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Construction Of A Lighting System Model

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ABSTRACT
This study focused on the construction of an automotive lighting system model for educational purposes at the Federal College of Education Technical Ekiadolor, Benin City. The research addressed the critical need for practical teaching aids in automobile technology education, specifically targeting the understanding of vehicle lighting systems. The study aimed to design and construct a functional lighting system model that simulates key operations of automotive lighting systems, including headlights, tail lights, turn signals, and brake lights. Using a 12-volt power supply system, the model incorporated various components including voltage regulators, control mechanisms such as main lighting switches, dimmer switches, flasher units, and emergency hazard switches, along with multiple illumination units. The construction process involved systematic assembly of components on a wooden board, comprehensive wiring, and thorough testing procedures. Results showed that the constructed model achieved a total power output of 26.4 Watts, with lighting points operating at 10,500 Volts and protected by a 3A fuse system. The model successfully demonstrated the conversion of electrical energy to light energy, providing students with hands-on experience in understanding automotive lighting systems. The research concludes that the model serves as an effective educational tool for teaching automotive lighting systems and recommends its incorporation into technical and engineering training programs.
Keywords: Automotive education, lighting systems, technical education, Practical training

INTRODUCTION

Automobile technology education is a comprehensive program dedicated to equipping students with essential skills and knowledge for the automotive industry. In Nigeria, this training is provided across various institutions including technical colleges, colleges of education (technical), polytechnics, and universities. The curriculum encompasses diverse automotive aspects, from design and diagnostics to repair, maintenance, and service operations (Denton, 2020). Students receive training in troubleshooting and resolving various vehicular issues, particularly focusing on critical systems like electrical components and lighting. While the program aims to prepare students for modern automotive challenges, including advances in electrical systems and lighting technology, there are significant constraints in practical instruction. A major challenge facing automobile technology education in Nigeria is the limited availability of instructional models and practical teaching aids. According to Okoye and Arimonu (2016), inadequate funding and poor facilities have severely restricted the use of educational models crucial for effective teaching of automobile technology concepts and lighting systems.

An automobile lighting system is an assemblage of light and other component that allows drivers and others to see the road at night. The lighting system, being a fundamental electrical component in vehicles, requires hands-on learning experiences for proper understanding. Like other practical aspects such as braking systems, suspension, and transmission systems, the lighting system's complexity necessitates the use of physical models for effective teaching and learning. Without these practical models, students may struggle to grasp the intricate relationships between various lighting components, their functions, and troubleshooting procedures.

The automotive lighting system model represents a complex network of electrical components designed to facilitate visibility, signaling, and safety in vehicles. According to Bosch (2023), the system comprises several integrated subsystems that work together to ensure proper illumination under various driving conditions.

The lighting system model serves as a crucial educational tool, bridging the gap between theoretical knowledge and practical application in automotive technology education. As noted by Parker (2024), these models enable students to develop essential diagnostic and repair skills while understanding the intricate relationships between various lighting system components. The lighting system model typically consists of the following key components (Zhang & Liu, 2021): Power Supply Unit which is a Battery (12V DC system), Voltage regulators for maintaining stable electrical output. Others are the Control Mechanisms consisting of Main lighting switch, Dimmer switch, Flasher unit for turn signals, Emergency hazard switch, Automatic light sensors (in modern vehicles). And finally the Illumination Units which is made up of Headlamps (high and low beam), Tail lights, Brake lights, Turn signal indicators, Position/parking lights, Interior cabin lights.

The modern lighting system models have advanced to include innovative features such as: Adaptive Front-lighting Systems (AFS) such as LED and HID technology integration, Daytime Running Lights (DRL), Automatic headlight leveling, smart light control modules (Thompson et al. 2022). The electrical circuit in the lighting system model follows a structured layout (Wilson, 2024): Primary circuit protection through fuses, Relay systems for high-current components, Ground connections for circuit completion, wiring harnesses for organized distribution. For educational purposes, Kumar and Ahmed (2023) suggest that lighting system models should demonstrate: Basic circuit principles, Component relationships and dependencies, Troubleshooting scenarios, Safety features and fail-safes, Energy efficiency considerations

Modern lighting system models incorporate diagnostic capabilities that allow students to: Identify common electrical faults, Practice voltage and current measurements, Understand circuit loading effects, Learn proper maintenance procedures, Study energy consumption patterns The model emphasizes safety features as outlined by the Society of Automotive Engineers (SAE, 2023): Short circuit protection, Overload prevention, Emergency backup systems, Fail-safe operations, Warning indicators. According to Martinez and Johnson (2023), effective lighting system models should be: Interactive and hands-on, Built with durable components, easily serviceable, Equipped with test points, Designed with clear visual indicators.

