# Car Battery and Charging System Voltmeter Indicator: An Innovation

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**Abstract**
In the rapidly evolving automobile industry, innovation is crucial for maintaining competitive advantage, particularly in enhancing vehicle efficiency and sustainability. This study focuses on developing a voltmeter indicator for car batteries and charging systems, aiming to address the widespread lack of monitoring tools in vehicles. The research investigates the acceptability of this voltmeter indicator among car owners, mechanics, and technicians, assessing its functionality, reliability, aesthetics, safety, and convenience. Using a descriptive research design, 50 participants evaluated the device, with data analyzed through descriptive statistics. The findings reveal a high level of acceptability across all evaluated aspects, particularly in functionality (M = 4.67, SD = 0.47) and reliability (M = 4.72, SD = 0.45). The device's design and safety features were also highly rated, reflecting strong user satisfaction. The study highlights the potential of the voltmeter indicator to enhance vehicle maintenance practices, especially for users with limited technical knowledge. By offering real-time monitoring of battery health and charging conditions, this innovation can significantly improve vehicle safety and reliability, promoting broader adoption of advanced automotive technologies. The results suggest that the voltmeter indicator is not only effective but also well-received by users, indicating its promise for widespread market acceptance and use.

**Keywords**: Automotive innovation, Car Battery Monitoring, Car Charging System

## 1. Introduction

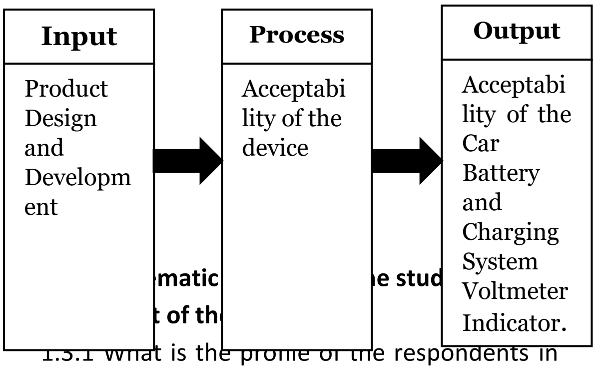
In today's highly competitive global environment a company's ability to introduce innovations is a key success factor for sustaining competitive advantage [1,2,3]. Launching new products on the market is important since product innovation is necessary for companies to adapt to changing conditions in markets, technologies and competences [4,5,6,7,8]. In this thesis I have chosen the definition of a product innovation made by the Organization for Economic Cooperation and Development [9].

The continuous demand of automobile transportation now a days, required more innovation to develop that would compensate the needs of the consumers. The up- grading of automobile technology methods are a major concern of the car industry. The entire car manufacturer throughout the world has been striving to continue improvement of their products like increasing fuel efficiency and less carbon dioxide emissions. In this sustainability effort, a range of technologies have been gaining traction, with the internal combustion engines, higher efficiency power train and different accessories, such as steering system, suspension system, braking system, lighting system, charging system and different sensors. Since charging system is the heart of automotive vehicle the principle behind of these components relays to the operation of this components.

The proposed study will focus in developing automobiles' voltmeter indicator for charging system and current load of the battery. Majority of the car manufacturer throughout the world they don't put voltmeter in the automobile. That's why most of the car owners they do not know where and when to fix the trouble of charging system component. Through this device even do you are not a technician or mechanic you will be able to interpret and understand the result appears in the screen of the gadget. Remember the charging system is the generating system which keeps the vehicles' battery in-charged condition. Basically, the charging system [10] convert mechanical energy into electrical energy when the engine is running. This current load is required to function the entire electrical system of the vehicle. When the current load output is higher than the required by the automobile, it sends current into the battery to stabilized the load.

**1.2 Conceptual Framework of the study**

Input-Process-Output (IPO) framework is a model that consists of concepts that are broadly defined and systematically, organized to provide a focus of the study. This framework emphasizes the flow of the study and specifies the relationship between Input, Process and Output variables by using flowcharts and process diagram. IPO framework is an outline of possible course of action or to present a preferred approach to an idea or thoughts [11]. Input-Process-Output (IPO) framework was utilized by the researcher as general guidelines and main structure in the development of this study. The Input variables were the Product Design and Development of the Car Battery and Charging System Voltmeter Indicator. The Process variables was the acceptability of the Car Battery and Charging System Voltmeter Indicator in terms of: functionality, reliability, aesthetics, safety and convenience. The output variable was the Acceptability of the research study which is the Car Battery and Charging System Voltmeter Indicator.




