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MINISTRY OF ENERGY AND MINERAL DEVELOPMENT
THE REPUBLIC OF UGANDA

TECHNICIAN TRAINERS' MANUAL | TIER I

# E-MOTORCYCLE

Norad
E4D
BODAWERK

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The manual was prepared and reviewed by the Bodawerk International Ltd.

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# ACRONYMS

| | |
|---|---|
| E4D | Employment and Skills for Development in Africa |
| PREEEP | Promotion of Renewable Energy and Energy Efficiency Programme |
| GIZ | Deutsche Gesellschaft für Internationale Zusammenarbeit |
| MEMD | Ministry of Energy and Mineral Development |
| ATP | Assessment and Training Package |
| DIT | Directorate of Industrial Training |

# INTRODUCTION

The transition to renewable energy in the mobility sector has the potential to decouple the cost of public transport and transportation of goods from the global oil market while reducing pollution and addressing climate change issues. Multiple stakeholders in East Africa have taken up the challenge, trying to initiate or accelerate the transition to Electric Mobility. This process includes its own challenges and hurdles.

One major challenge is the availability of talent with the right skills and tools to support the operations of e-mobility companies and vice-versa, many young East Africans lack the necessary education and skills in relevant fields and trades to participate in the transition to renewable energies. Therefore, there is a gap between the private sector efforts and the current educational and skilling levels among the youth. The transition to renewable energies requires closing of specific skills gaps on the managerial, technical and end-user level.

On the managerial level, modern workplace skills and competencies (including the use of digital solutions, project management and basic technical understanding of renewable energy technologies) are required to ensure the relevance and productivity of Ugandan managers in the e-mobility sector.

For technicians, knowledge about renewable energy technologies, their specific applications e.g. electric motorcycles and hands-on skills to maintain technology are crucial. In the experience of Bodawerk International Ltd, the diagnosis of a problem in an electric vehicle plays a key role.

Additionally, the end-user requires training to ensure a successful technology transfer and sustainable operation of renewable energy technologies. Besides a basic technical understanding, it is of utmost importance to educate users about road safety practices. This includes promoting awareness of traffic rules and regulations, safe driving techniques, and the importance of adhering to speed limits among other safety precautions.

We integrate the inclusion of financial literacy. This is because the technology transfer will largely happen on a financed basis, in order to successfully complete a financing scheme (e.g. lease-to-own/PAYGO), the end-user must understand the key success factors of managing such a loan. A comprehensive understanding of financial concepts is essential for the seamless execution of financing schemes such as lease-to-own or pay-as-you-go (PAYGO).

The development of applied and certified training will allow the Ugandan workforce to benefit from the economic potential of the transition to renewable energies. Vice-versa, the availability of a productive workforce with a sector-specific skill set will enable the growth of the renewable energy sector and specifically e-mobility sector fueled by private sector investments.

## Purpose of the Guide

This manual is an integral component of a comprehensive set consisting of three distinct manuals, individually tailored to cater to three occupations within the electric vehicle industry; managers, technicians, and operators.

The primary purpose of this manual is to provide instruction for trainers or facilitators to plan for and carry out upskilling and in-service training of technicians of the e-motorcycles by any individual or institution interested in providing capacity building for the named category exercitation.

## Using the Manual

This manual focuses on the preparation for organisation, implementation and evaluation of training for e-motorcycle technicians. The intention is to provide trainers or facilitators with basic training techniques and resources summarised in a simple and easily understandable manner. It is expected that trainers or facilitators will employ the processes and approaches prescribed in the manual when training the aforementioned category of e-motorcycle technicians.

Trainers or facilitators should ensure that the content is adapted to suit individual situations and target audiences, including participants skills and experience levels in electrical and mechanical conversion, assembly and testing and repair and maintenance of an e-motorcycle. The content can be presented by a facilitator and/or used by fellow operators whose capacities have been built individually or in groups using methodologies that are appropriate to each module. Training methods and approaches are not rigid and so a facilitator, in his/her planning, should choose the best methods that suit the category and context of a particular group of participants and are included for relevant practical topics.

Whereas training can occur at an offsite (e.g. a temporarily set-up training space) or onsite location, we would very much prefer that training takes place onsite at a fully-fledged e-mobility facility. This is important because actual e-mobility practices and skills can be demonstrated or observed to and by the operators immediately.

A fully-fledged e-mobility facility encompasses a comprehensive infrastructure and resources to support various aspects of electric mobility training key considerations and requirements could be in terms of:

**Physical space:** The training venue should have adequate space to accommodate training activities, including classrooms, practical training areas, and workshops. The size of the space should be determined based on the expected number of trainees and the types of training activities to be conducted.

**Charging Infrastructure:** The training venue should include charging infrastructure to facilitate hands-on training and practical sessions. This includes charging stations or access to charging equipment.

**Vehicle Fleet:** Electric motorcycles should be available at the training venue to provide trainees with hands-on experience.

**Integration with IT systems:** The training venue should have the necessary IT infrastructure to support digital training materials, simulations, and interactive learning experiences. This may include computers, internet access, and software

To ensure that the training is a success, users of this manual should carefully read and fully comprehend the content.

Considering the breadth of knowledge and practical skills to be covered, it is advisable to allocate a duration of 6 days for this intensive training program. This timeframe allows for a structured and in-depth exploration of key concepts while providing ample opportunities for hands-on practice and interactive learning.

To effectively utilise these 6 days, the facilitator should split the training into well-defined modules, each addressing specific aspects of e-mobility. By dividing the content into logical segments, trainees can immerse themselves in focused earning, gradually building their understanding and expertise.

## Target users of the Training Manual

The target users of the manual are individuals and institutions (government, NGO's, private sector players, vocational training institutions) who are interested in building the capacity of electric motorcycle technicians and other complementary competencies.

## Organisation of the Manual

The training program consists of four modules, each with a specific focus.

**Module 1** is an introduction that provides a comprehensive overview of the training, including an introduction to the features and functionality of the electric motorcycle and its different parts and how they differ from the conventional ones.

**Module 2** focuses on Electrical Conversion building the competencies and skills of technicians to convert the conventional petrol-powered power train to the electrical power train used by electric motorcycles.

**Module 3** focuses on building the competencies and skills of technicians' practical transformation of the chassis of the conventional motorcycle to be able to receive the motor and the mounts.