Aim and Objectives of the Study

The aim of this study is to construct a lighting system model that simulates the key operations of an automotive lighting system. Specifically, the study would:

1. Design a circuit that demonstrates the generation and control of high-voltage light.
2. Identify components of constructing a lighting system model.
3. Construct a lighting system model that simulates the key operations of an automotive lighting system.

METHODOLOGY

The vehicle lighting system model is built using several components including 12 volts Battery, Voltage regulators for maintaining stable electrical output. Others are the Control Mechanisms consisting of Main lighting switch, Dimmer switch, Flasher unit for turn signals, Emergency hazard switch, Automatic light sensors (in modern vehicles). And finally the Illumination Units which is made up of Headlamps (high and low beam), Tail lights, Brake lights, Turn signal indicators, Position/parking lights, Interior cabin lights. The components are assembled accordingly to construct a vehicle lighting system model for educational purpose.

How the Vehicle Lighting System Works

The mode of operation of a lighting system model is based on the principle of conversion of electrical energy to light energy, a fundamental aspect of the vehicle systems. When the switch is turned on, the battery sends low-voltage current to the circuit, creating a magnetic field. As the switch is rapidly turned on and off, the magnetic field in the circuit collapses and then re-establishes, inducing a high voltage in the secondary winding of the circuit. This high voltage is directed to the various lighting points, where it glows displaying light to signal what operation you want to perform across the vehicle. In a real automobile, the lighting system operates automatically based on vehicle design. However, in this model, the system allows the user to demonstrate the essential concepts of lighting system and voltage transformation.

Lighting system Power Supply includes: The car battery (12V DC) provides the primary power, the alternator recharges the battery and supplies power while the engine runs, A fuse box protects the electrical circuits from overload.

Parts of the lighting system: This includes Headlights (high and low beam)**,** Tail lights and brake lights, Turn signals/indicators**,** Interior lights**,** Emergency/hazard lights**,** License plate lights**,** Fog lights (if equipped).

Control Systems: Light switch on the dashboard or steering column controls main lights**,** Turn signal lever activates indicators**,** Brake pedal triggers brake lights**,** Door switches activate interior lights**,** Automatic headlight sensors (in modern vehicles) detect ambient light

Light Operation

Headlights: Low beam: Provides forward illumination while minimizing glare for oncoming traffic**,** High beam: Maximum forward illumination for dark roads**,** Modern vehicles often use LED or HID (High-Intensity Discharge) technology.

Tail Lights: Illuminate when headlights are on**,** Increase visibility from behind**,** Often combined with brake lights.

Brake Lights: Activate when brake pedal is pressed**,** Higher intensity than regular tail lights**,** some vehicles have a third (center) brake light.

Turn Signals: Flash when activated**,** Relay system controls the blinking pattern
, dashboard indicators show operation.

Safety Features of lighting system model : Automatic daytime running lights**,** Emergency flashers that activate all turn signals**,** Warning lights for bulb failure**,** Automatic high-beam control (in newer vehicles)**,** Adaptive headlights that turn with steering (in some models).

Major Components Used

1. Battery: The battery serves as the primary energy source for the ignition system. Typically rated at 12 volts in most vehicles, its function is to supply direct current (DC) to the ignition system and ensures consistent power delivery, enabling reliable engine startups.
2. Ignition Switch: The ignition switch is the user interface for the driver to control the ignition system. The function of this component is to enables or disables the flow of electrical current from the battery to other ignition components. Ignition switch also acts as a gateway to engine operation and overall vehicle electrical control.

3. Wiring: The wiring system connects all components of the ignition system, enabling the seamless transmission of electrical signals. Insulated wires are used to prevent energy losses and protect against short circuits.
4. Baseboard: A wooden board to mount components for display.
5. Mounting Materials: Screws, clamps, or adhesive.
6. Resistors: For smoothing current if necessary
7. Protective Components: Such as fuses for safety.

Construction Process

The lighting system model is made up of different components joined, fixed and couple together to act as a simple unit for the purpose of demonstrating the fundamental function of lighting system in an automobile. Various equipment/instrument were used, construction processes were adopted and sequences of operation taken for the construction. Also, quality control measure and safety precaution were considered. The construction process involved assembling, connecting of wires, drilling of holes, measuring and screwing components to a firm wooden surface.