1.3.1 What is the profile of the respondents in terms of;

1. Age
2. Gender
3. Experience in vehicle maintenance
4. How frequently do you check your car battery's voltage?
5. Do you currently use a voltmeter indicator for your car battery?

1.3.2. What is the level of acceptability of the Car Battery and Charging System Voltmeter Indicator in terms of:

1. Functionality;
2. Reliability;
2. Aesthetics;
2. Safety, and
2. Convenience?

**1.3 Significance of the Study**

The fabrication of car battery and charging system voltmeter Indicator. The actual system of today's automobile that demonstrates charging troubles and problems actually encountered by the vehicle. This proposed study aims to address existing problems encountered by the car owner and technicians during trouble shooting accuracy. Specifically, the car owner will have an actual visualization of the car battery and charging system voltmeter Indicator to monitor the current status of their battery and alternator charging condition. Then, it will be easy for the car owner and technician to familiarize the operation and behavior this device. Also, with this proposed study, the teacher can easily explain the concepts and operating principles of the car battery and charging system voltmeter Indicator (AVR type and IC type alternator).

## 2. Related Studies

According to [12] lundell alternator is the most common power generation device used in cars. It is a three-phase synchronous generator containing an internal three-phase diode rectifier and voltage regulator. The rotor consists of a pair of stamped pole pieces (claw poles), secured around a cylindrical field winding. The field winding is driven from the voltage regulator via slip rings and carbon brushes. The output voltage of the alternator is maintained at about 14V DC, as this is the nominal charging voltage of a 12V lead-acid battery. The voltage is regulated at 14V by an internal controller that continuously samples the battery voltage and adjusts the field current accordingly. Electromagnetic behavior of the alternator with claw-poles and its interaction with the bridge rectifier, the load and the vehicle power system are generally considered as a spatial-temporal feature. Thermal model was validated by comparing calculation of temperature distribution with the measured values.

In our modern world, electricity plays a pivotal role in driving industry and powering the systems used to meet our agricultural, health care, educational, and commercial needs. Among the among impacted industry is the automobile industry. The electrical power demands or requirements in vehicle transportation have been rising rapidly for many years and are expected to continue to rise (Fig. 1). This flow of direction is driven by the replacement of engine-driven loads with electrically-powered versions, and by the introduction and establishment of a wide range of new functionality in vehicles. The continuous increase in power requirements is pushing the limits of typical and traditional automotive power generation and control technology, and is motivating the development of both higher-power and higher-voltage electrical systems and components [13].

The faster the alternator, the more power it can produce. And when there is more power, the faster the charging of battery as the power to be supplied to another electrical consumer is more than enough. Current is inverse with voltage. When the alternator current is high at low speed, battery voltage will drop, and will need more time to get fully charged. But when alternator output current is low at low speed, the battery voltage is high as the battery get enough power for recharging. The Proton Preve used in the experiment has a crankshaft-alternator speed ratio of 1:2. At idling speed, the alternator still manages to supply the current demand from all the consumers, but has to reduce the current needed by the battery to get fully charge. As the speed of the alternator increase, it supplies more current to the consumers thus increase performance efficiency [14]

## 3. Methodology

### 3.1 Research Design

The descriptive research design is use to determine the acceptability of the Car Battery and Charging System Voltmeter Indicator. The participants evaluated the level of acceptability based on the functionality, reliability, aesthetics, safety and convenience

### 3.2 Target Population

The target population of the study are the car owners/drivers and automotive mechanic and technicians. They were chosen in this study considering that they are the direct beneficiary of the innovation.

### 3.3 Participant of the Study

The participants of the study consist of thirty-five (35) car owners/drivers and fifteen (15) automotive mechanic and technicians. They were chosen to evaluate the acceptability of the study.

