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CENTRE OF EXCELLENCE
for E-Mobility and Electric Vehicle

L&T
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EXPERIMENTAL MANUAL

Course 1 Experimentation Manual

**Centre of Excellence
for E-Mobility and
Electric Vehicle**

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Experiment 1: Understanding the Internal Architecture and Hardware Wiring of a Commercial Electric Vehicle (EV) Bike

Objective

To understand the internal architecture of a commercial electric vehicle (EV) bike, focusing on hardware wiring, powertrain components, and overall vehicle design. This experiment will provide hands-on experience with the electrical and mechanical systems of an EV bike.

Equipment Required

- EV bike (refer to the attached manual)
- Screwdrivers and wrenches (for opening panels and accessing components)
- Insulation tape and cable ties (for securing wiring)
- Notebook and pen (for recording observations)
- Safety gloves and goggles
- Camera (for documenting the internal architecture and wiring)

Theory

Electric Vehicle (EV) Architecture

The architecture of an EV bike includes various components that work together to provide power, control, and safety. Key components include:

1. **Battery Pack:** Stores electrical energy required to power the motor and other electrical components.
2. **Electric Motor:** Converts electrical energy from the battery into mechanical energy to drive the bike.
3. **Motor Controller:** Manages the power supplied to the motor, controlling speed and torque.
4. **Battery Management System (BMS):** Monitors and manages the battery pack to ensure safe and efficient operation.
5. **Charger:** Replenishes the battery pack with electrical energy from an external power source.

6. **DC-DC Converter:** Converts the high-voltage battery power to a lower voltage suitable for auxiliary systems.
7. **Throttle:** Controls the speed of the motor based on user input.
8. **Brake System:** Includes regenerative braking, which converts kinetic energy back into electrical energy during braking.
9. **Display and Controls:** Provides information to the rider and allows interaction with the vehicle's systems.
10. **Wiring Harness:** Connects all electrical components, ensuring proper power and signal flow.

Understanding these components and their wiring is crucial for diagnosing issues, performing maintenance, and optimizing the EV bike's performance.

Procedure

1. **Initial Setup:**
 - Park the EV bike on a stable surface.
 - Ensure the bike is turned off and the key is removed.
 - Wear safety gloves and goggles.
2. **Battery Pack Inspection:**
 - Locate the battery pack as per the manual.
 - Use screwdrivers to carefully open the battery compartment.
 - Observe the battery connections, noting the positive and negative terminals.
 - Record observations with notes and photos.
3. **Motor and Controller Examination:**
 - Locate the electric motor and controller.
 - Trace the wiring from the battery to the motor controller and then to the motor.
 - Note the connections and wiring colors.
 - Record observations with notes and photos.
4. **Battery Management System (BMS):**
 - Locate the BMS within the battery compartment or near the battery pack.
 - Observe the wiring connections to the battery cells and the BMS unit.
 - Record observations with notes and photos.
5. **DC-DC Converter and Auxiliary Systems:**
 - Identify the DC-DC converter.

- Trace the wiring from the converter to auxiliary systems like lights, horn, and display.
- Record observations with notes and photos.

6. Throttle and Brake System:

- Locate the throttle and observe its wiring to the motor controller.
- Note the connections and how the throttle is integrated into the system.
- Locate the brake system and observe the wiring for regenerative braking (if applicable).
- Record observations with notes and photos.

7. Display and Controls:

- Identify the display unit and control buttons/switches.
- Trace the wiring from the display to the main controller.
- Observe how the display interacts with the bike's systems, showing speed, battery level, and other information.
- Record observations with notes and photos.

8. Wiring Harness Inspection:

- Inspect the overall wiring harness, noting how different components are interconnected.
- Look for any signs of wear, damage, or loose connections.
- Secure any loose wires with insulation tape or cable ties.
- Record observations with notes and photos.

9. Documentation and Analysis:

- Create a detailed diagram of the EV bike's internal wiring and component layout.
- Annotate the diagram with wiring colors and component connections.
- Analyze the wiring architecture for potential improvements or areas that need maintenance.

Data Collection Table

Component	Location	Observations
Battery Pack		



Electric Motor		
Motor Controller		
Battery Management System (BMS)		
DC-DC Converter		
Throttle		
Brake System		
Display and Controls		
Wiring Harness		

Analysis and Discussion

1. Component Interactions:

- Discuss how the battery, motor, controller, and other components interact to power the EV bike.
- Analyze the efficiency of the powertrain and suggest potential improvements.

2. Wiring Integrity:

- Evaluate the condition of the wiring harness.
- Identify any areas that may require maintenance or replacement.

