specializing in automotive systems.

i. Failure to operate turn signals: Failure to operate turn signals is a common complaint from drivers who have issues with their automotive combination switch. *Turn signals* are a vital aspect of driving safety and ensure other drivers can understand the intentions of the vehicle operator. When turn signals fail to operate, it poses a risk to the driver and other vehicles on the road. The cause of the failure can be attributed to several issues, such as a faulty switch, blown fuse, or damaged wiring. It is crucial to get the issue fixed promptly to ensure the safety of everyone on the road. Ignoring the problem can lead to accidents and fines for compliance with traffic laws.

ii. Wiper control not functioning correctly: The wiper control is an essential component of the automotive combination and allows the driver to operate the wipers. However, the wiper control may sometimes fail and exhibit various symptoms, such as the wipers not working at all or only intermittently. A wide range of problems, such as a faulty wiper motor, damaged wiring, or a defective wiper switch, can cause this. Additionally, the control module or circuit board that controls the wiper function also malfunctions, resulting in issues with wiper control. It is essential to promptly address any problems with the wiper control; a faulty or unreliable wiper system can compromise visibility and increase the risk of accidents on the road.

iii. Headlights not working: Headlights not working can be a widespread problem car owner face. Numerous things, like a blown fuse, a broken bulb, or malfunctioning, can be the root of this problem. Poor wiring or a faulty generator can also be the culprits. Furthermore, failing headlights can be a safety hazard, and addressing the problem at the earliest is essential. It is crucial to seek professional help to diagnose the problem to ensure optimal safety on the road. The automotive combination switch may need to be replaced to fix the issue. Regular maintenance and checking of the headlights can prevent

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the problem from arising in the first place.

D. Contact-less Lever Combination Switches

The contact-less lever combination switch is an advanced technology used in modern cars for controlling various things such as headlights, turn signals and windshield wipers. The switch works without a physical connection, which means it does not have any physical switch contacts for detecting the position of the lever. Instead, the switch uses a non-contacting magnetic sensor that can detect the position of the lever through the magnetic field. This technology has numerous benefits over traditional switch systems, including improved reliability, no wear and tear, better response times, and lower power consumption. With the increasing demand for advanced automotive technology, the contactless automotive lever combination switch is set to revolutionize the sector. [5], [6]

E. Different types of contact-less technology

Contact-less technology has become increasingly popular in recent years as it has many advantages over traditional, contact-based methods. There are several types of contact-less technology, including magnetic induction, capacitance, infrared and radio frequency identification (RFID). Magnetic induction technology utilizes the transfer of magnetic fields to detect the presence of a conductive object, while capacitance technology detects changes in electrical charges. The technology utilizes light waves to detect objects, and RFID technology uses radio waves to communicate between devices. Each technology has its unique benefits and drawbacks, and it is essential to carefully consider which type of contact-less technology will be most suitable for specific applications. The development of different kinds of contact-less technology has paved the way for the advancement of various products, such as the contact-less automotive lever combination.

F. Optical Sensor

An *optical sensor* is a device that detects and responds to light. It converts light signals into electrical signals, which various electronic devices can interpret. Applications for sensors are numerous, ranging from motion and distance measurement to the detection of smoke and fire. They are used to detect subtle changes in light intensity, allowing them to see even the slightest movement changes in the environment. As such, they are widely used in industrial, medical, and scientific applications; highly accurate and precise measurements are required. Optical sensors are increasingly popular in consumer electronics, including digital cameras and gaming consoles, where they are used to track motion and gesture.

G. Advantages of Optical Sensors

Advantages of Optical sensors offer several advantages over other types of sensors. They are highly accurate, reliable, and provide a fast response time. In comparison to mechanical sensors, optical sensors have no movement, making them more robust and less prone to wear and tear. They are also less affected by changes in temperature and pressure, making them suitable for use in harsh environments. Another advantage of optical is their ability to measure various parameters, including distance, velocity, displacement, and temperature. Optical sensors are also non-contact, which means they do not require physical contact with the object being measured, making them ideal for detecting small and delicate components. Additionally, optical sensors are low-power, making them suitable for portable and battery-powered applications. Thanks to their advantages, optical sensors are a popular option for various industrial, automotive, and consumer applications.

