Government Polytechnic West Champaran

Electrical Engineering

Electric Vehicle (Basic) (2000505G) Lab Manual

Scheme of Studies:

CourseCode	Course Title	Scheme of Studies (Hours/Week)					
		Classroom Instruction (CI)		Lab Instruction (LI)	Notional Hours (SW+ SL)	Total Hours (CI+LI+SW+SL)	Total Credits(C)
		L	T				
2000505G / 2000508G / 2000511H	Electric Vehicles (Basic)	02	-	04	02	08	05

Scheme of Assessment:

Course Code	Course Title	Scheme of Assessment (Marks)						Total Marks (TA+SWA+LA)
		Theory Assessment (TA)		Sessional Work Assessment (SWA)		Lab Assessment (LA)		
		Progressive Theory Assessment (PTA)	End Theory Assessment (ETA)	Progressive Sessional Work Assessment (PSWA)	End Sessional Work Assessment (ESWA)	Progressive Lab Assessment (PLA)	End Laboratory Assessment (ELA)	
2000505G / 2000508G / 2000511G	Electric Vehicles (Basic)	30	70	20	30	20	30	200

Laboratory (Practical) Session Outcomes (LSOs) and List of Practical [2000508G]

Practical/Lab Session Outcomes (LSOs)	S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
LSO 2.1 Use the relevant digital meter for the given application. LSO 2.2 Use a measuring instrument for the given application. LSO 2.3 Use safety kits while working in the	1.	• Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc. • Practice using Screw Driver Kit, Vernier	CO1

Practical/Lab Session Outcomes (LSOs)		S. No.	Laboratory Experiment/Practical Titles	Relevant COs Number(s)
laboratory.			Caliper, Micrometer, Ampere Meter, Voltage Meter, and Techno-meter. • Practice using safety kits.	
LSO 2.1	Identify the motors used in EV applications	2.	• Identification of motors used in EVs	CO2
LSO 2.2	Identify the given motor terminals			
LSO 3.1	Identify the batteries available in the	3.	• Testing of Batteries used in EVs	CO3
	laboratory.			
LSO 3.2	Measure an open circuit voltage of the			
	given battery.			
LSO 3.3	Determine the Ampere -Hour Capacity of			
	the given battery with a given load.			
LSO 3.4	Test the performance of the given battery			
	with different charging rates and at			
	different ambient temperatures			
LSO 3.5	Demonstrate the effect on the state of			
	health of the battery after several charge/			
	discharge cycles.			
LSO 3.6	Evaluate the temperature cut-off point for		• Battery Management System	
	the given BMS.			
LSO 4.1	Identify the Electrical & Electronics	4.	• Power electronic circuits	CO4
	components available in the laboratory			
	using Digital Multimeters.			
LSO 4.2	Test the given power electronic			
	components using digital meters			
LSO 4.3	Identify the given Power Electronic Circuits			
	used in EVs			
LSO 4.4	Identify the components of the Charging		• Identification of Charging systems	
	System			
LSO 4.5	Recognize the types of Charging Systems			
	available in the Laboratory			

List of Experiments/ Practical's-

1. Study of Testing of Battery in Electrical vehicle (Hub Motor) Training system
2. Study of Key switch testing in Electrical Vehicle (Hub Motor) Training system.
3. Study of Display Meter in Electric Vehicle (Hub Motor) Training System.
4. Study of Controller is testing in Electrical Vehicle (Hub Motor) Training system
5. Study of Convertor tests in Electrical Vehicle (Hub Motor) Training system.
6. Study of Indicator test on Electric Vehicle (Hum Motor) Training System.
7. Study of Headlight and Tail light test in Electric Vehicle (Hub Motor) Training System.
8. Study of Charging & Discharging of Battery in Electric Vehicle (Hub Motor) Training System.
9. Study the N-T (Speed –Torque) characteristic, Input Power, Output Power & Efficiency.
10. Study of running Hub (BLDC) Motor in Forward & Reverse direction

Experiment 1

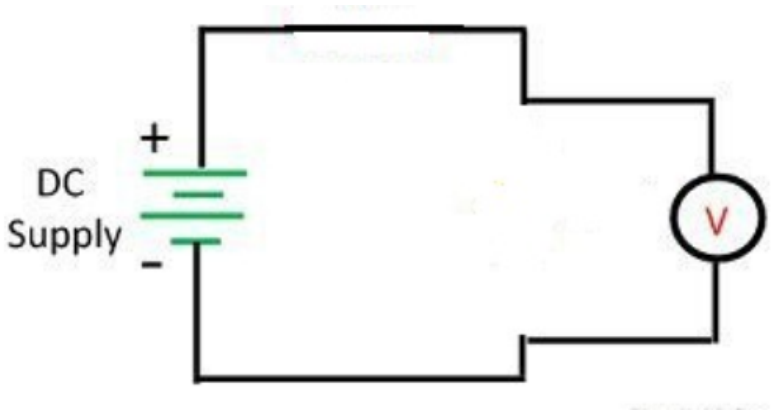
Aim: - Study of Testing of Battery in Electrical vehicle (Hub Motor) Training system.

Apparatus Required:

- **Electric Vehicle (Hub Motor Training System) -(MI-EV01)**
- Digital multi meter.
- Patch cords.
- Power Cable.

Theory: -

A voltmeter is an instrument used for measuring electric potential difference between two points in an electric circuit. It is connected in parallel. It usually has a high resistance so that it takes negligible current from the circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage measured and can be built from a galvanometer and series resistor. Meters using amplifiers can measure tiny voltages of microvolts or less. Digital voltmeters give a numerical display of voltage by use of an analog-to digital converter.