Finally, in **Module 4**, focus on troubleshooting to identify the errors and faults on both the mechanical and electrical components of the e motorcycle Lastly **Module 5** focuses on assessment and evaluation of theoretical and practical assessment during and after completion of the training modules.

The E-Motorcycle Technicians Training Manual provides all the necessary information required to conduct the training effectively. The manual includes a list of learning outcomes that participants will gain during the session. The session overview provides details on teaching methods, time required, and materials needed for each activity. The manual also includes a series of training activities with step-by-step nstructions that explain how to carry out the activities.

# OCCUPATIONAL PROFILE OF ELECTRIC MOTORCYCLE TECHNICIANS

The occupational profile for e-motorcycle technicians defines the duties and tasks that are expected to be performed on job in the sector.

As it reflects the skill requirements of work life, the Occupational Profile is the reference document for the subsequent development of a curriculum, training modules and assessment instruments (test items). These are strongly interconnected with the duties and tasks of an electric motorcycle technician.

A key issue that arises when looking at the Occupational Profile of an e-motorcycle technician is that the e-mobility sector is just developing in Uganda, technicians are not yet easily available in the market and so in this context we shall look at Automotive Mechanics, Solar, Electrical Installation, Electronics and Mechatronics Technicians to form the core pool of personnel from which e-motorcycle technicians can be sourced and trained to perform duties and tasks.

## Duties and Tasks of an EV Technician

By definition, a duty describes a large area of work in performance terms and also serves as a title for a cluster of related tasks. This means the duties of an EV technician within the e-mobility space relates to the broad areas within which their daily activities are clustered, and these are majorly planning for their work, implementation of the planned activities, reporting and documentation for effective delivery of results and also optimum utilisation of resources.

Meanwhile, a task or job tasks represent the smallest unit of job activities with a meaningful outcome. Tasks result in a product, service, or decision. They represent an assignable unit of work and have a definite beginning and ending point. Tasks can be observed and measured.

# Duties and Tasks of an EV Technician

| DUTIES | TASKS | | |
|---|---|---|---|
| **Duty A** | **A1** | **A2** | **A3** |
| Work planning | Identify daily tasks. | Secure workplace. | Prepare workplace. |
| | **A4** | **A5** | **A6** |
| | Prepare budget. | Make consultation. | Mobilise tools, materials and equipment. |
| | **A7** | **A8** | **A9** |
| | Make work plan. | Identify team members. | Develop maintenance schedules. |
| **Duty B** | **B1** | **B2** | **B3** |
| Perform Health, Safety and environmental protection practices | Display safety signs. | Apply safety regulations. | Wear personal protective gear. |
| | **B4** | B5 | **B6** |
| | Carry out first aid. | Maintain hygiene and sanitation. | Sensitise co-workers on occupational hazards. |
| **Duty C** | **C1** | **C2** | **C3** |
| | Diagnose technical faults. | Dismantle an electric vehicle. | Replace faulty parts of the electric vehicle. |
| Repair e-Motor cycle | **C4** | **C5** | **C6** |
| | Provide technical information. | Tighten loose connections. | Assemble electric vehicles to a functional state. |
| **Duty D** | **D1** | **D2** | **D3** |
| Service and Maintain Electric Vehicle | Check and fit back gear cables and clutch cables. | Carry out chain tensioning. | Fasten loose components e.g. the torque on the nuts. |
| | **D4** | **D5** | **D6** |
| | Change the bearings and ball races. | Change Dimmer switches. | Check and replace the gearbox oil. |
| **Duty E** | **E1** | **E2** | **E3** |
| Perform administrative function | Prepare reports | Manage finance | Make both internal and external communications and get appointments and timelines |
| | **E4** | **E5** | **E6** |
| | Organise and take minutes and notes during meetings. | Assign work. | Procure and dispose of tools, materials and equipment |
| **Duty F** | **F1** | **F2** | **F3** |
| Maintain records | Prepare job cards. | Maintain inventory. | Keep track and record of log sheets and equipment maintenance schedule. |
| | **F4** | **F5** | **F6** |
| | Store tools, materials and equipment. | File and store records. | Obtain, keep and use service manuals for the electric vehicles. |
| **Duty G** | **G1** | **G2** | **G3** |
| Participate in Professional Development | Undertake research. | Consult manufacturers and equipment dealers. | Participate in seminars/workshop and other capacity building trainings. |
| | **G4** | **G5** | **G6** |
| | Train for new technology. | Acquire and update new and existing certifications. | Undertake psychometric tests and performance reviews/evaluations/ appraisals. |
| **Duty H** | **H1** | **H2** | **H3** |
| Perform Customer Service function | Advise customers proper use and maintenance of the motorcycles. | Carry out after sales services. | Offer products and services. |
| | **H4** | **H5** | **H6** |
| | Negotiate prices. | Bill services. | Obtain, keep and use service manuals for the electric vehicles. |

# MODULE 1: INTRODUCTION TO E-MOBILITY AND E-MOTORCYCLE

**Overview:** The purpose of this module is to enrich trainees' understanding of the e-mobility space and also how e-motorcycles are different from the conventional ones including knowledge on the different parts and their uses.

## Sub-module 1.1: E-mobility

**Overview:** In this section, we are going to focus on what e-mobility is, why it is a new phenomenon, the advantages and disadvantages that come with it. The module shall also cover the adoption and uptake of e-mobility around the world, East Africa and Uganda specifically.

By the end of the session, participants shall be able to;

1. Understand the e-mobility sector.
2. Understand the adoption and uptake of e-mobility in East Africa.
3. Evaluate the opportunities and challenges for technicians in e-mobility.

Time: 1 Hour

**Tools, Equipment and Materials**

- Computer
- Projector

STEP 1

Welcome trainees to the technician training for e-mobility and ask them to introduce themselves.

- Inquire about the training goals and expectations of the participants.
- Request each participant to jot down their expectations on a sticky note and place them to a previously prepared board designated for expectations.
- Share your own professional background in the field of e-mobility
- Encourage participants who possess relevant experience to provide a brief over view of their own experiences to the entire group.

2 STEP Define e-mobility from a broad perspective listing other types of electric vehicles like electric scooters, bicycles, cars, buses, and tractors show pictures projected on a screen of the various types and discuss each type briefly.

Allow participants to ask questions and provide feedback.