3. Safety Considerations:



- Discuss the safety features incorporated into the EV bike's design, such as the BMS and regenerative braking.
 - Suggest additional safety measures that could enhance the bike's operation.
4. **Optimization Opportunities:**
- Identify opportunities for optimizing the wiring and component layout for better performance and ease of maintenance.
 - Propose any modifications that could improve the bike's efficiency or reliability.

Conclusion

Summarize the key findings from the experiment, emphasizing the importance of understanding the internal architecture and wiring of a commercial EV bike. Highlight how this knowledge can aid in troubleshooting, maintenance, and performance optimization.

Safety Precautions

- Always wear safety gloves and goggles when handling electrical components.
- Ensure the EV bike is turned off and the key is removed before beginning any work.
- Be cautious of high-voltage components and connections.
- Follow all safety protocols provided in the EV bike manual.

Experiment 2: Analysis of Hub Motor Using Mechanical Loading

Objective:

To analyze the performance of the hub motor under various mechanical loading conditions and observe the impact of different throttle inputs and other accessories on motor performance.

Equipment Required:

1. 2-wheeler EV simulator
2. Spring weigh (newton meter)
3. Multimeter (for voltage and current measurements)
4. Power supply (integrated within the simulator)
5. Mechanical load setup

Components Involved:

1. Hub Motor
2. Throttle Control
3. Voltmeter and Ammeter
4. Brake Light Indicator
5. Headlight Indicator
6. Blinkers

Theory:

Hub Motors in Electric Vehicles

Hub motors are electric motors integrated directly into the wheel hub, making them an efficient and compact solution for electric vehicles (EVs). They eliminate the need for transmission and drive shafts, offering direct drive to the wheels, which improves efficiency and simplifies the vehicle's mechanical design.

Working Principles of Hub Motors

1. **Design and Structure:**

- **Stator:** The stationary part of the motor, mounted to the vehicle frame. It contains windings through which current flows, creating a magnetic field.
 - **Rotor:** The rotating part connected to the wheel hub. It contains permanent magnets that interact with the magnetic field produced by the stator windings, causing rotation.
 - **Bearings:** Allow the rotor to spin freely within the stator.
 - **Controller:** Manages the power supplied to the stator windings, controlling the speed and torque of the motor.
2. **Operation:**
- **Electromagnetic Interaction:** When current flows through the stator windings, it generates a magnetic field. This field interacts with the permanent magnets on the rotor, producing a force that causes the rotor to turn.
 - **Pulse Width Modulation (PWM):** The controller uses PWM to regulate the voltage and current supplied to the motor. By adjusting the duty cycle of the PWM signals, the controller can precisely control the motor's speed and torque.
 - **Feedback Mechanism:** Sensors (e.g., Hall effect sensors) provide feedback on the rotor position and speed, allowing the controller to adjust the current flow and maintain optimal performance.
3. **Advantages of Hub Motors:**
- **Efficiency:** Direct drive reduces energy losses associated with transmission components.
 - **Simplicity:** Fewer mechanical parts result in lower maintenance requirements.
 - **Compactness:** Integrating the motor into the wheel hub saves space and allows for more flexible vehicle designs.
4. **System Stabilization:** When recording each reading, switch on the machine and wait for 100 seconds to allow the system to stabilize.
5. **Recording Preparation:** Before taking each reading, switch off the machine and wait for another 100 seconds for the system to stabilize.
6. **Weight Limits:** Take readings within a weight range of 5 kg to 17.5 kg.

Mechanical loading refers to the application of resistance to the motor's rotation, simulating real-world driving conditions. This resistance can come from various sources, such as the vehicle's weight, road friction, and aerodynamic drag.

1. Types of Mechanical Loads:

- **Constant Load:** A fixed resistance that remains unchanged during operation.
- **Variable Load:** Resistance that changes with speed, terrain, or other factors.

2. Impact of Mechanical Loading:

- **Performance:** The motor's ability to maintain speed and torque under different loads is crucial for vehicle performance.
- **Efficiency:** Higher loads typically require more power, affecting the overall efficiency of the motor.
- **Thermal Management:** Increased loads generate more heat, necessitating effective cooling mechanisms to prevent overheating.

3. Testing Mechanical Loading:

- **Load Simulators:** Devices that mimic the effects of real-world loads, allowing for controlled testing of motor performance.
- **Data Collection:** Sensors and meters measure parameters such as speed, current, voltage, providing data for analysis.
- **Analysis:** Evaluating the motor's response to different loads helps in optimizing its design and performance.