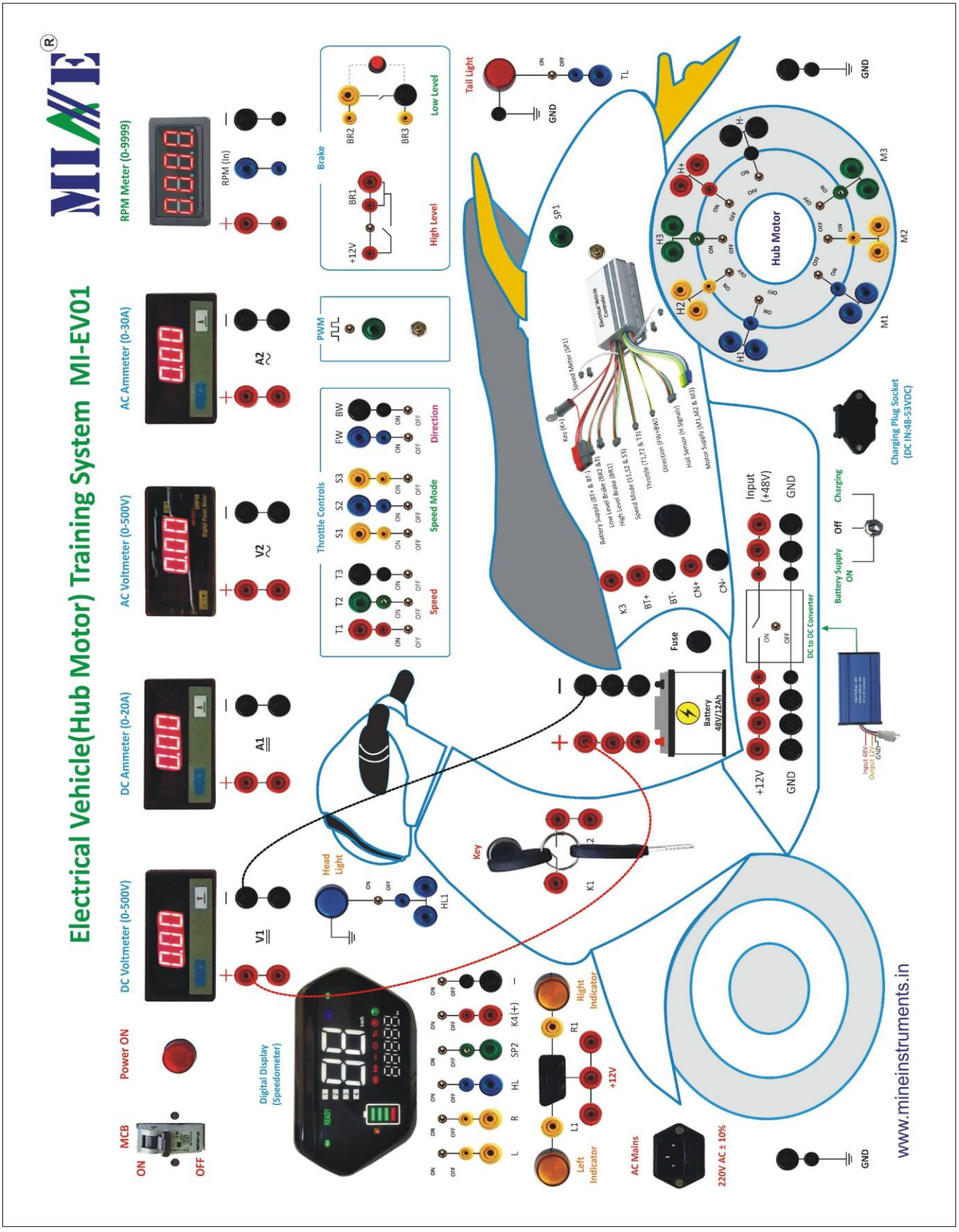


Circuit diagram

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

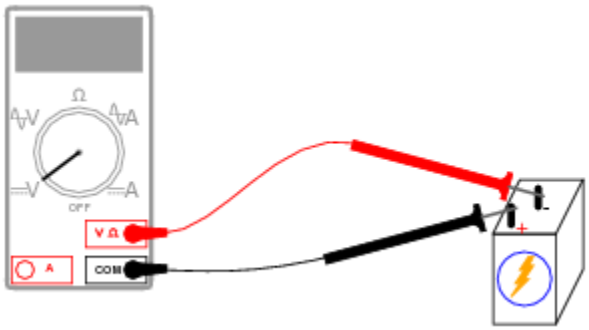
Connection Diagram:



Connection diagram of Battery

Procedure:

- First of all, connect the DC Voltmeter (0-500V) of +V & -V to the Battery (48V) of +V & -V terminal via patch cords.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Voltage value shown on DC voltmeter it is near to 48V-52V DC.
- Measure the voltage through digital multimeter on Battery terminals of +V & -V test points.
- If you found same voltage on both test points of voltmeter & Battery.
- As per above process your Battery is enable to work.
- Now your trainer is ready to perform other experiments.



Conclusion:

As per the experiment Battery is enabling to work and trainer is ready for other experiments.

Experiment 2

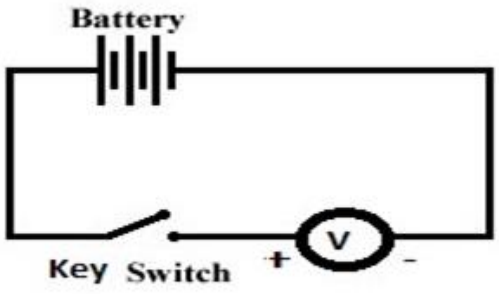
Aim: - Study of Key switch tests in Electrical Vehicle (Hub Motor) Training system.

Apparatus Required:

- **Electric Vehicle (Hub Motor Training System) -(MI-EV01)**
- Digital multi meter**.**
- Patch cords**.**
- Power Cable**.**

Theory: -

The Key switch is an electrical component usually located by in between of handle and with which you power on a E vehicle. If it is faulty, you don't expect your E vehicle accessories to come on.

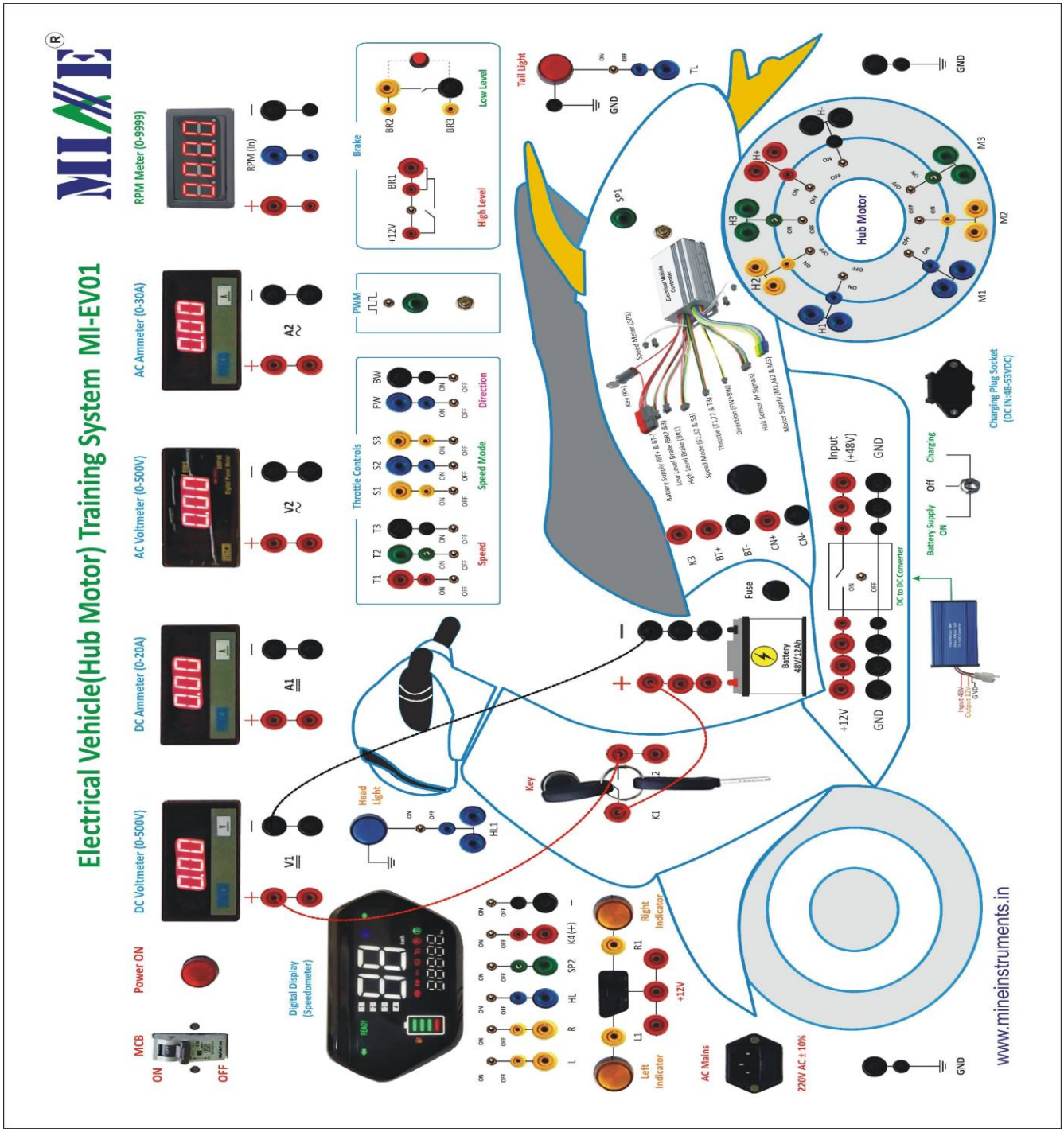


Circuit diagram of key switch

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection diagram of Key Switch

Procedure:

- First of all, Connect Key K1 to the Battery +V terminal.
- Connect the +V of DC Voltmeter to the key K2 & -V to the -V of Battery terminal via patch cords.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.
- Key section is enabling to communicate with accessories of E vehicle.
- When Key is in OFF condition so DC Voltmeter shown "0" voltage, if Key switch is in ON condition DC Voltmeter shown the appropriate voltage.