3 STEP Engage in a discussion about the e-mobility industry by utilising visual aids such as logos and images showcasing products or services offered by various players in the sector. This can include a diverse range such as automakers, battery manufacturers, charging infrastructure providers, ride-sharing companies, and asset financing companies, both from local and international contexts

## Sub-module 1.2: Design and functionality of the E-Motorcycle

**Overview:** In this section we shall cover the design of the motorcycle and its different parts/components and their uses. We shall also cover the differences between the conventional motorcycle and the electric motorcycle after under going the conversion process. The advantages and disadvantages of the electric motorcycle measured against the conventional motorcycles shall be explained.

By the end of the session, participants shall be able to;

1. Understand and explain the design of the electric motorcycle and its components
2. Explain the advantages and disadvantages of the electric motorcycle against the conventional motorcycle.

Time: 2 Hours

**Tools, Equipment and Materials**

- Conventional motorcycle
- Converted motorcycle

**NOTE:** In the absence of the two, drawings of them shall be used.

1 STEP Provide participants with a hands-on opportunity to examine and appreciate an electric motorcycle, allowing them to physically interact with the various components that constitute what makes up an electric motorcycle such as electric engine, battery, controller, DC-DC converter.

2 STEP Initiate a discussion among participants to conduct a physical comparison between a petrol-powered motorcycle and an electric motorcycle. Encourage them to explore and identify the key differences between the two types of vehicles.

3 STEP Discuss the advantages and disadvantages of e-mobility. Provide an overview of the benefits that electric motorcycles Simultaneously, discuss the limitations and challenges of e-mobility compared to traditional motorcycles.

4 STEP Engage participants in an interactive session to share insights regarding the advantages and disadvantages of e-mobility. Encourage them to discuss any specific scenarios or considerations that they have encountered.

## Sub-module 1.3: Electric tools used on e-motorcycle

**Overview:** In this section we shall look at the electric tools that are used to carry out the conversion of the conventional motorcycles to electric and their uses.

By the end of the session, participants shall be able to;

1. Identify and properly use electrical tools as per required quality standards.

Time: 1 Hour

### Tools, Equipment and Materials

- Soldering station (gun, blower and wires)
- Measuring/testing tools (tape measure, multimeter)
- Fastening tools (different sizes with the mechanical ones)
- Cutting tools (snip cutters, pliers, tin snips)
- Wire stripperr and crimping tools

1 STEP **Personal Protective Equipment (PPE)**

- Emphasize the importance of wearing appropriate PPE during electrical conversion tasks.
- Outline the recommended PPE, including safety glasses, insulated gloves, and protective clothing.
- Educate technicians on safe working practices and procedures.

2 STEP Highlight the need for technicians to understand the tools used in the electrical conversion and their specific uses.

**Essential Tools for Electrical Conversion such as;**

**Multimeter:**

- Explain the purpose and importance of a multimeter in electrical conversion.
- Describe the various functions of a multimeter, including voltage measurement, continuity testing, and resistance measurement.
- Provide step-by-step instructions on how to use a multimeter effectively and safely.

**Power Inverter:**

- Introduce the concept of a power inverter and its role in converting DC (direct current) to AC (alternating current).
- Discuss the different types and capacities of power inverters.
- Explain the considerations for selecting the appropriate power inverter for a specific electrical conversion project.

**Battery Chargers:**

- Describe the necessity of a battery charger for electric motorcycles. Explain the types of battery chargers available and their specific functionality
- Provide guidelines on how to safely charge and maintain electric motorcycle batteries using a battery charger.

**Wire Strippers and Crimping Tools:**

- Highlight the significance of wire strippers and crimping tools in electrical conversion.

- Explain the proper techniques for stripping and crimping wires. Discuss the different types of wire strippers and crimping tools available and their respective uses.

**Battery Management System (BMS):**

- Describe the role of a BMS in electric motorcycles.
- Explain the functions of a BMS, such as monitoring battery health, balancing cells, and protecting against overcharging or discharging.

**Controller:**

- Introduce the electric motor controller and its significance in regulating motor performance.
- Explain the purpose of motor controllers in managing speed, torque, and regenerative braking.

**DC-DC Converter:**

- Show the participants a DC DC converter.
- Explain the purpose of the DC-DC converter.
- Demonstrate how a DC-DC converter works.

**Accelerator:**

- Show the participants an accelerator
- Explain the purpose of the accelerator
- Demonstrate how an accelerator converter works.

3 STEP

Encourage technicians to further explore new tools and technologies as the field of electrical conversion continues to evolve.

## Sub-module 1.4: Mechanical tools used on e-motorcycles

**Overview:** In this section we shall look at the mechanical tools that are used to carry out the conversion of conventional motorcycles to electric and their uses.

By the end of the session, participants shall be able to:

1. Identify and properly use mechanical tools as per required quality standards.

Time: 1 Hour

**Tools, Equipment and Materials**

- Spanners
- Screwdrivers
- Allen keys
- Angle grinders
- Cutting discs
- Drilling machine
- Adjustable spanners
- Drill bits

1 STEP

Highlight the significance of selecting the right tools and using them correctly for safe and efficient conversions.

Emphasize following manufacturer guidelines, industry standards, and safety regulations when using fastening and cutting tools.

Emphasize proper safety equipment, such as gloves and goggles, should always be worn when working with these tools.

2 STEP

**Essential Tools for Mechanical Conversion such as;**

**Spanners:**

- Describe the different types of spanners, including open-end, ring end and combination spanners.
- Explain their specific uses for fastening and loosening nuts and bolts.
- Provide guidelines on selecting the appropriate spanner size for different applications.

**Screwdrivers:**

- Describe the different types of spanners, including  open-end, ring end and combination spanners.
- Explain their specific uses for fastening and loosening nuts and bolts.
- Provide guidelines on selecting the appropriate spanner size for different applications.

**Allen Keys (Hex Keys):**

- Introduce allen keys and their role in mechanical conversion.
- Explain their use for fastening and loosening hexagonal socket screws.
- Discuss the common sizes of allen keys and their applications.

**Pneumatic impact wrench and Adjustable Spanners (Wrenches):**

- Describe the functionality of adjustable spanners.
- Explain their use for fastening and loosening nuts and bolts of various sizes.

**Cutting and polishing discs:**

- Describe the different types of cutting disks, such as abrasive cutting discs and diamond cuttin discs.
- Explain their specific uses for cutting various materials, such as metal or plastic.
- Provide guidelines on selecting the appropriate cutting disk for different applications.