Equipment/Tools used for the Construction

The equipment/tools used in this construction are as follows

1. Screwdriver Set: to mount components and tighten screws.
2. Drill Machine: to create mounting holes in the baseboard.
3. Wire Strippers: to strip insulation from wires.
4. Soldering Iron: to solder connections (where needed).
5. Multimeter: to test connections and measure voltage/current.
6. Electrical Tape: for insulation of connections.
7. Cable Ties: to organize wires neatly.
8. Clamps or Adhesive: to secure components to the baseboard.

Construction phases

Designing the circuit diagram

1. Designed a detailed circuit diagram showing connections between the components: battery and switch as shown in figure 3.1.
2. Included safety features like fuses to prevent damage.

Preparing the baseboard and mounting of components

1. Cut the baseboard into a suitable size and fitted as the top of a table.
2. Marked positions for components like the battery, headlight, tail light, switch, and others.
3. Installed the battery and secure it under the baseboard using clamps or adhesive. Made sure the terminals are accessible for wiring.
4. Mount the lighting points on the baseboard and labeled the primary and secondary terminals for easy connections.
5. Fixed the light points vertically into drilled holes on the baseboard, positioning it visibly so that the light is easy to observe.
6. Mounted the switch on the baseboard in a convenient position.

Wiring of components

1. Primary Circuit:
    - Connected the positive terminal of the battery to one terminal of the switch.
    - Connected the other terminal of the switch to the primary input of the ignition coil.

Testing of the circuit and safety features

1. Ensured all connections are secured.
2. Activated the switch to check if the lighting points are powered.
3. Included a fuse in the circuit to protect the battery and components.
4. Encased high-voltage parts to prevent accidental contact.

Additions for educational purposes

1. Clearly label each component on the baseboard for educational purposes.

2. Used a transparent casing for aesthetic appeal and safety.
3. Created an instruction sheet or placard explaining how the circuit works.
4. Include details about the role of each component and the ignition process.

Construction process safety tips

1. Always wear insulated gloves while working with electrical circuits.
2. Keep high-voltage components covered to avoid shocks.
3. Do not connect the circuit for extended periods to prevent overheating.

TEST AND RESULT

Experiment I: Cutting and Assembling

Aim: Cutting and assembling of a lighting system model.

First stage

1. Cutting the baseboard into a suitable size and properly fitted as the top of a table.
2. Marking positions for components like the battery, headlight, taillight, switch, and turn light.
3. Drill holes on the board where wires will pass through

Second stage

4. Installing the battery and securing it under the baseboard using clamps on wooden frame. Making sure the terminals are accessible for wiring.
5. Mounting the basic lighting components on the baseboard and labeling the primary and secondary terminals for easy connections.
6. Fixing the connectors into the drilled holes, positioned visibly so that the setting of the light is easy to observe.
7. Mounting the switch on the baseboard in a convenient position.

Third stage

8. Connecting the positive terminal of the battery to one terminal of the switch.
9. Connecting the other terminal of the switch to the primary input of the control switch.
10. Connecting the control switch output to the negative terminal of the headlight.
11. Connecting the headlight's high-voltage terminal to the control box.
12. Connecting the spark control box ground terminal to the battery's negative terminal.

Materials, Tools and Equipment

Materials, tools and equipment used for the construction of a manually operated ignition system circuit display.

S/N	MATERIALS/ ITEMS	QUANTITY
1.	12 volts battery	1
2.	Headlight	2
3.	Taillight	1
4.	Turn light	2
5.	Conductors (wires)	40 meters
6.	Control box	2
7.	Relay	4
8.	Condenser	1
9.	Brake light sensor	4
10.	Battery connectors	1
11.	Fuse holder	4
12.	Sheet metal	1
13.	Black Square Pipe	3
14.	Plywood	1
15.	Round pipe	1

16.	Bolts/ nuts	25 pcs
17.	Screws	12 pcs
18.	Black paint	4 liters
19.	Emery cloth (sand paper) (R&S)	2 yards
20.	Round clips	4
21.	Screw bolts	1
22.	Bulbs	12
23.	Wooden support	4
24.	Hack saw & blades	2 frames & 5 blades
25.	Try squares	2
26	Hammers	2
27	Mallets	2
28	Cramps/clamps	2
29	Power hand drilling machine	1
30	Filing machine	1
31	Measuring tape	2
32	Scribers	2
33	Chisels	2
34	Sharpening stone and oil	1
35	Welding machine	1
36	Complete tool box	1
37	Electrodes	4 packs
38	Spraying machine	1
39.	Generator	1
40..	Fuel	40 liters
41.	Riveting machine	1
42.	Paint Thinner	4 liters
43.	Multimeter	1
44.	Resistor	1
45.	Fuse	1
46.	Miscellaneous	

RESULTS

The experiment and testing shows that:

i. The lighting system model circuit constructed gives a total power of 26.4 Watts
ii. Each lighting points of the circuit has an output of 10,500Volts with 87,500 secondary turns.
iii. A fuse of 3A is required to protect the components of the designed circuit from been damaged by high current or voltage.
iv. The lighting points used in the designed circuit displays 4.48Watts of power.