**Table 1: Participants of the Study**

| Participants | Population size | Percentage |
|---|---|---|
| Car owners/drivers | 35 | 70% |
| Automotive mechanic and technicians | 15 | 30% |
| **Total** | **50** | **100%** |

### 3.4 Sampling Procedure

The researchers chose non-random purposive sampling because this study needs special qualification of the participants. In order to maintain confidentiality and anonymity, respondents were entitled as P1, P2, and so on. The researchers assured them that their confidentiality and privacy would be maintained ethically [15]. All the fifty (50) participants will evaluate the trainer model using descriptive evaluation.

### 3.5 Research Instrument

A researcher made descriptive survey questionnaire was used to determine the acceptability of the of the device. The questionnaire was evaluated by 3 experts in the field of Automotive technology. The rating scale on the acceptability of the trainer model were constructed on the basis of five-point likert-scale.

**Table 2: Five-point likert scale scoring procedure**

| Scale | Range | Description |
|---|---|---|
| 5 | 4.21 - 5.00 | Very Highly Acceptable (VHA) |
| 4 | 3.41 - 4.20 | Highly Acceptable (HA) |
| 3 | 2.61 - 3.40 | Acceptable (A) |
| 2 | 1.81 - 2.60 | Less Acceptable (LA) |
| 1 | 1.00 - 1.80 | Not Acceptable (NA) |

### 3.6 Data Analysis

The Statistical Package for Social Sciences (SPSS) was used to perform the statistical analysis [16]. The data was analyzed using descriptive statistics [17] to determine the profile of the respondents in research question #1 frequency and percentage will be used, on the other hand mean and standard deviation will utilize in research question #2 to determine the level of acceptability of the device.

**3.7 Ethical Consideration**

Ethical principles and considerations were observed throughout this study. It also follows appropriate permission in seeking the data. Further, personal and other important information involved in this study was treated with the highest level of confidentiality in adherence to the Data Privacy Act of 2012 (RA 10173). We properly cite and acknowledge the works of other researchers and materials used in the study. Moreover, the study does not use any offensive or discriminatory language [17]. To follow ethical procedures, the researchers sought permission from the rightful authorities to have the study conducted at their institution. As soon as the permission was granted, the researchers coordinated with the class adviser and began the orientation and filling out of consent forms by students [18].

## 4. Results and Discussion

The results presented in this section sought to answer the research question of this study which was intended to determine the profile of the participants and level of acceptability of the device in terms of functionality, reliability, aesthetics, safety and convenience.

**4.1 Profile of the Respondents**

This section determines the profile of the respondents which includes; Age, Gender, Experience in Vehicle Maintenance, How Frequently you check your car battery, and Do you currently use a voltmeter indicator in your car battery.

**Table 3: Profile of the respondents**

| Profile of the respondents (n=50) | | Frequency | Percentage |
|---|---|---|---|
| Age | Under 18 | 1 | 2% |
| | 18-24 | 5 | 10% |
| | 25-34 | 21 | 42% |
| | 35-44 | 11 | 22% |
| | 45-54 | 10 | 20% |
| | 55 and above | 2 | 4% |
| Gender | Male | 32 | 64% |
| | Female | 18 | 36% |
| Experience in Vehicle Maintenance | Novice | 40 | 80% |
| | Intermediate | 7 | 14% |
| | Expert | 3 | 6% |
| How Frequently you check your car battery | Daily | 2 | 4% |
| | Monthly | 8 | 16% |
| | Occasionally | 12 | 24% |
| | Rarely | 28 | 56% |
| Do you currently use a voltmeter indicator in your car battery | Yes | 5 | 10% |
| | No | 45 | 90% |

Table 3 above shows the profile of the respondent. The study surveyed 50 respondents, with a majority aged between 25-34 years (42%) and 35-44 years (22%). Smaller proportions were aged 45-54 years (20%), 18-24 years (10%), 55 and above (4%), and under 18 years (2%). In terms of gender, 64% of the respondents identified as male, while 36% identified as female. Regarding experience in vehicle maintenance, 80% of respondents classified themselves as novices, 14% as intermediate, and only 6% as experts.

When it comes to car battery maintenance habits, 56% of respondents admitted that they rarely check their car batteries, 24% do so occasionally, 16% monthly, and just 4% check their battery daily. Furthermore, only 10% of respondents reported using a voltmeter indicator in their car batteries, while a significant 90% do not use one.