**Drilling Machine:**

- Introduce the drilling machine and its role in mechanical conversions.
- Explain the types of drilling machines, such as hand-held drills or drill presses.
- Discuss the various drill bits used with drilling machines and their specific applications.

**Drill Bits:**

- Explain the different types of drill bits.
- Discuss their uses for drilling holes of different sizes and materials.
- Guidelines on selecting the appropriate drill bit for specific applications.

## Sub-module 1.5: Quality Control Tools

**Overview:** These are tools that are used for quality assurance and control purposes. In this section, we shall learn how to use these tools for the said purpose.

By the end of the session, participants shall be able to:

1. Comprehend and articulate the tools utilized for quality assurance and control in the e-mobility industry.
2. Gain an understanding of these tools and their significance in ensuring the reliability and consistency of e-mobility systems and components.
3. To effectively implement quality control measures and contribute to the overall improvement and advancement of e-mobility technologies.

Time: 1 Hour

**Tools, Equipment and Materials**

- Computer
- Testing board
- Torque wrenches
- Multimeter

STEP 1 Start by defining quality, importance of importance of quality assurance and control, dimensions of quality

STEP 2 **Quality Assurance and Control**

- Define quality assurance
- Explain the role of quality assurance in preventing defects, identifying potential issues, and establishing processes and standards to achieve consistent quality.
- Define quality control
- Discuss the role of quality control in identifying and addressing deviations from quality requirements, ensuring compliance, and maintaining consistency in output.

STEP 3 **Continuous Improvement**

- Emphasise the importance of continuous improvement in achieving and sustaining high-quality standards.
- Introduce concepts such as Total Quality Management (TQM), which focuses on continuous improvement methodologies and techniques.
- Explain how technicians play a vital role in identifying areas for improvement and contributing to ongoing quality enhancement efforts.

4 STEP

## Quality Tools for Assurance and Control

### Testing Board:

- Describe the purpose and importance of a testing board in quality assurance.
- Explain how a testing board is used to perform various tests and inspections.
- Provide guidelines on utilizing a testing board effectively.

### Quality Checklists:

- Discuss the significance of quality checklists in ensuring consistent and accurate work.
- Explain how quality checklists help technicians follow standardized procedures and identify potential issues.
- Provide examples of quality checklists for different tasks and guide technicians on how to use them efficiently.

# MODULE 2: ELECTRICAL CONVERSION

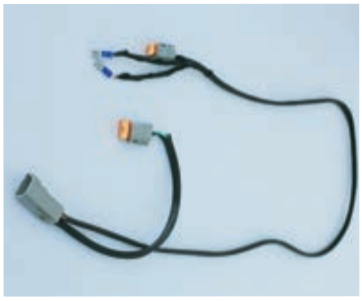
Overview: The purpose of this module is to build the competencies and skills of the participants in the practical transformation of the petrol powertrain of the conventional motorcycle to the electrical powertrain that the e-motorcycles use.

## Sub-module 2.1: The 48V wiring harness

**Overview:** This sub-module shall be used for building the capacity of participants in the interpretation of the wiring diagrams, and preparing them both theoretically and using multimeters.
Orientation to different pins and connectors used in the conversion process

By the end of the session, participants shall be able to;

1. Prepare for wire harnesses assembly
2. Assemble fully functioning harnesses as per the requirement



Time: 2 Hours

**Tools, Equipment and Materials**

- Testing board
- Multimeters
- Wiring diagrams

1 STEP

Before starting the harness preparation process, it is very important to understand its quality requirements needed for an E-bike. This document provides step-by-step procedures on how to ensure the preparation of a quality harness to be used for the E-Bike assembly".

## Preparation

- Ensure your work table is clean and free from any hazard before you start the wiring harness preparation process.

## Operation

Instruct and demonstrate to participants to;

- Measure and cut the cables as per the dimensions; 1020mm of pink wire ( 2pcs), 320 mm of purple and black ( 2 pieces)

- Strip both ends of the cables at least 10 mm.
- Crimp firmly one end of all cables with male pins and the other end of the cables with female pins.
- Fix the side that has male pins into the 6 pin male connector in the orientation of pink cable at position 1, another pink cable is at 2,green cable at position 3, purple in 4 and one black at position 5 and another black at 6.

- Apply 6 pins male lock into the connector with the help of a nozzle plier.
- Apply tesa electrical thread tape for insulation. i.e. ; insulate the two pink wires together, the two black wires together leaving the green and purple wire untaped.
- Cut two braided sleeves at a length of 1000mm and 300mm. Apply heat at the ends of the braided sleeves.
- Insert the insulated cables into the 10mm braided sleeve. i.e; the insulated pinks alone, the two insulated blacks , green and purple into another sleeve.
- Insert the pins of the green, purple and the two black cables into the 6 pin female connector in the orientation of first black cable at position1, second back

- Apply a 6 pin connector lock female to hold the pins firmly into the connector.

- Insert the two pink cables into the 2 pins female connector.
  Apply a 2 pin female lock into the connector.

**Post Operation**

- Instruct and guide participants to ensure that the harness is well prepared,
- Test it by visually looking to ensure the right cable orientation, Test for continuity using a multimeter to ensure that cables are not broken and pins are firmly crimped and Test on a testing board to ensure that it's working. properly

## Sub-module 2.2: The Power Train

**Overview:** This sub-module shall introduce and build the competencies of the participants on understanding, preparing and testing powertrain components ready for assembling.

By the end of the session, participants shall be able to;

1. Prepare a quality power cable with the aim of ensuring all power cable components are fully connected, functioning and are assembled as per the

Time: 8 Hours

**Tools, Equipment and Materials**

- Motor
- DC-DC convertor
- Keyswitch
- Voltage display meter
- 48V harness
- Spanners
- Controller
- Crimping tools (wire stripper, heat gun).
- Soldering station (gun, blower and wires)
- Measuring/testing tools (tape measure, multimeter)
- Fastening tools (different sizes with the mechanical ones)
- Cutting tools (snip cutters, pliers, tin snips)

1 STEP Introduce to participants the power cable quality requirements needed for an E-bike before starting the preparation process.

2 STEP **Pre-Operation**

Guide participants to:

- Ensure your work table is clean and free from any hazard before you start the power cable preparation process.

- Ensure all the necessary tools and materials such as Anderson connectors, Anderson T-handle, Anderson bolts and nuts, Anderson pins, SC10-6 Lugs, 20mm Flexible conduit 900mm long, 8 AWG Black and red cables 1000mm long.