II. EXPERIMENT DETAILS

A. ESP32 Dev Kit V-1

The ESP32 is a series of chip microcontrollers developed by Espressif.

i. Specifications: The following table shows a summary of the ESP32 DEVKIT V1 DOIT board features and specifications:

Number of cores	2 (dual core)
Wi-Fi	2.4 GHz up to 150 Mbits/s
Bluetooth	BLE (Bluetooth Low Energy) and legacy Bluetooth
Architecture	32 bits
Clock frequency	Up to 240 MHz
RAM	512 KB
Pins	30,36 & 38 (depending on the model)
Peripherals	Capacitive touch, ADC (Analog to Digital Converter), DAC (Digital to Analogue Converter), I2C (Inter-Integrated Circuit), UART (universal asynchronous receiver/transmitter), CAN 2.0 (Controller Area Network), SPI (Serial Peripheral Interface), I2S (Integrated et al.), RMII (Reduced Media-Independent Interface), PWM (pulse width modulation), and more are examples of such technologies.
Built-in buttons	RESET and BOOT buttons
Built-in LEDs	the built-in red LED that indicates the board is powered, and the built-in blue LED connected to GPIO2
USB to UART bridge	CP2102

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There are 36 pins on this ESP32 board, 18 on each side. The board model determines the number of GPIOs that are available. [7] [8]

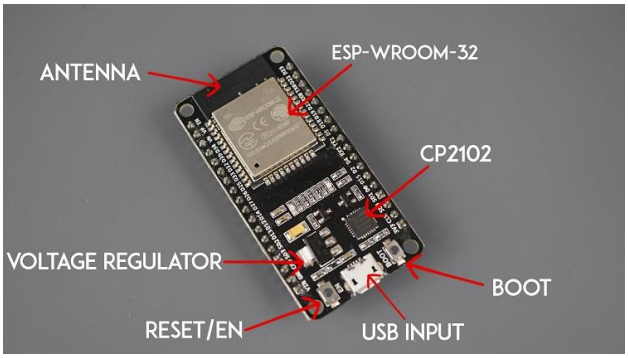

Figure 3: Major Components on ESP32 Dev Kit V1[7]

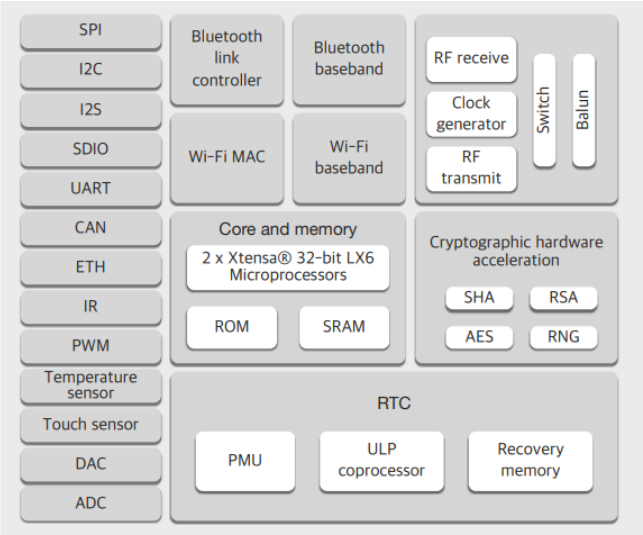

Figure 4: Functional Block Diagram [8]