These findings suggest that many respondents lack experience in vehicle maintenance and do not regularly monitor their car batteries. This indicates a potential need for educational interventions and innovations to promote better vehicle maintenance practices, especially in terms of battery health monitoring. The low adoption rate of voltmeter indicators could be due to limited awareness or accessibility, making it a key area for future initiatives to enhance vehicle safety and reliability.

**4.2 What is the level of acceptability of the Car Battery and Charging System Voltmeter Indicator**

**4.2.1 Functionality**

Functionality refers to the performance and proper operation of these components, particularly as monitored by a voltmeter indicator. It also involves ensuring that both the car battery and the charging system operate within their expected voltage ranges, as indicated by the voltmeter. This ensures the vehicle's electrical systems remain powered and the battery stays charged.

**Table 4: Extent of Acceptability in terms of Functionality**

| Functionality | M | SD | Descr. |
|---|---|---|---|
| The voltmeter indicator measures the voltage of the car battery | 4.62 | 0.49 | VHA |
| The voltmeter provides any warning signals for battery and charging issues effectively | 4.66 | 0.48 | VHA |
| The interpretation of the voltage readings displayed on the light indicator | 4.62 | 0.49 | VHA |
| The voltmeter indicator to changes based on the battery voltage | 4.72 | 0.45 | VHA |
| The voltmeter indicator’s functionality consistent across different vehicles | 4.74 | 0.44 | VHA |
| **Over all M and SD** | **4.67** | **0.47** | **VHA** |

Table 4 shows the results indicate a high level of user satisfaction with the voltmeter indicator's functionalities (M = 4.67, SD = 0.47). Specifically, participants rated the voltmeter's ability to measure battery voltage (M = 4.62, SD = 0.49), provide warning signals (M = 4.66, SD = 0.48), and accurately interpret voltage readings (M = 4.62, SD = 0.49) as very highly acceptable. Additionally, the voltmeter's responsiveness to battery voltage changes (M = 4.72, SD = 0.45) and consistency across different vehicles (M = 4.74, SD = 0.44) were also rated highly.

The consistently high ratings across all functionality aspects suggest that the voltmeter indicator is highly reliable and effective in real-world applications. The low standard deviations further indicate a high level of agreement among users, reinforcing the product’s consistency and quality across various contexts. These findings imply that the voltmeter could be widely accepted in the market and trusted by consumers to perform its intended functions across different vehicle types.

**4.2.2 Reliability**

Reliability in terms of a car battery and charging system voltmeter indicator refers to the consistent and accurate performance of these components in ensuring the vehicle's electrical system operates correctly.

**Table 5: Extent of Acceptability in terms of Reliability**

| Reliability | M | SD | Descr. |
|---|---|---|---|
| The voltmeter and light indicator for battery condition and state of charge provide accurate voltage readings | 4.78 | 0.42 | VHA |
| The voltmeter has a consistent reading under different conditions, such as temperature or load changes. | 4.66 | 0.48 | VHA |
| There is no malfunctioning issue encounter with the voltmeter and light indicator | 4.72 | 0.45 | VHA |
| The voltmeter was recalibrated for accurate readings | 4.76 | 0.43 | VHA |
| The light indicator displays the accurate reading based on the battery and charging condition | 4.66 | 0.48 | VHA |
| **Over all M and SD** | **4.72** | **0.45** | **VHA** |

The table 5 shows the results in terms of reliability, it indicates that the accuracy of voltage readings was rated as very highly acceptable, with a mean of 4.78 and a standard deviation of 0.42. Similarly, the voltmeter's consistency under different conditions, such as changes in temperature or load, was also deemed very highly acceptable (M = 4.66, SD = 0.48). The absence of any malfunctioning issues with the voltmeter and light indicator was rated very highly acceptable as well (M = 4.72, SD = 0.45), as was the recalibration for accurate readings (M = 4.76, SD = 0.43). Lastly, the accuracy of the light indicator in displaying readings based on the battery and charging condition was found to be very highly acceptable (M = 4.66, SD = 0.48). The overall mean reliability score was 4.72 with a standard deviation of 0.45, demonstrating that the reliability of the voltmeter and light indicator is consistently high and very highly acceptable. These findings suggest that the voltmeter and light indicator are dependable instruments, providing accurate and consistent readings under various conditions, with minimal risk of malfunction. This level of reliability is crucial for applications where precise monitoring of battery conditions is essential.