PROCEDURE:

1. Put the key in the run position, set the multimeter to 200V DC voltage position.
2. Connect the black lead to the –V terminal and red lead to the key of K2 terminal.
3. DC voltage is usually represented by a "V" with a dash and three dots beside it".
4. A reading that is close to your Battery voltage means that the key switch is working properly.
5. For instance, if you make use of a "48" volt Battery, a reading of "47" volts are still considerable and means the key switch is working properly.
6. If the multimeter values "0" or a reading far from this range, then the key switch is bad and needs to be replaced.

Conclusion: Above method is the best to directly pinpoint if your key switch is working or not.

Experiment 3

Aim: - Study of Display meter in Electric Vehicle (Hub Motor) Training System.

Apparatus Required:

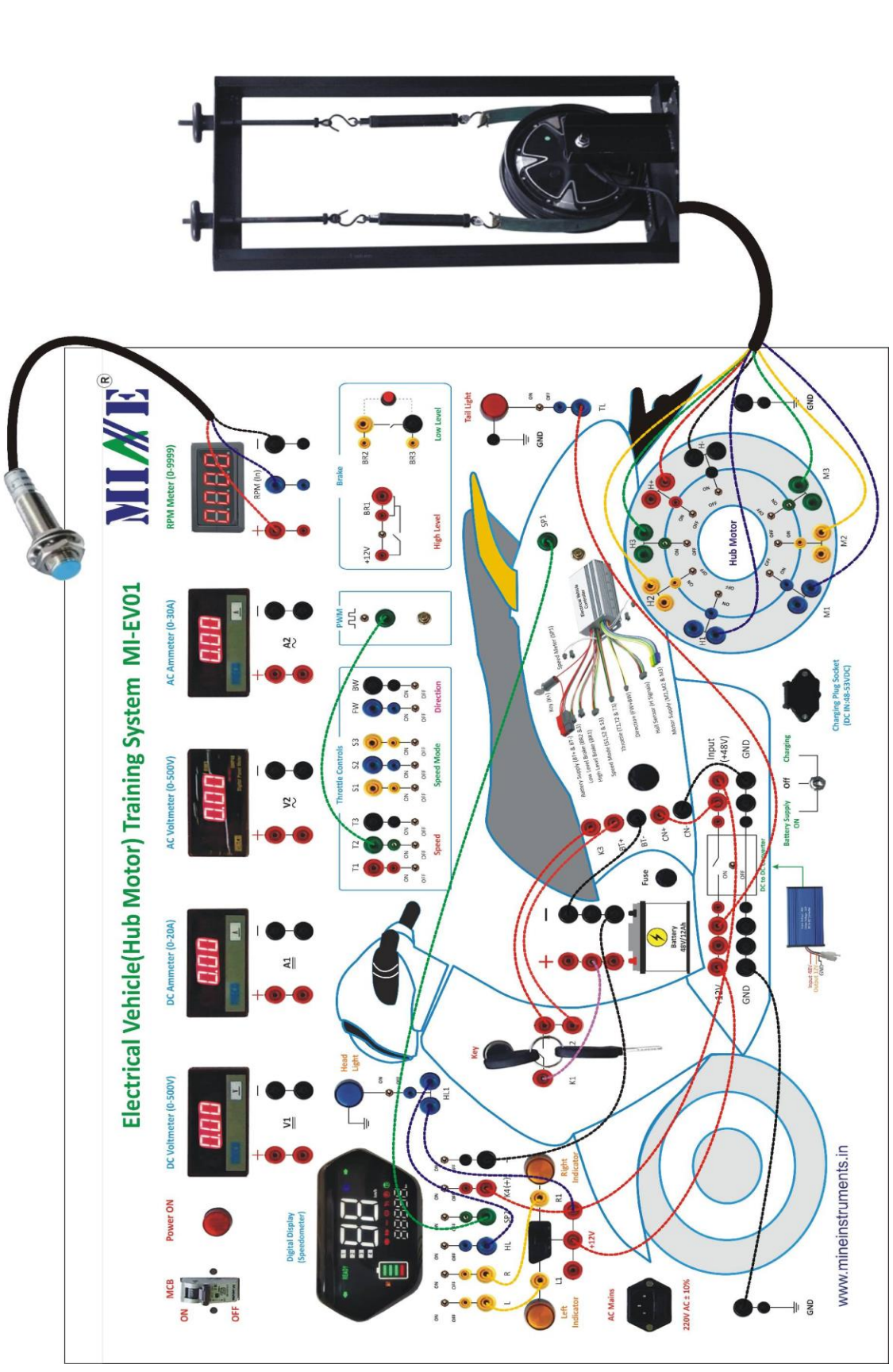
- Electric Vehicle (Hub Motor Training System) -(MI-EV01)
- Patch cords.
- Power Cable.

Theory: -

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection Diagram of Digital Display

Procedure:

- First of all, connect the Battery input (+48V) to the CN+ of controller.
- Connect the Battery –V to the CN- of controller.
- Connect Key K1 to the Battery +V terminal.
- Connect Key K2 to the K3 of controller.
- Connect Battery K2 terminal to the BT+ of the controller.
- Connect Battery -V terminal to the BT- of the controller.
- Connect the Hub motor three phase wire M1, M2, M3 (Blue, Yellow & Green to panel Three phase input terminal and 5 pin Hall sensor H1(Blue), H2 (Yellow), H3 (Green) H+(Red) & H-(Black) to the panel to hub motor.
- Additional, Now connects the Digital Display meter on panel board terminal L, R & H to the L1, R1 to the indicator & H to the H1 headlight section and SP2 to the SP1 in controller section and Tail Light TL terminal connect to DC converter +12 terminal via patch cord.
- Also connect the K4 terminal from digital display to the Battery +V terminal, and –V terminal to the GND.
- Connect PWM to Throttle section T2 from speed.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.
- When moves the PWM knob speed of motor is vary and output is shown on display meter.
- Now Digital Display meter section is enabled to show the indicator (left & right), headlight and speed.

Conclusion: As per Digital Display meter experiment we are able to see speed, indicator and headlight identification on display meter.

Experiment 4

Aim: - Study of Controller is testing in Electrical Vehicle (Hub Motor) Training system.