Procedure:

1. Initial Setup:

- Ensure the simulator is connected to a power source and the control panel is functional.
- Verify all connections are secure and the emergency stop button is not engaged.

2. Throttle Control Calibration:

- Set the throttle control to the minimum position (0%).
- Gradually increase the throttle to 100% in increments of 20%.
- Measure and record the voltage, current, and motor speed at each increment.

3. Mechanical Loading:

- Use the spring weigh to apply a mechanical load to the hub motor.
- Measure the force applied using the spring weigh.
- Gradually increase the load and observe the changes in motor performance.

4. Parameter Measurement:

- At each throttle position (20%, 40%, 60%, 80%, 100%) and load condition (no load, half load, full load), measure the following parameters:
 - Voltage across the motor
 - Current through the motor
 - Input voltage and current
 - Motor efficiency
 - Activation of brake light indicator
 - Activation of head light indicator
 - Activation of blinkers

5. Data Collection:

- Compile all the readings in a tabular format.
- Analyze the relationship between throttle input, load conditions, and motor performance.

Observations:

Throttle Position : 0%

Load (kg)	Voltage (V)	Current (A)	Weight 1 (Kg) (W1)	Weight 2 (Kg) (W2)	RPM	Torque = (W2-W1)* 9.8*0.14M	Input Power	Output Power= (2*3.14*R.P.M* TORQUE)/60	Efficiency
5									
7.5									
10									
12.5									



15									
17.5									

Throttle Position : 25%

Load (kg)	Voltage (V)	Current (A)	Weight 1 (Kg) (W1)	Weight 2 (Kg) (W2)	RPM	Torque = (W2-W1)* 9.8*0.14M	Input Power	Output Power= (2*3.14*R.P.M* TORQUE)/60	Efficiency
5									
7.5									
10									
12.5									
15									
17.5									

Throttle Position : 50%

Load (kg)	Voltage (V)	Current (A)	Weight 1 (Kg) (W1)	Weight 2 (Kg) (W2)	RPM	Torque = (W2-W1)* 9.8*0.14M	Input Power	Output Power= (2*3.14*R.P.M* TORQUE)/60	Efficiency
5									



7.5									
10									
12.5									
15									
17.5									

Throttle Position : 75%

Load (kg)	Voltage (V)	Current (A)	Weight 1 (Kg) (W1)	Weight 2 (Kg) (W2)	RPM	Torque = (W2-W1)* 9.8*0.14M	Input Power	Output Power= (2*3.14*R.P.M* TORQUE)/60	Efficiency
5									
7.5									
10									
12.5									
15									
17.5									

Analysis:

- Evaluate the impact of different throttle positions on motor performance.
- Analyze how mechanical loading affects motor voltage, current, and speed.





- Study the activation and performance of brake light, head light, and blinkers under various conditions.

Conclusion:

Summarize the findings, highlighting the performance characteristics of the hub motor under different throttle and load conditions. Discuss the practical implications for EV design and the importance of accessory performance in overall system efficiency.

Experiment 3: Understanding of Various Power Electronics Converters and Parameter Measurements at Various Test Points

Objective:

To understand the functioning of different power electronics converters used in the 2-wheeler EV simulator and measure key parameters at various test points under different operating conditions.

Equipment Required:

1. 2-wheeler EV simulator
2. Multimeter (for voltage and current measurements)
3. Connecting wires
4. Power supply (integrated within the simulator)

Components Involved:

1. Control Panel
2. Step-down DC Converter
3. Hub Motor
4. Throttle Control
5. Voltmeter and Ammeter

Theory:

Power electronics converters are essential in electric vehicles (EVs) for controlling and managing the flow of electrical energy from the battery to the various components, especially the motor. They are responsible for ensuring that the power is delivered efficiently, reliably, and in a manner that maximizes the performance of the EV.

Types of Power Electronics Converters:

1. **DC-DC Converters:**
 - **Function:** DC-DC converters step up or step down the DC voltage from the battery to match the voltage requirements of various components.

- **Types:**
 - **Buck Converter:** Steps down the voltage.
 - **Boost Converter:** Steps up the voltage.
 - **Buck-Boost Converter:** Can step up or step down the voltage as needed.
- **Importance in EVs:** They regulate the voltage supplied to the motor, control systems, and other electronic devices, ensuring they operate within their specified voltage ranges.