## 3 STEP Operation

Instruct and demonstrate to participants to;

- Cut the 8 AWG black and red cables at a length of 1000mm each.

- Strip both ends of the cables at least 10 mm using a wire stripper.

- Crimp Anderson pins on one end of the cable and SC10-6 lugs on the other end using a pneumatic crimping tool.

- Fix the Anderson cable pins into the connector in the right orientation of Red cable to positive (+) and the black cable to the negative (-).

- Using Anderson bolts and nuts, firmly fix the T-handle onto Anderson connector.

- Insert the conduit to cover both the black and red cables of the Anderson connector.

- Apply silicone sealant to the back of the anderson connector around the cables

## 4 STEP Post Operation

- Guide participants to ensure that the power cables are firmly fixed into the connector and that the polarity is not reversed.

## Sub-module 2.3: Assembly and Testing

**Overview:** This sub-module shall introduce the mounting of the prepared components onto the chassis of the motorcycle and connecting them and making pre and final testing.

By the end of the session, participants shall be able to;

1. Perfectly and smartly wire the Electric motorcycle during conversion function as per the quality requirement.

Time: 8 Hours

### Tools, Equipment and Materials

- Motor
- DC-DC convertor
- Controller
- Spanners
- Soldering station (gun, blower and wires)
- Measuring/testing tools (tape measure, multimeter)
- Fastening tools (different sizes with the mechanical ones),
- Cutting tools (snip cutters, pliers, tin snips)
- Crimping tools (wire stripper, heat gun).

STEP 1 Introduce to participants the power cable quality requirements needed for an E-bike before starting the preparation process.

STEP 2 **Pre Operation**

- Ensure your work area is clean and free from any hazardous items before you start the bike assembly wiring process.
- Ensure all the necessary tools and components for wiring are available in place.
- Ensure that the motor, controller, accelerator, display and DC-DC are mounted firmly on their respective mounting positions.

## Operation

Instruct and guide participants to;

- Insert red the terminal caps on each of the motor phases and the red power cable while the black terminal cap should be inserted on the black power cable.

- Make sure all the motor phase cables are tightened down firmly on their respective terminals.

- Strip off the white and black cables of the bike's 12V harness and crimp SC10-6 lugs on them.

- Connect the positive (red) power cable, the 12V harness (white) input cable for the tracker and the pink cable that comes with the controller onto the B+ terminal of the controller.

- Connect the negative (black) power cable, the 12V (black) ground wire from the DCDC to the B- terminal of the controller.

- Using spanner and torque wrench, ensure firm connection throughout the connected points.

- Using a spanner and torque wrench, firmly connect all the negative terminals from the geared accelerator onto the chassis.

- Connect the 48V harness deutsch controller connector to the controller, the geared accelerator connector to the accelerator and the key switch connector to the key switch.

## STEP 4 Modification of 12V harness

Instruct and guide participants to;

- Connect the DC-DC output cable (yellow cable) to the brown cable of the 12V harness as brown acts as the output cable of the 12V harness.
- Connect the display / dashboard meter positive terminal to the key switch and its negative terminal to the negative terminal of the DC-DC.
- Connect the neutral cable terminal from the 12V harness to the motor neutral cable {light green}.
- Connect the hall sensor connector from the motor to the controller.
- Confirm all the connections made to ensure that everything is tightened well and connected to their right positions and signals. Setting the controller.
- Using the KMC user app, set the motor parameters and bike controls parameters.
- Test the motorbike to ensure that everything is working very well.

**Post Operation**

Instruct and guide participants to;

- Use zip ties to clean up the wiring making sure that the cables are freely moving at the bike steering stem.

- Perform QC visual checks, ensure that all wiring cables are well fitted and the bike is functioning.

- Mount back the fuel tank and the bike seat.

- Using a silicone gun, apply silicon inside the terminal caps and covers or enclosed all connected terminals.

- Cut arches on the side covers so that they can fit around the receiver allowing for a hand to open the receiver latch and mount them on the bike using zip ties.

- Align the bike tyre well and perform a test drive on the bike with a passenger on a steep hill.

# MODULE 3: MECHANICAL CONVERSION

**Overview:** The purpose of this module is to build the competencies and skills of the participants in the practical transformation of the chassis of the conventional motorcycle to be able to receive the motor and the mounts.

## Sub-module 3.1: The Chassis

**Overview:** This section covers the modification of the chassis using the cutting jig and how to mark, drill, grind and polish the surfaces of the prepared chassis ready for mounting the geared motor, the batter receiver, the controller, the DC-DC converter mounts.

By the end of the session, participants shall be able to;

1. Prepare quality bike conversion kits with the right dimension and fit for purpose.

Time: 1.5 Hours for an already chassis.
3 Hours if the chassis is not prepared.

### Tools, Equipment and Materials

- Centre punch
- Scriber
- Hammer
- Drilling machine
- Cutting disks
- Angle grinders
- Polishing discs
- Spray paint
- Cutting jigs

### Pre-Operation

- Ensure that your work area and equipment are clean and free from dust.
- Ensure all the working materials required are present on your workstation.
- Ensure that all trainees are wearing PPE.

## Operation

Instruct and guide participants to;

Preparing Battery Receivers

- Use a cutting disc, cut the required material into pieces with dimension as specified in both material specification document and the receiver component drawing. Using both angle grinder and polishing disc, polish the cut pieces of material in order to remove rust and sharp edges.

- To make the main frame of the battery receiver, align cut pieces of 3mm 30-30 angle bar on the edges of the wooden jig/mold. Using MIG welder, gently weld aligned cut pieces joint to each other while on their respective jig edge.

- Slide the main frame of the battery receiver onto a jig for fixing the to mount.

- Weld the receiver top mount on the centerpiece at the center of the battery receiver main frame.

- With the help of a jig, weld the receiver half top mount on the centerpiece opposite to the top mount.

- Weld the receiver to the bike frame bottom mount onto the receiver main frame at the center.

- Using hinges, weld the receiver lid on the main receiver frame install latches.

- Polish the surface.

- Spray the surface.

## Sub-module 3.2: Mounts

**Overview:** This section covers the different types of mounts like motor mount, controller mount, DC-DC mount, battery receiver, battery case and bottom and top receiver mounts and how they can be fastened and positioned on the chassis ready for receiving the electrical components.