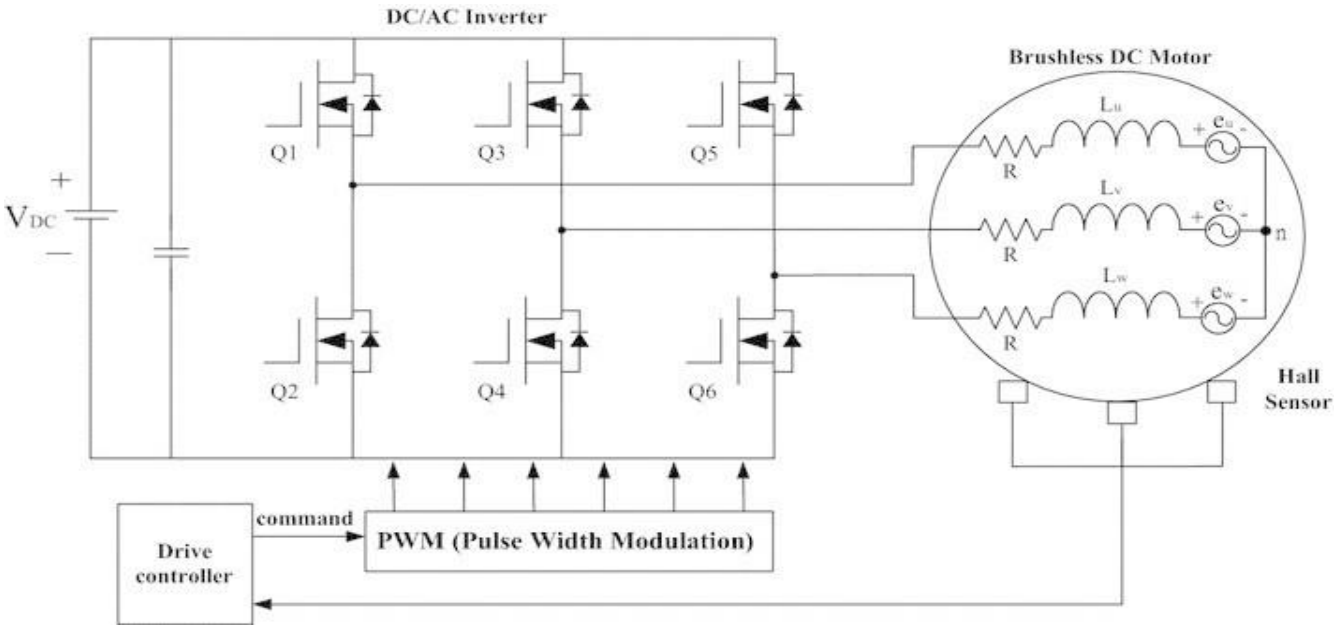
Apparatus Required:

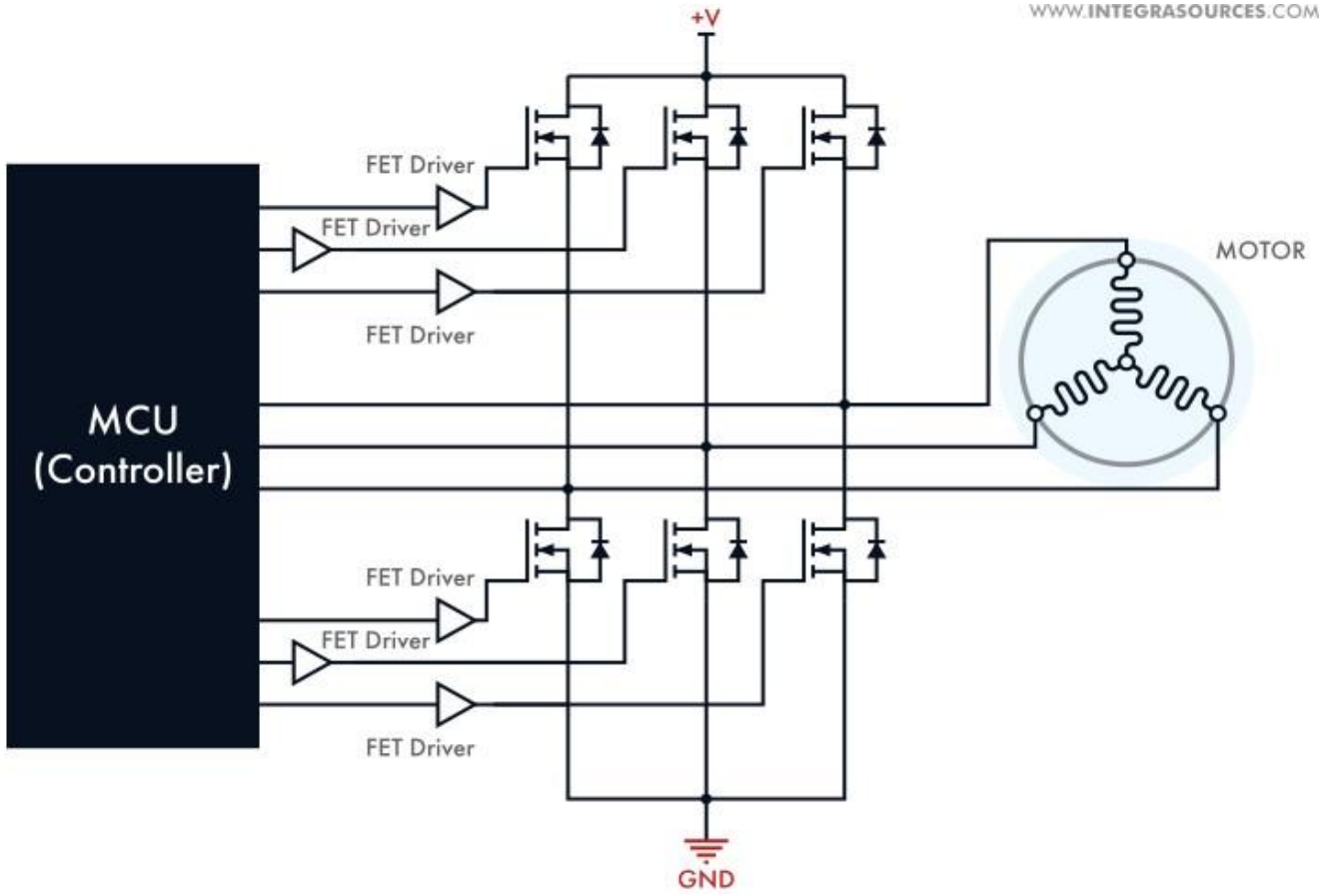
- Electric Vehicle (Hub Motor Training System) -(MI-EV01)
- Digital multi meter.
- Patch cords.
- Power Cable.

Theory: -

A controller is one of the most important features of Electric bikes. It works as the brain of the and manages every aspect of the bike. To operate the E-bike, we have to connect all electrical components like Battery, motor, throttle, brake, sensor to the controller. With the help of a controller, you can control the power from the motor, speed of the bicycle, acceleration of the bike, etc. A controller is a component that connects all electrical parts on the E-bike together. It connects the things like the Battery, motor, throttle, display, pedal-assist, and various sensors. It is a small computer that acts as the heart of the e-bike. It can manage the overall functioning of the bike.

Generally, controllers come in a sealed protective box. The controllers can be placed open on a bicycle; however, some designs are mounted inside of the frame and hidden away. As a rule, controllers come in a sealed protective box because they are exposed to the elements. However, some designs can be mounted inside the bike's frame and hidden away from sight.