Diagram of Assembled Lighting System Model

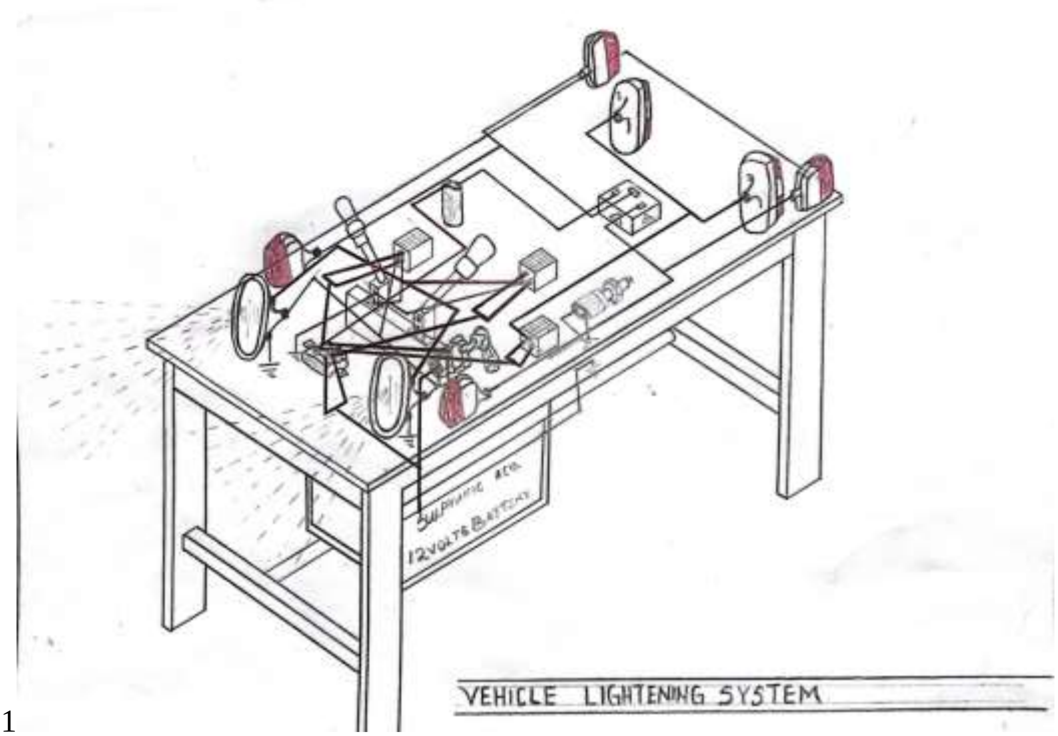

Figure 1

The lighting system model is constructed based on the principle of conversion of electrical energy to light energy. When the switch is turned on, the battery sends 12Volts and 2.2 Ampere current to the ignition switch and then the control box, creating a magnetic field. As the switch is rapidly turned on and off, the magnetic field in the circuit re-establishes, inducing a high voltage of 10,500Volts to the main components of the lighting system model. This high voltage is directed to the lighting points that need high Volts to produce light at the lighting points where it glows across the system between the main components, creating a bright light. In a real automobile, the lighting system operates automatically based on the vehicle operation. This model demonstrates the essential concepts of lighting of a motor vehicle.

Limitations: This includes Simplified compared to modern vehicle systems**,** Limited to basic lighting functions**,** fixed configuration. The constructed lighting system model successfully demonstrates the fundamental principles of automotive lighting systems while serving as an effective educational tool. The model achieves its primary objectives of providing hands-on experience with automotive electrical systems in a controlled environment. Its implementation in technical education programs can significantly enhance students' understanding of automotive lighting systems and provide valuable practical experience.

CONCLUSION

The constructed lighting system model successfully demonstrates the fundamental principles of automotive lighting systems while serving as an effective educational tool. The model achieves its primary objectives of providing hands-on experience with automotive electrical systems in a controlled environment. Its implementation in technical education programs can significantly enhance students' understanding of automotive lighting systems and provide valuable practical experience.

RECOMMENDATIONS

1. Integration into technical education curricula
2. Development of comprehensive operational documentation
3. Exploration of energy-efficient component alternatives
4. Addition of diagnostic tools for performance monitoring
5. Further research into design optimization and modernization.

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