Time: 1hr and 30 minutes

### Tools, Equipment and Materials

- Spanners,
- Screw drivers,
- Allen keys,
- Adjustable spanners
- Angle grinders
- Cutting disks
- Drilling machine
- Drill bits
- Bolts and nuts,
- Washers,
- Lock nuts

Instruct and guide participants to;

### Operator Controller mount preparation

- Cut 1.5mm mild steel material to the required size using plasma cutting technology.
- Create mounting points for controllers and bike connection points. Polish the surface.
- Bend the controller mount to the required shape.
- Spray the surface.

### DC-DC Mount Preparation

- Cut 1.5mm mild steel material to the required size.
- Polish the surface for smooth finishing.
- Bend cut piece to the required shape.
- Drills mounting points at a defined location.
- Spray the surface of DC-DC Mount.

### Motor Mount

- Cut 1.5mm mild steel material to the required size.
- Polish the surface for smooth finishing.
- Bend cut piece to the required shape.
- Drills mounting points at a defined location.
- Spray the surface of the motor Mount.
- Ensure that your work table is clean and clear at the end of the production shift.

2 STEP

### Post Operation

Instruct and guide participants to;

- Switch off all powered devices when not in use.
- Return all tools and the remaining raw material to their respective place of storage.

## Sub-module 3.3: Assembly and Testing

**Overview:** This sub-module covers fixing the mounts onto the chassis and testing the assembly for motor/sprocket alignment, chain tensioning and rear wheel alignment.

By the end of the session, participants shall be able to;

1. Fully assemble all mechanical parts of the bike and ensure the bike functioning as per the quality requirements.

Time: 5 Hours

### Tools, Equipment and Materials

- Centre punch
- Scriber
- Hammer
- Drilling machine
- Cutting disks
- Angle grinders
- Spanners
- Screwdrivers
- Allen keys
- Adjustable spanners
- Drill bits
- Bolts and nuts
- Polishing discs
- Spray paint
- Cutting jigs
- Washers
- Lock nuts

STEP 1 Before starting the assembling of mechanical parts of the bike, it is very important to understand the components and their dimensions required for an E-bike conversion.

## Pre-Operation

Instruct and guide participants to;

- Ensure your work area is clean and free from any hazardous items before you start the assembling of mechanical parts of the bike.
- Ensure all the necessary tools and components such as bolts, nuts, mounts, etc. are available.
- Record the number plate, chassis number and delivery date f or the bike to be converted.
- Check the working condition of all the 12V components i.e all lights and horn.
- Using the right spanners, screwdrivers and allen keys dismantle the bike and put aside the parts that will be reused into a separate container like bolts and nuts, fuel tank, chain, seat and record and store away parts hat will not be used like engine assembly and exhaust system.
- Remove the dashboard/ display of the bike to be converted.

## Operation

Instruct and guide participants to;

- Mount the bike cutting Jig, on the engine mount and trace out the areas to be cut and the holes to be drilled.
- Remove the jig and using an angle grinder, cut away the traced area.
- Using center punch, estimate the center of the holes and drill through ending with a 10mm drill bit.
- Polish the cut edges to have a smooth finishing.

- Insert the motor and controller mounts to their respectives cut parts using the bolts that were originally on the bike and additional two M8x 4 inch bolts.

- Using a spanner and torque wrench, tighten the motor and controller mounts from their respective bolting points.

- Place the motor into the motor mount and the controller into the controller mount matching their respective bolting points.

- Mount the battery receiver onto the bike below the bike tank.

- Mount the DC-DC mount to its respective mounting holes using M5 allen bolts.

- Use a faulty accelerator to mark out the two mounting holes for the accelerator and drill M6 Holes into it.

- Fix the DC-DC onto the DC-DC mount and geared accelerator onto the accelerator mounting holes using M5x 25mm bolts and nuts.

- Complete wiring process by following work instruction BIL/PNA/AWI 08.

**Post Operation**

Guide participants to;

- Tighten down all mounting bolts using a pneumatic impact wrench except for the Display, DC-DC, controller and accelerator.

- Make sure the display, DC-DC, accelerator and controller are tightened down firmly.

- Through QC visual checks, ensure that all the mounted components are well fitted.

# MODULE 4: REPAIR AND MAINTENANCE OF E-MOTORCYCLE

**Overview**: The purpose of this module is to build the competencies of the participants in identifying the errors and faults on both the mechanical and electrical components of the e-motorcycle.

## Sub-module 4.1: Common Faults and their Diagnosis

**Overview:** This sub-module covers the common mechanical and electrical faults that normally present when the motorcycle is being operated.

Time: 1 Hour

### Tools, Equipment and Materials

- Multimeter
- Clamp metre
- Computer installed with software for diagnosing the controller

By the end of the session, participants shall be able to;

1. Identify and explain common mechanical faults during e motorcycle operation
2. Identify and explain common electrical faults during e motorcycle operation.
3. Understand key maintenance practices to prevent faults.

STEP 1

Begin the training session by providing an overview of the training's purpose. Clearly state the learning outcomes participants are expected to achieve.

Emphasize the importance of identifying and addressing common mechanical and electrical faults to ensure safe motorcycle operation.

2 STEP Conduct a pre-assessment to gauge participants' current knowledge and understanding of motorcycle faults. This can be in the form of a short quiz or open-ended questions.

3 STEP Recep from the previous module the key mechanical components in a motorcycle (e.g., brakes, suspension, transmission, engine) and their functions and the key electrical components (e.g., battery, DC DC) and their roles in the motorcycle's operation.

4 STEP Present a comprehensive list of common mechanical faults that can occur during motorcycle operation.

Use visual aids, diagrams, and real-life examples to illustrate each fault. Encourage active participation by asking participants to share any additional faults they might have encountered.

5 STEP Present a list of common electrical faults that can occur during motorcycle operation. Explain the symptoms and consequences of each electrical fault.

6 STEP Conduct demonstrations of fault identification using Multimeter, clamp metre, computer installed with software for diagnosing the controller. Provide participants with the opportunity for hands-on practice.

7 STEP Explain the significance of regular maintenance in preventing faults and ensuring optimal e motorcycle performance.
Present a checklist of key maintenance practices and recommended intervals for service.

## Sub-module 4.2: Diagnosis and Troubleshooting

**Overview:** This sub-module covers checking of loose connections, testing voltages of each component, and continuity in the circuit.

By the end of the session, participants shall be able to:

1. Understand and apply systematic troubleshooting techniques to common mechanical and electrical faults of an electric motorcycle.