2. Inverters:

- **Function:** Inverters convert DC voltage from the battery to AC voltage required by the motor.
- **Types:**
 - **Single-phase Inverter:** Used in smaller applications.
 - **Three-phase Inverter:** Commonly used in EVs for driving the motor.
- **Importance in EVs:** Motors in EVs typically operate on AC power, making inverters crucial for converting the DC power from the battery to AC power.

3. Motor Controllers:

- **Function:** Motor controllers regulate the power supplied to the motor, controlling speed, torque, and direction.
- **Types:**
 - **Brushless DC Motor Controller:** Used with brushless DC motors.
 - **AC Motor Controller:** Used with AC induction motors.
- **Importance in EVs:** They manage the performance of the motor based on user inputs (such as throttle position) and feedback from sensors, optimizing the vehicle's performance and efficiency.

Procedure:

1. Initial Setup:

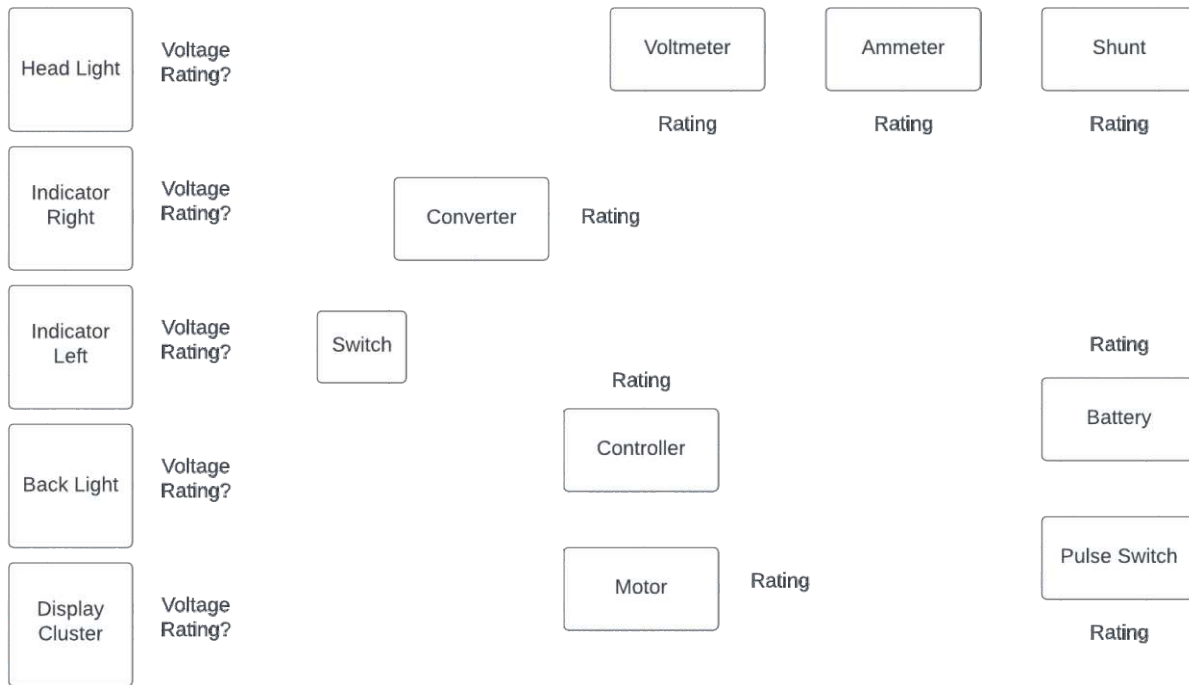
- Ensure the simulator is connected to a power source and the control panel is functional.
- Verify all connections are secure and the emergency stop button is not engaged.

2. System Overview:

- Familiarize yourself with the entire EV simulator kit, noting the locations and functions of all components (Control Panel, Display Screen, Connections and Terminals, Brake Light Indicator, Simulated Load, Spring Weigh, Controller, Hub Motor, Step-down DC Converter, Blinkers, Physical Toggle, Banana Connectors, Throttle Control, Voltmeter, Ammeter, and Head Light Indicator).
- 3. DC-DC Converter Analysis:**
 - Identify the DC-DC converter on the control panel.
 - Highlight the specifications of the converter used.
- 4. Controller Analysis:**
 - Locate the controller section of the simulator.
 - Highlight the specifications of the inverter used.
- 5. Motor Analysis:**
 - Locate the motor section of the simulator.
 - Highlight the specifications of the motor used.
- 6. Accessory Functionality Testing:**
 - Test the activation and functionality of accessories such as the brake light indicator, headlight indicator, and blinkers.
 - Measure the voltage and current drawn by these accessories when activated.

Observations:

- 1: Prepare the schematic of the simulator test bench and complete the connections.