Circuit diagram of BLDC controller

Function of the Controller

The controller's main function is to take inputs from all the parts like throttle, Battery, speed sensor, display, motor, etc., and determine what to be returned signal. The different controller design has multiple protections that are,

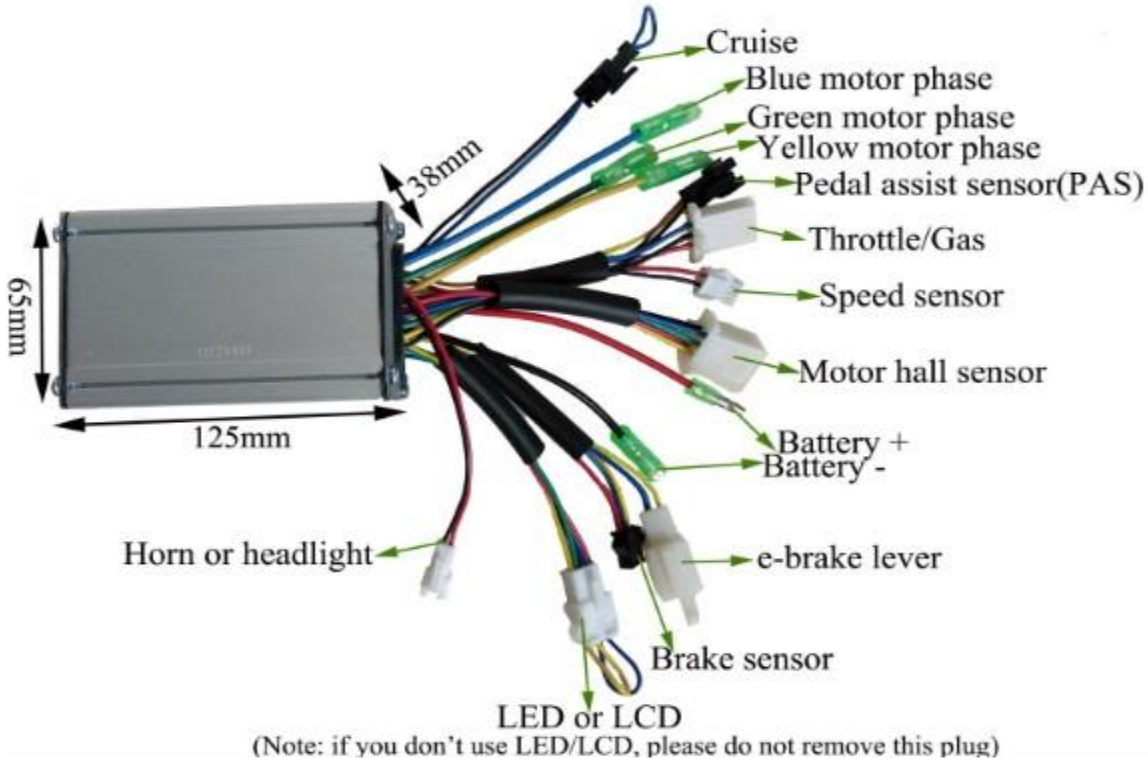
• **Low-voltage Protection**- The controller monitors the Battery voltage continuously, and it shuts down the motor whenever the voltage reaches its cut-off level. It will protect the Battery against over-discharge.

• **Over-voltage Protection**- The controller also monitors the charge level of the Battery voltage. It will automatically shut down when the Battery voltage reaches its full charge.

• **Over-temperature Protection**- The controller monitors the temperature of the FET (Field effective Transistors). It will shut down the motor whenever they become too hot.

• **Over-current Protection**- If the motor takes more current, the controller reduces the current flow to the motor. It protects the motor windings as well as the FET power transistors.

• **Brake Protection**- The controller provides more priority to the braking signal as compared to others. For instance, if you apply the brakes and throttle simultaneously, it will perform the brake function.

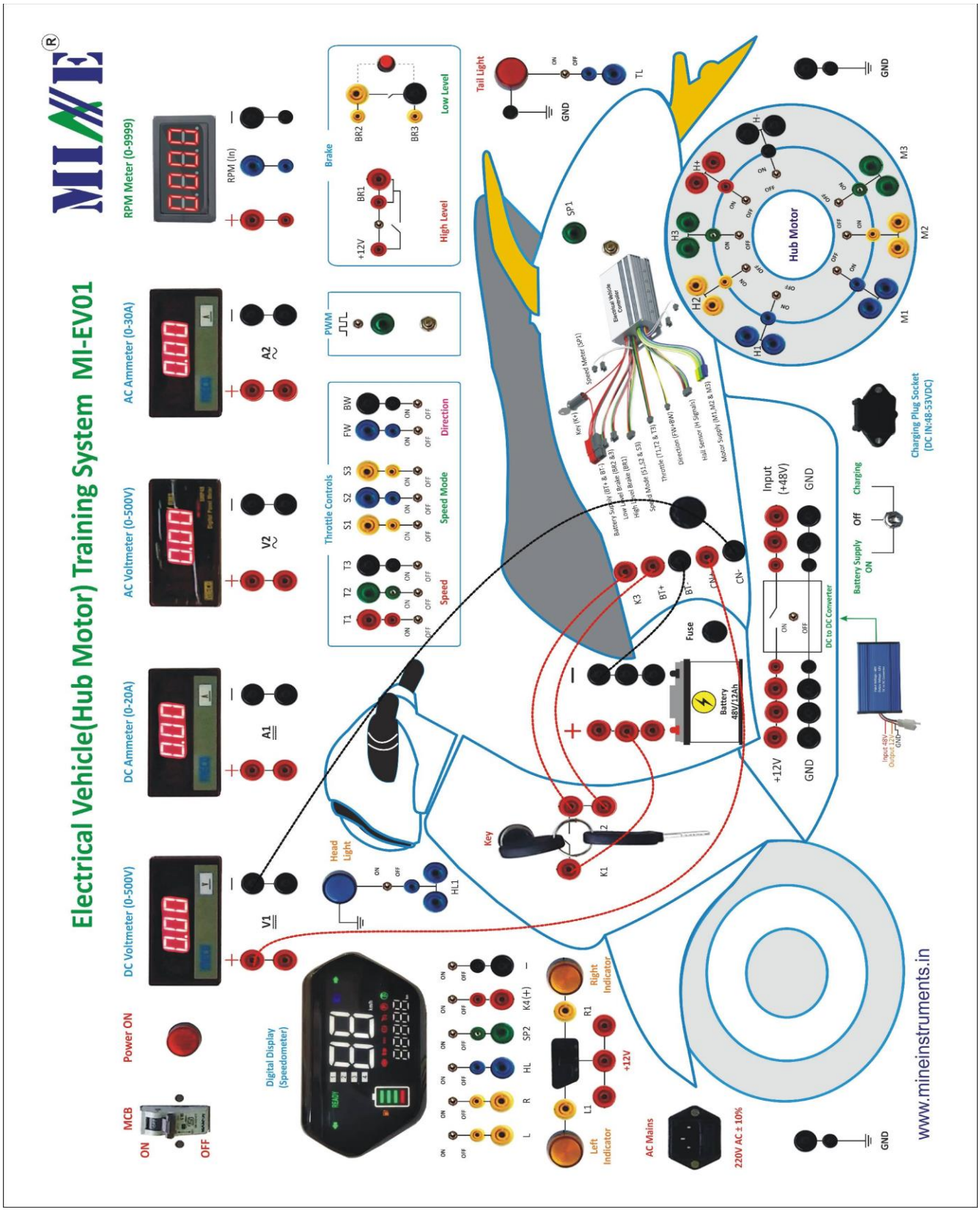


Safety Precaution:

- ❖ Please make sure your power cable is connected properly to the trainer.
- ❖ Please make connections properly as mentioned.
- ❖ Do not apply any external high voltage or current source by which trainer get damaged.
- ❖ Do not touch motor pulley when motor is running condition.

- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection diagram of Controller

Procedure:

- First of all, connect the DC Voltmeter +V to the CN+ of controller.
- Connect the DC Voltmeter –V to the CN- of controller.
- Connect Key K1 to the Battery +V terminal.
- Connect Key K2 to the K3 of controller.
- Connect Battery K2 terminal to the BT+ of the controller.
- Connect Battery -V terminal to the BT- of the controller.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now Key turn from OFF to ON condition.
- Now Controller section is enabling for E vehicle.

Conclusion: As per controller experiment, we are able to enable controller section.

Experiment 5

Aim: - Study of Convertor tests in Electrical Vehicle (Hub Motor) Training system.

Apparatus Required:

- **Electric Vehicle (Hub Motor Training System) -(MI-EV01)**
- Patch cords**.**
- Power Cable

Theory: -

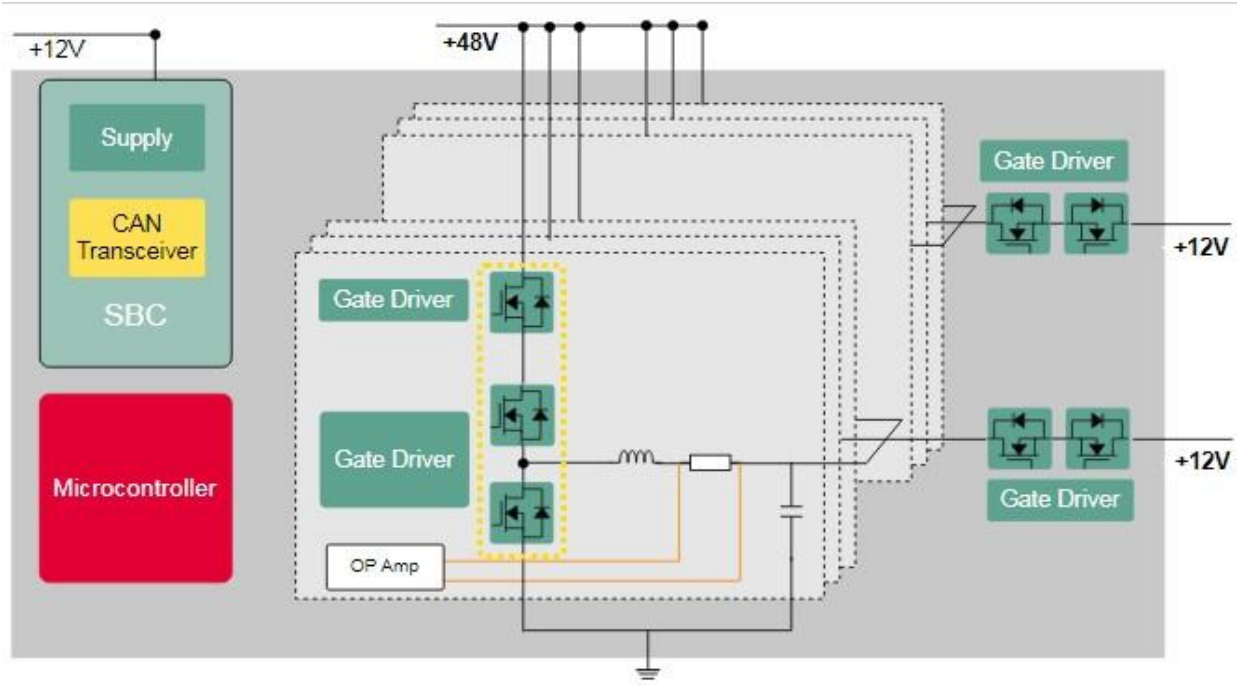
The principle of operation of a converter is based on the switch mode action of its switches. Commutations of the switches generate very fast current and/or voltage transients so that the transient behavior of the sources is fundamental for converter design.

48V to 12V 10A DC-DC converter for electric bike

- 48V to 12V DC-DC Convertor, 10A
- Over Current Protection
- Short Circuit Protection
- Low Voltage Protection
- Red/Input: DC48V
- Yellow/output: DC12V
- Black: Cathode Wire

48V / 12V DC-DC converter in buck-mode (step down)

In Mild Hybrid Electric Vehicles (MHEV), the only generator is on 48V. To continuously supply the 12V network with energy, a DC/DC converter in buck-mode (step down) from 48V down to 12V is mandatory. The same DC/DC can be used as well in boost-mode (step-up), but this is today rarely the case and may come into the game when highly automated drive functions are realized in 48V. Infineon offers a complete and comprehensive system solution with high integration for space-saving ranging from supply IC's with integrated transceivers (SBC), microcontroller, gate driver, and high power MOSFET. The block diagram below shows the basic layout of the semiconductors used for an up to 3 kW DCDC 48V/12V converter.



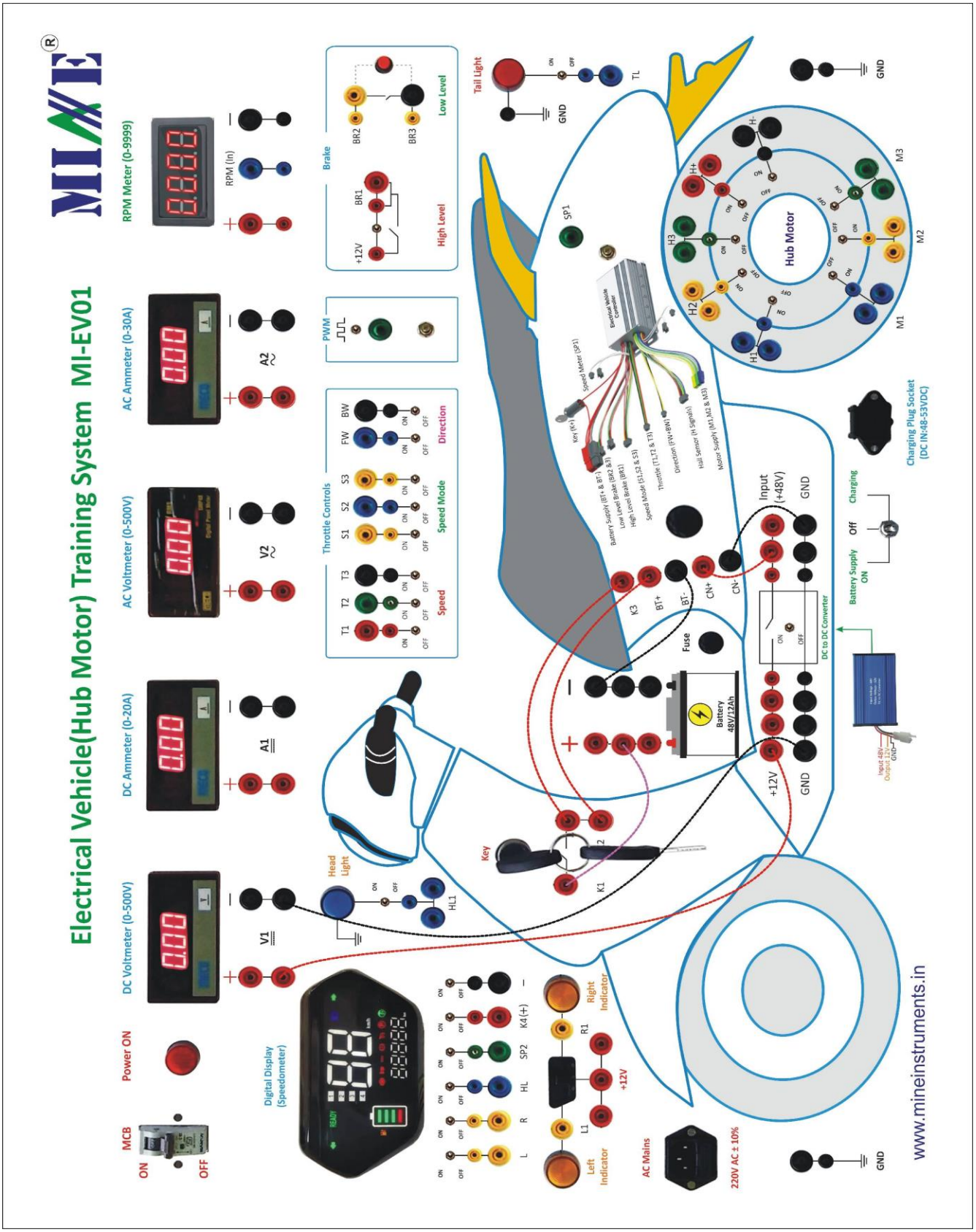
Design requirements:

- 48-V to 12-V DC/DC converter systems require:
- High performance and fast digital control loops enabling highly efficient power conversion and increased power density.
- Simplified and efficient integration of bidirectional 12-V to 48-V DC/DC converter solutions.
- Load balancing for parallel operating (multi-phase) power supplies.

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection diagram of convertor

Procedure:

- First of all, connect the DC Voltmeter +V to the +12v of convertor.
- Connect the DC Voltmeter –V to the GND of convertor.
- Connect Key K1 to the Battery +V terminal.
- Connect Key K2 to the K3 of controller.
- Connect Battery K2 terminal to the BT+ of the controller.
- Connect Battery -V terminal to the BT- of the controller.
- Connect CN+ from controller to the +V terminal of convertor.
- Connect CN- from controller to the GND terminal of convertor.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.
- Whenever Key is OFF output voltage shown on DC Voltmeter is “0” if Key is ON condition output voltage is shown as per appropriate voltage.
- Now Convertor section is enabling for E vehicle.
- You can check the convertor voltage shown on DC Voltmeter is 12V.
- Also check the convertor voltage via multimeter is 12V.

Conclusion: As per convertor experiment, we are able to convert the voltage from 48V to 12V.

Experiment 6

Aim: - Study of Indicator test on Electric Vehicle (Hum Motor) Training System.

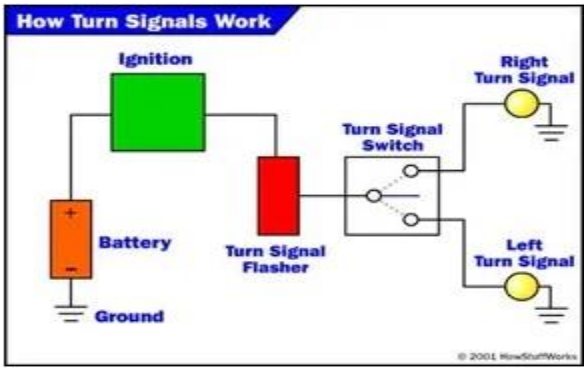
Apparatus Required:

- Electric Vehicle (Hub Motor Training System) -(MI-EV01)
- Patch cords.
- Power Cable.