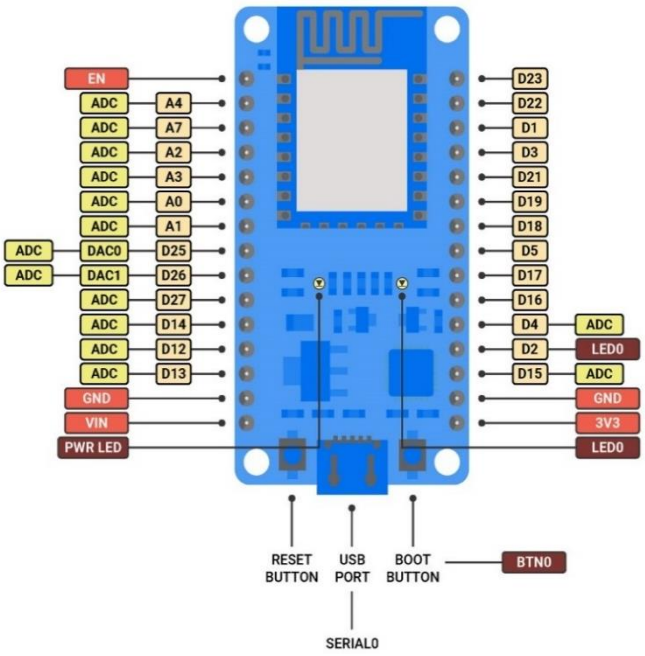

Figure 5: ESP32 Dev Kit V-1 Pinout [9]

B. TEMT6000 Light Sensor Module

The TEMT6000 Ambient Light Sensor Module is a visible light to analog voltage converter for measuring light intensity.

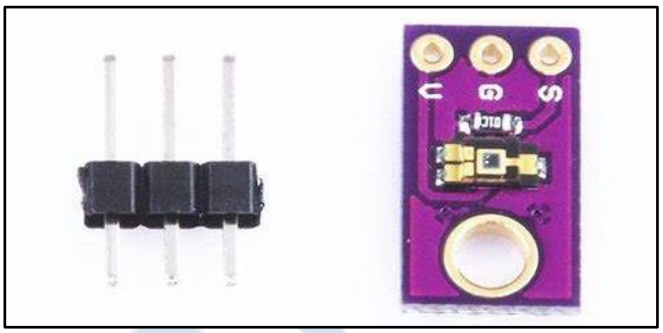

Figure 6: TEMT6000 Light Sensor Module with connecting pins [10]

This CJMCU-TEMT6000 Ambient Light Sensor module uses a particular ambient light detector (TEMT6000) with a spectral response that closely emulates the human eye. It helps detect the light density and reflect the analog voltage signal to the controller.

It is a silicon NPN epitaxial planar phototransistor mounted on the surface in a tiny transparent 1206 packaging. Similar to the human eye, it is sensitive to visible light, with a peak sensitivity of 570 nm. The visible spectrum has more outstanding responsiveness, whereas this device is sensitive to ambient light but inhibits the infrared (IR) spectrum, which can offer results similar to those seen by the human eye. [10]

C. Operation Modes

A Lever combination switch can be installed in two different ways on the Steering Column, i.e., Light Switch on the right-hand side & Wiper Lever Switch on the left-hand side or the opposite combination. For this experiment, we have taken the right-hand Light lever switch.

An Automotive Light Lever Switch has six different lever positions or can be termed operational modes, which are as follows:

i. Lane-change Right: The driver gently moves the lever in the counter-clockwise direction. This is momentary, i.e., the lever will return to its original position after the force is removed from the lever. Electrically, the Right Indicator will blink three times in this position, indicating Lane Change toward the right side to the other drivers.

ii. Turn Right: In this, the driver moves the lever in the counter-clockwise direction, similar to the Lane change operation, but it is a steady position, i.e., the lever will not return to its original position after the force is removed from the lever. It will return to its original position in two cases; one is when the driver moves it manually to its original position, and another is when the driver moves the Steering in the clockwise direction, which will automatically disengage the lever position.

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Electrically, in this position, the Red Indicator will remain ON until the lever returns to its original position.

iii. Lane-change Left: It has a similar function and works to Lane Change Right. The only difference is that the lever moves clockwise.

iv. Turn Left: Similar function to Turn Right. The only difference is that the lever is moved clockwise.