#### 4.2.3 Aesthetics

Aesthetics refers to the design elements, visual appeal, and user experience of the voltmeter's display and interface. It encompasses how the voltmeter looks, how easy it is to read and understand the information it presents, and how it integrates with the overall design.

**Table 6: Extent of Acceptability in terms of Aesthetics**

| Aesthetics | M | SD | Descr. |
|---|---|---|---|
| The design of the device is appealing and user friendly | 4.8 | 0.40 | VHA |
| The color coding used in the voltmeter effectively communicate the charge level | 4.58 | 0.50 | VHA |
| The clarity of symbols and icons used on the voltmeter is properly labeled | 4.68 | 0.47 | VHA |
| The size of the voltmeter and charge monitoring indicator suit the costumers need. | 4.6 | 0.49 | VHA |
| The device is a state-of-the-art design and commercially presentable. | 4.8 | 0.40 | VHA |
| **Over all M and SD** | **4.69** | **0.45** | **VHA** |

Table 6 shows the data on the aesthetics of the voltmeter reveals very high levels of acceptance among users. The mean scores for various aspects of the voltmeter’s design, ranging from 4.58 to 4.8, indicate that users find the device to be highly appealing and user-friendly. Specifically, the design's overall appeal and user-friendliness, as well as its state-of-the-art commercial presentation, received the highest ratings (M = 4.8, SD = 0.40). The color coding for charge levels and the clarity of symbols and icons were also rated highly, with means of 4.58 and 4.68, respectively, and standard deviations of 0.50 and 0.47, suggesting consistent approval among users. The size of the voltmeter and the charge monitoring indicator, rated at 4.6 (SD = 0.49), was also considered very highly acceptable. The overall mean score of 4.69 (SD = 0.45) reflects a strong consensus on the device's aesthetic qualities, highlighting its effectiveness in meeting customer needs and expectations.

The high ratings across all aspects of the voltmeter’s design suggest that users are exceptionally satisfied with its aesthetics and functionality. This positive feedback implies that the device not only meets but exceeds user expectations in terms of visual appeal, ease of use, and practical design. Such strong user acceptance could enhance the device’s marketability and reinforce its competitive in the industry.

#### 4.2.4 Safety

Safety refers to the proper functioning and monitoring of the battery and charging system to prevent damage, electrical failures, or hazardous situations.

**Table 7: Extent of Acceptability in terms of Safety**

| Safety | M | SD | Descr. |
|---|---|---|---|
| The voltmeter indicator is safe while testing the car battery | 4.76 | 0.43 | VHA |
| The device has a warning indicator to notify the user | 4.78 | 0.42 | VHA |

| | | | |
|---|---|---|---|
| The safety precaution was indicated in the device user's manual | 4.74 | 0.44 | VHA |
| The voltmeter and charge monitoring indicator protect against common battery hazards | 4.78 | 0.42 | VHA |
| The visibility of warning signs was clear | 4.8 | 0.40 | VHA |
| **Over all M and SD** | **4.77** | **0.42** | **VHA** |

Table 7 shows the safety features for the voltmeter used in testing car batteries, the results indicate a high level of acceptability across all evaluated criteria. The mean ratings for the safety features ranged from 4.74 to 4.80, with standard deviations between 0.40 and 0.44. Specifically, the safety of the voltmeter indicator while testing the car battery received a mean score of 4.76 (SD = 0.43), and the presence of a warning indicator earned a mean score of 4.78 (SD = 0.42). The inclusion of safety precautions in the device's user manual was rated at 4.74 (SD = 0.44), while the protective features against common battery hazards also received a mean score of 4.78 (SD = 0.42). The clarity of warning signs was rated the highest, with a mean of 4.80 (SD = 0.40). Overall, the mean score of 4.77 (SD = 0.42) across all safety aspects signifies that these features are considered "Very Highly Acceptable" by the respondents.

The consistently high ratings across all safety features suggest that the voltmeter is designed with effective safety measures, making it a reliable tool for users. The strong emphasis on clear visibility of warning signs and comprehensive safety precautions underscores a commitment to user safety, which could enhance user confidence and reduce the risk of accidents during battery operation.