Time: 1 Hour

**Tools, Equipment and Materials**

- Multimeter
- Clamp metre
- Computer installed with software for diagnosing the controller.

STEP 1 Emphasise the importance of following a systematic approach when troubleshooting e motorcycle faults. Encourage participants to start with basic observations and tests before diving into complex diagnostics.

STEP 2 Instruct participants to gather relevant information, such as the history of the issue, any recent maintenance or repairs, and specific symptoms observed during motorcycle operation.

STEP 3 Demonstrate the significance of a thorough visual inspection of the motorcycle's mechanical and electrical components. Participants should check for visible damages, loose connections, leaks, or signs of wear.

STEP 4 Encourage participants to listen carefully while operating the motorcycle to detect any unusual sounds, vibrations, or odors that might indicate potential faults.

STEP 5 Show participants how to perform basic tests such as checking the battery voltage explain what results might indicate a fault.

STEP 6 Provide trainees with different scenarios involving motorcycle faults, and encourage them to apply the systematic approach to identify and diagnose the issues correctly.

STEP 7 Provide trainees with different scenarios involving motorcycle faults, and encourage them to apply the systematic approach to identify and diagnose the issues correctly.

## Sub-module 4.3: Battery Charging Techniques

**Overview:** This sub-module covers techniques of selecting and using the right charges, the importance of fully charging a battery and how to make correct connections between the battery connector and the charger connector. Additionally the techniques of setting the correct charging current and the different charging systems of solar and grid power.

By the end of the session, participants shall be able to;

1. Properly place a depleted or used battery to either an AC-DC wall socket charger or hybrid inverter chargers.

Time: 1 Hour

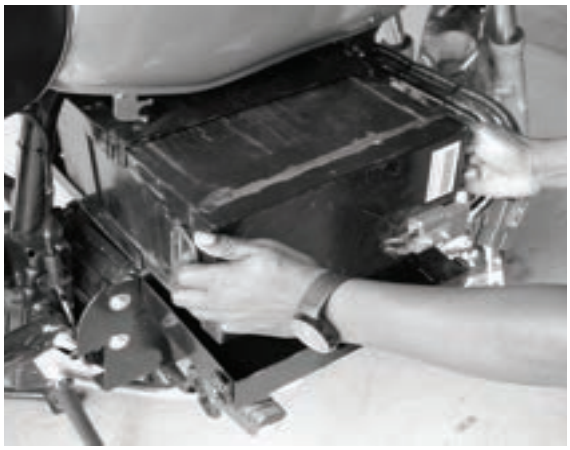
**Tools, Equipment and Materials**

- Charging station
- Multimeter
- The charger

STEP 1 Begin by explaining what battery charging is.

- Define and briefly explain common terms used such as Life span, Voltage, Current, Capacity of Battery, Ampere-hour,Power, Energy, Battery energy density.

A cell. State of charge (SOC), Depth of Discharge( DOD), Battery management system( BMS)



2 STEP Inorder to explain the time a battery takes to charge

- Explain using Bodawerk Smart Battery as an example
- A 4.6kw battery stores approximately 4.6 yaka units
  **(1 unit of yaka= 1000W/ 1KW).**
  Therefore **4.6KW** = (1×4.6) = **4.6** yaka units
- Discuss various chargers of different currents(A) that can be used,such as ; 5A, 10A, 20A, 30A,among others.
- Explain to participants that the time the battery takes to charge depends on the rating of the charger. i.e;

From: P=IV And Energy =IVT = PF

Units: I = [A] Ampeere

V = [V] Voltages

Explain Powerand Power over time to the participants though exxamples.

**Examples for trainees:**

- A 20A Charger takes roughly 4-5 hours to fully charge the battery.
- A 10A charger takes 8 hours of constant current.
- 5A Charger takes 16 hours

**NOTE:** the discharge will depend on the usage/load.

3 STEP **Give participants a quick quiz**

Qn: how long does a 5A, 30A and 10A charger take to fully charge the battery?

4 STEP Discuss cable sizing techniques and current capacity

5 STEP Ask participants to suggest what would constitute safe charging precautions.

- Provide feedback on each suggested precaution.
- Ensure all safety precautions are covered within the discussion.

6 STEP Introduce the concept of battery swapping. Using pictures projected on a screen discuss the step-by-step procedures or processes involved in battery swapping.

**6 Steps of Service - should take max 3 minutes**

Step 1:

- Greet the Customer
- Welcome the customer to the battery swap station.
- Ask the customer if they have used the station before and if they need any assistance.

Step 2:

- Prepare the Battery.
- Verify that the battery to be swapped is fully charged and in good condition.
- Remove the battery from the motorcycle and place it on the charging dock.

Step 3:

- Retrieve a fully charged replacement battery from the battery storage rack.
- Install the replacement battery onto the motorcycle, ensuring proper alignment and connection.

Step 4:

- Verify and demonstrate the Connection.
- Check the battery connection to confirm that it is secure and properly connected.
- Demonstrate how to check the battery display screen on the motorcycle to ensure it is charging.
- Explain how the customer can monitor the battery status and range on their motorcycle display.

Step 5:

- Record in Smartsheets and collect payment.
- Record the battery swap in smart sheets to track usage and maintenance history.
- Complete Mobile Money Payment in the system.

Step 6:

- Thank the customer.
- Thank the customer for using the battery swap station and ask if they have any further questions or needs.
- Say goodbye to the customer and wish him a good journey (Go Well).

By following this 6-step process, the customer attendant can create a friendly and interactive experience for each customer, helping to build trust and loyalty. This process is designed to be simple and straightforward, with clear instructions and demonstration, allowing the customer to feel confident in their ability to swap batteries and use their electric motorcycle effectively.

Step 7:

Ask participants to role-play acting as swap officers and customers and act out the battery-swapping process.

## Sub-module 4.4: Waterproofing

**Overview:** This sub-module covers how to waterproof connectors, the motors and controllers.

Time: 1 Hour

### Tools, Equipment and Materials


Silicon gun


Silicon

### 1 STEP Pre Operation

- Ensure your work table is clean and free from any hazard before you start the motor preparation process.
- Ensure all the necessary tools and materials such as RTV silicone sealant, 4mm allen keys, 8mm socket with ratchet handle.