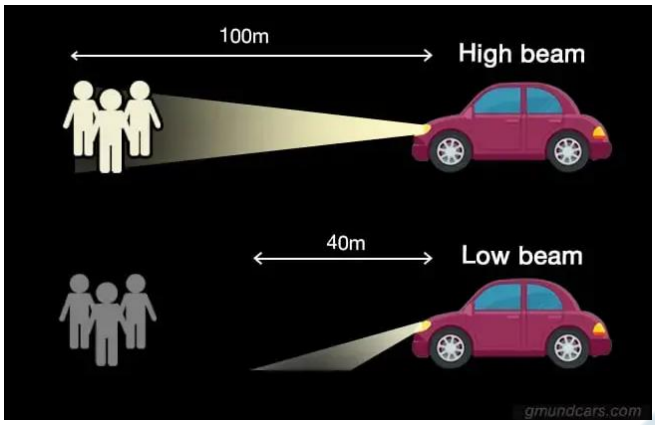

Figure 7: Difference Between Low Beam & High Beam

v. High Beam (Headlight): In the above operation modes, the lever moves in an X-Y plane, and in this position, the lever moves in the Z-direction Upwards. This position is momentary. This function is used with less traffic, like on Highway or in a No light environment.

vi. High Beam (Headlight): Similar to the previous operation mode, the lever will move in the Z direction but downwards. This position is steady. Electrically, the headlights will have a high beam until the lever is returned to its original position, which can only be changed manually. This function is used with less traffic, like on Highway or in a No light environment.

vii. Low Beam (Headlight): In this operation mode, the lever is not moved and will be in its normal position; only the rotary Knob on the switch will be rotated to switch ON the Low Beam. They are most suited for driving at night when there is heavy traffic. Low beams are ideal for driving in rainy, foggy, or snowy conditions.