2: Highlight the characteristics and properties of the individual components used in the simulator machine.

Component	Specifications	Usage

Analysis:



- Study the machine in detail and understand the placement of the individual components.
 - Study the specifications of the individual components.
 - Understand the schematic and interconnection of the components within the machine set.
-

Experiment 4: Wiring an EV Design on a 2D Board

Objective

To understand and practice the process of wiring an electric vehicle (EV) design on a 2D board using color-coded raw wires. This experiment will help participants learn proper wiring techniques, component connections, and the importance of organized and efficient wiring in EV systems.

Equipment Required

- 2D EV design board (provided)
- Color-coded raw wires (various colors)
- Wire strippers and cutters
- Soldering iron and solder (if required)
- Insulation tape and cable ties
- Marker or labels for wire identification
- Notebook and pen (for recording observations and explanations)
- Presentation materials (e.g., poster board, markers, slides)

Theory

Wiring in Electric Vehicles

Wiring is a critical aspect of electric vehicle design, ensuring that all electrical components are properly connected and receive the correct voltage and current. Proper wiring ensures the safety, reliability, and efficiency of the EV. Key concepts include:

1. **Color Coding:** Different colors are used to identify different types of wires and their functions. Common color codes include:
 - Red: High power supply
 - Blue: Low power supply
 - Yellow/Green/other: Signal or communication wires
2. **Wiring Diagram:** A schematic representation of the electrical connections within the EV, showing how components are interconnected. This diagram is crucial for troubleshooting and maintenance.

3. **Component Connections:** Understanding how to connect various components such as the battery, motor, controller, throttle, and auxiliary systems is essential for proper wiring.
4. **Safety:** Ensuring that all connections are secure, insulated, and free from shorts or exposed wires to prevent accidents and component damage.

Procedure

1. **Initial Setup:**
 - Gather all the required equipment and ensure the 2D EV design board is placed on a stable surface.
 - Review the EV design on the board and familiarize yourself with the components and their locations.
2. **Planning the Wiring:**
 - Study the wiring diagram provided with the EV design.
 - Identify the starting and ending points for each wire.
 - Plan the routing of wires to ensure neatness and minimize crossover.
3. **Wire Preparation:**
 - Cut the raw wires to the required lengths based on your planned routing.
 - Strip the insulation from the ends of each wire using wire strippers.
 - If necessary, twist the wire strands together for easier connection.
4. **Connecting the Wires:**
 - Use the color-coded wires to make connections, ensuring each wire matches the function indicated by its color.
 - Use insulation tape to cover any exposed wire or connection points.
 - Organize and bundle wires using cable ties to maintain a clean layout.
5. **Labeling and Documentation:**
 - Label each wire with its function or destination using markers or labels.
 - Document the wiring process in your notebook, noting any challenges or changes from the original plan.
6. **Final Check:**
 - Double-check all connections against the wiring diagram to ensure accuracy.
 - Verify that all wires are securely connected and properly insulated.
7. **Presentation Preparation:**
 - Use the provided materials to prepare a presentation of your wiring design.
 - Include the following in your presentation:

- An overview of the wiring process
- Key components and their connections
- Color coding used and its significance
- Any challenges faced and how they were overcome
- The final wiring diagram with annotations

8. Submission:

- Ensure your presentation is clear, concise, and well-organized.
- Submit your design and presentation materials as per the instructions provided

Data Collection Table

Wire Color	Function	Starting Points	Ending Points	Remarks
Red	High power supply			
Blue	Low power supply			
Other	Signal/control/data			

Analysis and Discussion**1. Component Interactions:**

- Discuss how the different components are connected and the flow of electricity through the system.
- Highlight any specific challenges faced in making certain connections.

2. Wiring Integrity:

- Evaluate the overall neatness and organization of the wiring.
- Identify any potential issues such as loose connections or exposed wires.

3. Safety Considerations:

- Discuss the importance of proper insulation and secure connections for safety.
- Suggest additional measures that could improve the safety of the wiring.



4. Optimization Opportunities:

- Identify areas where the wiring could be optimized for better performance or ease of maintenance.
- Propose any modifications that could enhance the overall design.

Conclusion

Summarize the key findings from the experiment, emphasizing the importance of understanding and executing proper wiring techniques in EV systems. Highlight the practical skills gained and how this knowledge can be applied to real-world EV design and maintenance.

This experimental manual provides a comprehensive guide to understanding and practicing the wiring of an EV design on a 2D board, emphasizing hands-on experience, proper techniques, and safety considerations.



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