### 2 STEP Operation

**Instruct and guide participants to;**

- Ensure your work table is clean and free from any hazard before you start the geared motor preparation process.
- Ensure all the necessary tools and materials such as RTV silicone sealant, 4mm allen keys, 8mm socket with ratchet handle.
- Open the 6 allen bolts around the phase cables on the motor using 4mm allen key and remove the cover.

- Open the 4 M6 bolts on the motor housing using an M8 socket and ratchet.
- Use a soft mallet to tap open the motor casing.
- Push in the cables so that the motor opening can be bigger.
- Remove the original gasket which is no longer usable.
- Use RTV silicone sealant to cover the hall sensor board completely.
- Use silicone grease to cover around the exposed area of the bearing
  Apply Sikaflex on the mating surfaces of the motor housing.
- Screw back all the bolts tightening them in the diagonal manner evenly and use a torque wrench to do the final tightening.
- Screw back the allen bolts and tighten them down to the right torque.
- Apply RTV silicone sealant around the cables at the area where they mate with the housing.
- Apply Araldite outside all the mating surfaces of the housing.


**Post Operation**

Instruct and guide participants to;

- Inspect the housing mating surfaces to ensure that the mating surfaces are sealed well.

## Sub-module 4.5: Chain and Rear Sprocket Alignment

**Overview:** This sub-module covers how the chain tensioners are used in aligning the wheel in a straight line to control damage to the sprocket bearing in cases where the rear tyre is wobbling.

By the end of the session, participants shall be able to;

1. Understand how the chain tensioners are used in aligning the wheel in a straight line to control damage to the sprocket bearing.

Time: 1 Hour

### Tools, Equipment and Materials

- Sprocket gauge
- Assorted spanners (numbers 30, 27, 19, 17, 13 and 10)
- Ratchet spanners.

STEP 1

Begin the training by providing participants with an overview of the importance of chain and sprocket systems in electric motorcycles and their role in transmitting torque/power. Explain the potential issues that can arise from improper installation or maintenance.

Utilise visual aids such as diagrams, charts, and cutaway models to enhance the participants' understanding of chain types, sizes, sprockets, and their corresponding hubs.

STEP 2

Ask participants to touch different chain types and sizes. For example, pro video samples of chains and sprockets for participants to examine closely and discuss their characteristics.

STEP 3

Show participants the sprocket mounting on the hub, and provide them with bikes or bike components to practice mounting the sprockets themselves.

4 STEP Demonstrate sprocket alignment using tools such as the sprocket gauge, but also encourage participants to actively participate in the alignment process.

5 STEP Provide step-by-step instructions and guide them through the alignment procedure, allowing them to adjust the chain tension and achieve proper alignment independently.

6 STEP Provide an opportunity for chain adjustment exercises to practice adjusting the chain tension on their own. Guide them through the process while explaining the importance of proper tensioning.

7 STEP Present participants with scenarios where they need to determine when it's necessary to change the entire chain tensioning system. Encourage them to analyze the situation, consider factors such as wear, damage, and safety, and make informed decisions.

# MODULE 5: ASSESSMENT AND EVALUATION

**Overview:** This section covers assessment for learning (AFL), Assessment of Learning (AOL) and assessment as learning (ASL) that shall be employed during and after the completion of the training of modules. These shall take the form of both formative and summative assessments.

## Sub-module 5.1: Theoretical Assessment

**Overview:** This section covers assessment for learning (AFL), Assessment of Learning (AOL) and assessment as learning (ASL) that shall be employed during and after the completion of the training of modules. These shall take the form of both formative and summative assessments.

Time: 2 hours: Throughout the different sessions.

### Tools, Equipment and Materials

- Testing items
- Physical items
- Digital

1. Electromobility represents the concept of using electric power train technologies in-vehicle information and communication to enable electric vehicle propulsion. TRUE or FALSE
   a) TRUE
   b) FALSE

2. The following are the advantages of electric motorcycles except?
   a) Low running costs
   b) Environmentally friendly since there is no pollution.
   c) Over current and voltage protection.

3. An electric motorcycle uses the following form of current.
   a) AC
   b) DC

4. For the electric motorcycle to be electric, it should have the following components: Motor controller, Regulator, stator, Motor, Battery, and harness.
   a) None
   b) Only four
   c) All

5. A motor controller is one of the components used on an electric motorcycle, what is the importance of this component?

6. The system supplies a voltage of 48 and a nominal capacity of 44Ah, the energy available in the system is?
   a) 4.6kwh
   b) 2.112KW
   c) 3.7KWh
   d) 2.112kwh

7. The current of 10A flowing through a 22 AWG cable counters a resistance of 30hms. What is the power in kWh
   a) 300W
   b) 3.5Kkwh
   c) 0.3kwh
   d) None.

8. Briefly describe how you would determine a faulty bearing.

9. How do you tell if the motorcycle chain is properly tensioned?

10. The following are the importance of changing motor oil except?
    a) Keep Your Engine Clean
    b) Longer Engine Life
    c) Lubrication
    d) Proper lighting systems of the electric Motorcycle.

## Sub-module 5.2: Practical Assessment

**Overview:** This section covers assessment for learning (AFL), Assessment of Learning (AOL) and assessment as learning (ASL) that shall be employed during and majorly after the completion of the training of modules. These shall majorly take the form of summative assessments.

Time: 2 hours: Throughout the different sessions.

### Tools, Equipment and Materials

- Multimeter
- Wiring diagram
- Sprocket gauge
- Screwdrivers
- Allen keys
- Assorted spanners (nos 30, 27, 19, 17, 13 and 10)
- Ratchet spanners.

### Practical Assessment

1. Draw a schematic wiring of an electric motorcycle and briefly explain its working principle.

2. Mention the key components in the explanation and the flow of current and signals.

3. The controller provides the following control switches, forward and reverse, engine brake, three gears, throttle/accelerator and controller power ( controller enable. The controller also provides one power wire (red for all switches.

4. Draw a wiring diagram having all the switches. Include the voltage for each switch/ signal. Use 6 pins, 2 pins, and 3 pin connectors on the diagram.

5. Draw a simple wiring diagram for the lighting system having a headlight switch, headlight, indicator switch , two indicators( left and right), flasher, horn switch horn, dc-dc converter and a 5A Fuse.

6. Briefly explain the circuit.

7. Draw the following waveforms:
   a. Pulsating dc waveform
   b. Modified AC waveform
   c. Pure sine wave
   d. Dc waveform ( do research)

8. Use plain paper to draw these schematics.