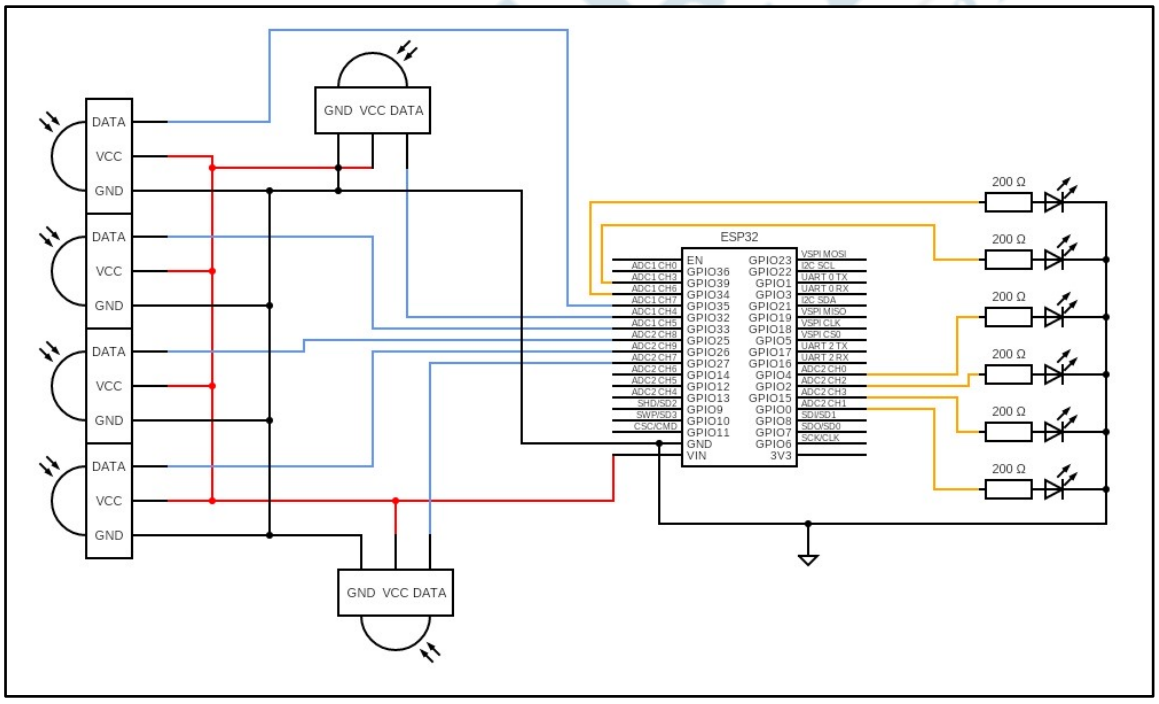

Figure 8: Circuit Diagram

D. Experimental Setup

We took an ESP32 board as the Main controller for the experiment and connected our six TEMT6000 light sensors assembled inside the Lever Switch with the ESP32 Board.

Inside the switch, two different LEDs are also present; these two LEDs are assembled on the lever portion of the switch in such a way that in every position the lever is moved then, the light will fall on the light sensor, and the microcontroller will interpret the signal as per the logic entered in it.

To collect the experiment data quickly and visually, we have attached six different LEDs and prepared a Switch Verification Box to show the interpretation of the switch's lever movement once it is connected to the ESP32 board.

III. OBSERVATIONS & RESULT

After completing the circuit, the switch was operated in the previously discussed operation modes, and the following data were collected on the Switch Verification Box.

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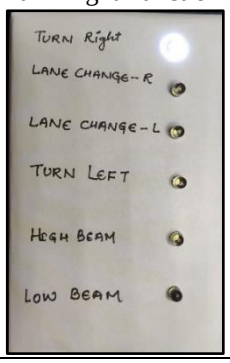
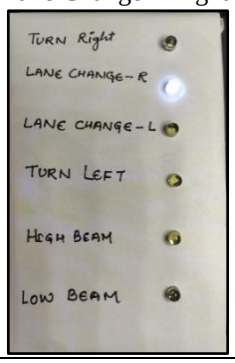
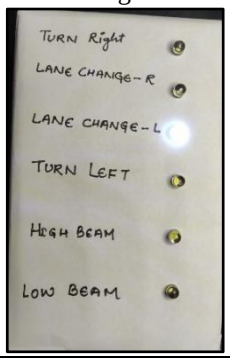
i. Turn Right Function



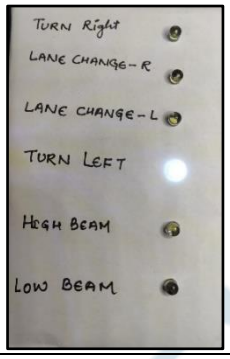
ii. Lane Change – Right



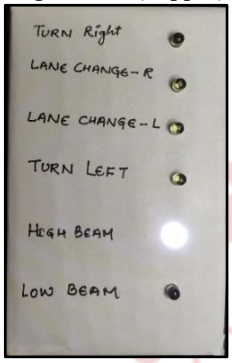
iii. Lane Change – Left



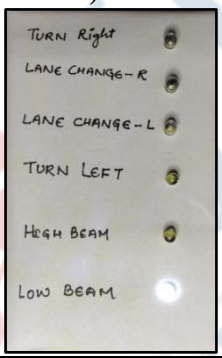
iv. Turn Left



v. High Beam (Dipper)



vi. Low Beam (Normal Position)



vii. High Beam (Steady)

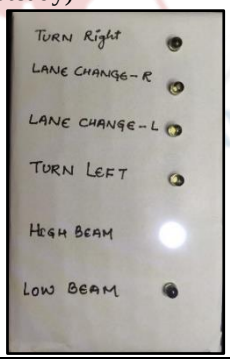


Figure 9: Result at Each Operation Mode of Light Switch

IV. CONCLUSION

In this paper, we experimented with an Optical sensor-based circuit to operate an Automotive Lever Combination Switch, and we were successful in the same.

Now the question arises whether this type of sensor is feasible to replace the physical contact-based switches that the Automotive Industry has been using for a long time. To conclude that discussion, we have to do multiple experiments on this type of Switch to determine its life cycle & reliability. We will use different Optical sensors and processor specs to find the more reliable and cost-effective configuration.

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