#### 4.2.5 Convenience

Convenience refers to the ease and accessibility with which a driver can monitor the health and status of the vehicle's electrical system. This includes the ability to quickly and accurately check the battery voltage, charging system performance, and overall electrical status without the need for specialized tools or technical expertise.

**Table 7: Extent of Acceptability in terms of Convenience**

| Convenience | M | SD | Descr. |
|---|---|---|---|
| The device is easy to set up | 4.6 | 0.49 | VHA |
| It is more convenient to check the battery condition and state of charge | 4.76 | 0.43 | VHA |
| The position of the device in convenient for the vehicle preventive maintenance | 4.6 | 0.49 | VHA |
| The indicator is easy to read | 4.82 | 0.39 | VHA |
| The device made the user more convenient in driving knowing that their battery and charging is in good condition. | 4.68 | 0.47 | VHA |
| **Over all M and SD** | **4.69** | **0.46** | **VHA** |

Table 7 shows the high levels of user satisfaction with various aspects of the device's convenience, as evidenced by the mean ratings and low standard deviations. Specifically, the device was rated as "Very Highly Acceptable" across all evaluated dimensions, including ease of setup (M = 4.6, SD = 0.49), convenience in checking battery condition (M = 4.76, SD = 0.43), positioning for vehicle maintenance (M = 4.6, SD = 0.49), readability of the indicator (M = 4.82, SD = 0.39), and overall convenience in driving with confidence in battery status (M = 4.68, SD = 0.47). The overall mean rating of 4.69 (SD = 0.46) further supports these findings, suggesting that the device is perceived as highly convenient and effective by users. The consistently high ratings across all convenience-related items indicate that users find the device exceptionally easy to use and beneficial in maintaining their vehicle's battery health.

### 4.3 Summary of the device level of Acceptability

This section shows the summary of the device acceptability across functionality, reliability, aesthetics, safety and convenience.

**Table 8: Summary of the device level of Acceptability**

| Level of Acceptability | M | SD | Descr. |
|---|---|---|---|
| Functionality | 4.67 | 0.47 | VHA |
| Reliability | 4.72 | 0.45 | VHA |
| Aesthetics | 4.69 | 0.45 | VHA |
| Safety | 4.77 | 0.42 | VHA |

| | | | |
|---|---|---|---|
| Convenience | 4.69 | 0.46 | VHA |
| **Over all Mean and SD** | **4.71** | **0.45** | **VHA** |

Based on the data, the overall evaluation of the criteria indicates a high level of acceptability. Specifically, the mean scores for Functionality (M = 4.67, SD = 0.47), Reliability (M = 4.72, SD = 0.45), Aesthetics (M = 4.69, SD = 0.45), Safety (M = 4.77, SD = 0.42), and Convenience (M = 4.69, SD = 0.46) are all categorized as "Very Highly Acceptable." The overall mean score across all criteria is 4.71 with a standard deviation of 0.45, also reflecting a "Very Highly Acceptable" rating. These results suggest that the subject is consistently rated highly across all evaluated dimensions, with Safety receiving the highest mean score, indicating a particularly strong performance in that area. The relatively low standard deviations across the criteria point to a high degree of consistency in the evaluations. This suggests that stakeholders perceive the subject as exceptionally reliable, functional, aesthetically pleasing, safe, and convenient, reinforcing its overall effectiveness and user satisfaction.

## 5. Conclusion

The voltmeter indicator received very high ratings across all evaluated criteria from the respondents. Most users are aged 25-44, predominantly male, with novice experience in vehicle maintenance. The device is highly acceptable for its functionality, reliability, aesthetics, safety, and convenience. It performs well in measuring and interpreting battery voltage, remains reliable under various conditions, and is considered visually appealing and user-friendly. Its safety features and ease of use further enhance its value. Overall, the device's consistent high ratings suggest strong user satisfaction and a promising market reception. This high level of satisfaction suggests that the device is a valuable tool for vehicle maintenance, offering reliable battery monitoring and enhancing user confidence. The positive feedback and consistent high ratings across diverse criteria imply that the voltmeter indicator has a strong potential for widespread adoption and market success, addressing existing gaps in battery monitoring practices and promoting better vehicle maintenance habits.

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