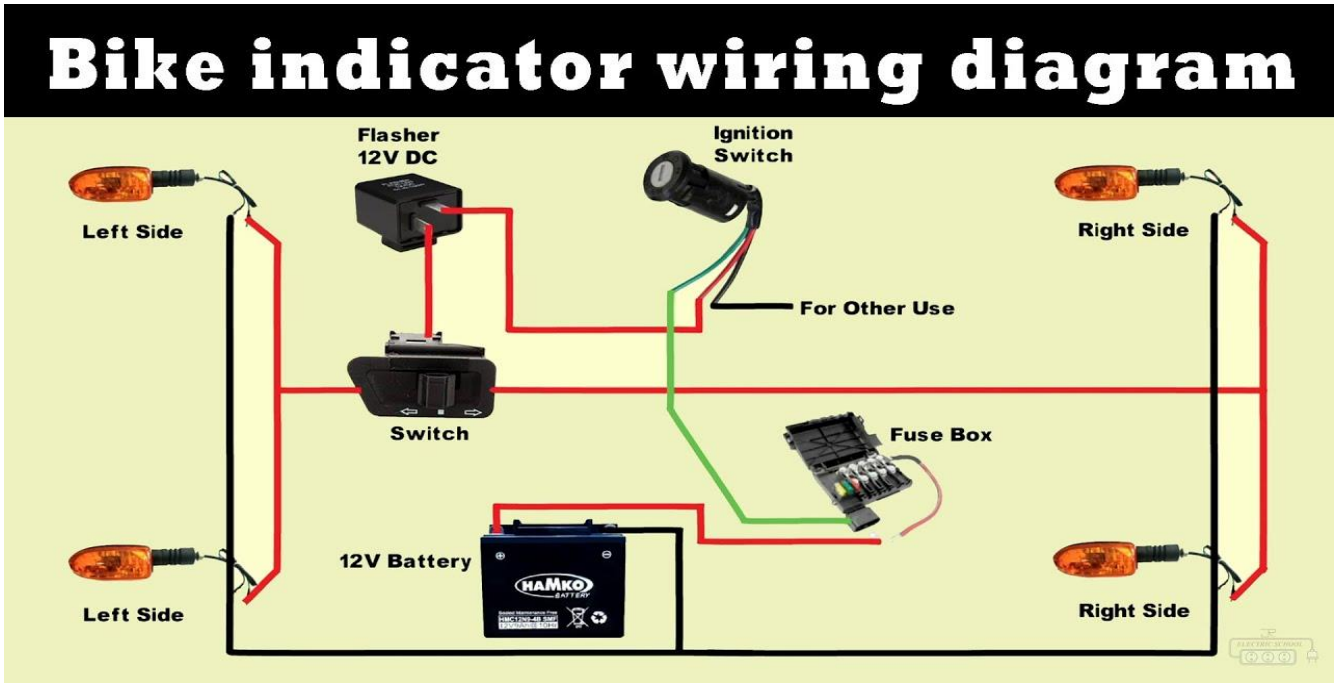
Theory: -

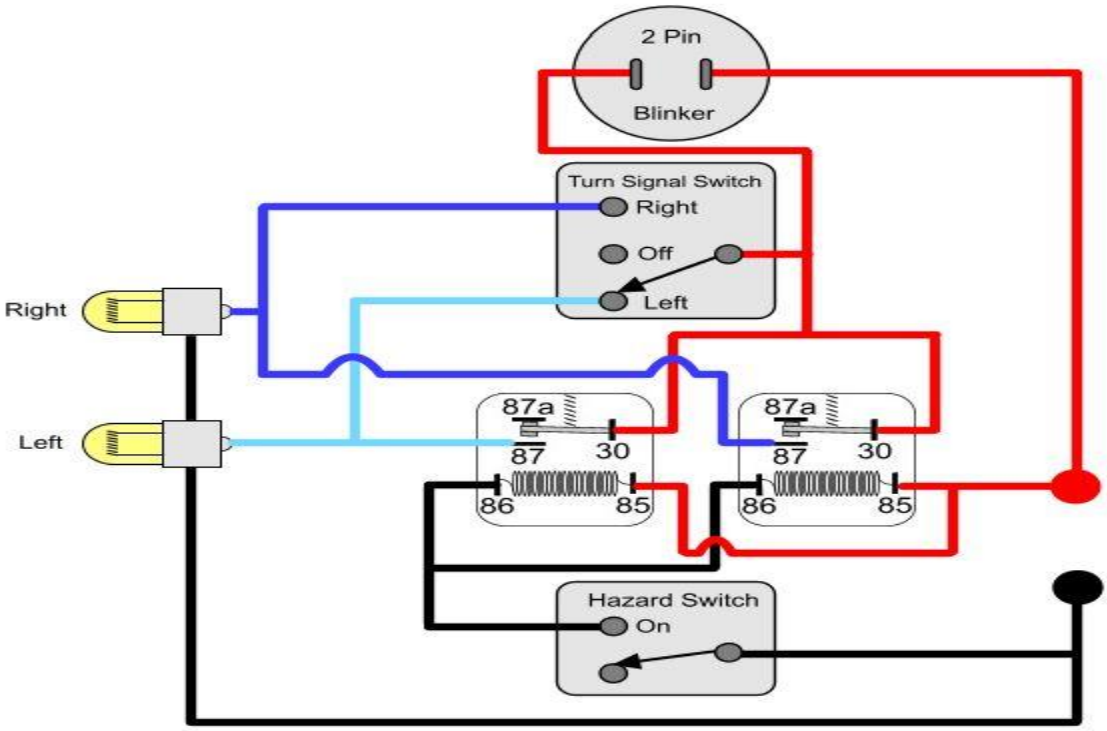
E vehicle has several signaling devices - indicators, brake light, hazard warning light, headlights, reversing light and the horn. These signaling devices are used by drivers to communicate to other road users what they intend to do. They help drivers "read the road". Signals give a warning to other road users that you intend to make a manoeuvre. Giving appropriate signals at the correct time and place and correctly interpreting the signals of other road users is important for the safety of all road users. Your signals must be given in good time before you start your manoeuvre and for long enough for their meaning to be clear to other road users. Don't signal too soon as this could confuse other road users.

Indicator lights are amber in color and can be located at the front, the rear and sometimes at the side of the car on both the left and right-hand sides. You use your indicators to show an intended change of direction, whether turning left or right or moving out into traffic.



You only need to use your indicators if other road users (vehicles, cyclists or pedestrians) are visible. Use them in good time, giving other road users plenty of time to react and adapt to your signal. Once you have completed the man oeuvre, make sure the indicator has been cancelled, or you may confuse other road users.

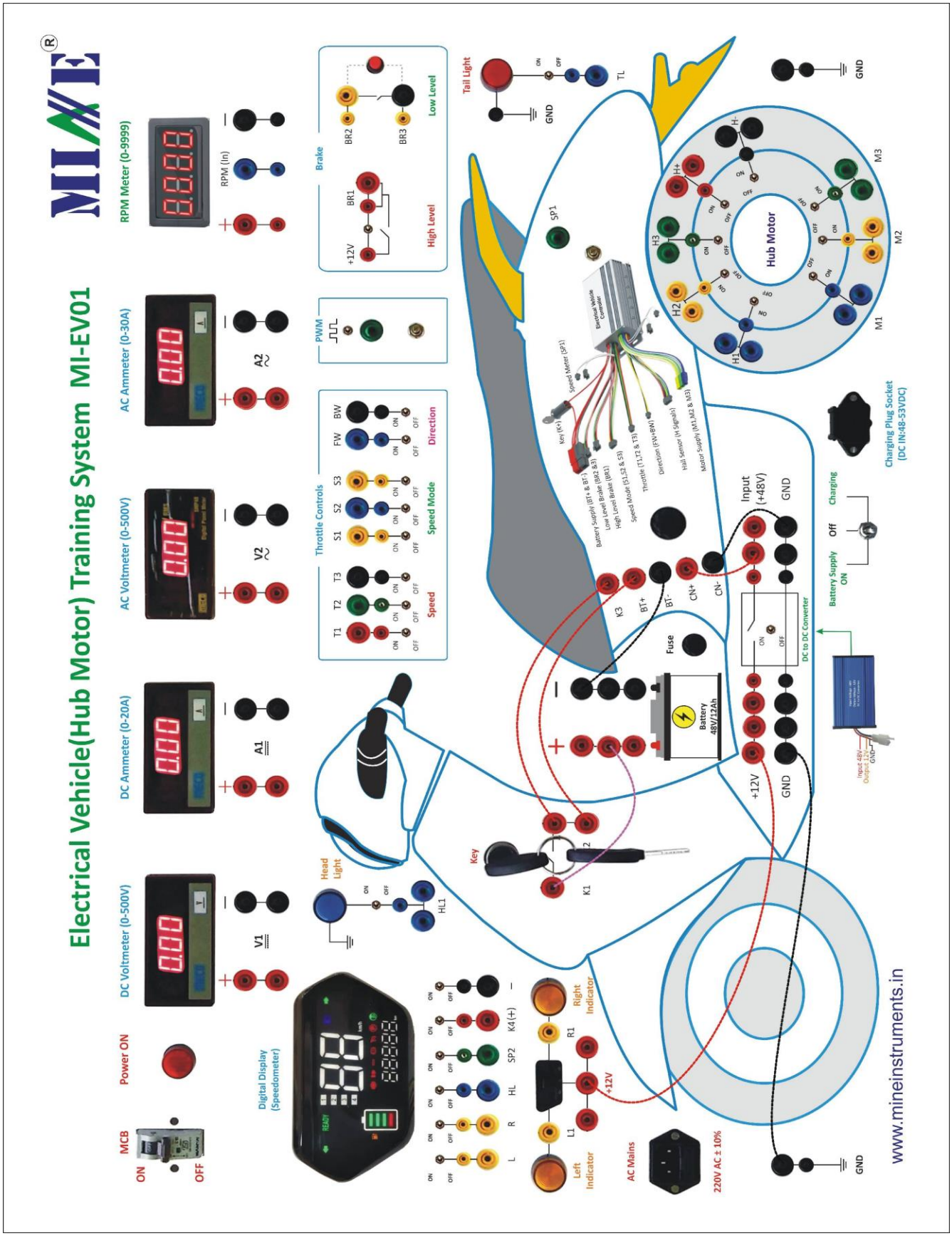




Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection diagram of Indicator

Procedure:

- First of all, Connect the +12v of convertor to the +12v indicator input.
- Connect the DC Voltmeter –V to the GND of convertor.
- Connect Key K1 to the Battery +V terminal.
- Connect Key K2 to the K3 of controller.
- Connect Battery K2 terminal to the BT+ of the controller.
- Connect Battery -V terminal to the BT- of the controller.
- Connect CN+ from controller to the +V Input (48V) terminal of convertor.
- Connect CN- from controller to the GND terminal of convertor.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.
- Now Indicator section is enabling for E vehicle.
- You can check the convertor & Indicator voltage shown on DC Voltmeter is 12v.
- Also check the convertor voltage and indicator voltage via multimeter is 12v.
- Connect the left L1 or right R1 indicator terminal to the DC Voltmeter one by one and see the output voltage near 12V.
- After above connections indicator output is depend on toggle indicator switches. If toggle switch is on for L or R the appropriate signal (left or right) indication is shown on DC Voltmeter.

Conclusion: As per indicator experiment, we are able to test the left or right signal indication.

Experiment 7

Aim: - Study of Headlight and Tail light test in Electric Vehicle (Hub Motor) Training System.

Apparatus Required:

- Electric Vehicle (Hub Motor Training System) -(MI-EV01)
- Patch cords.
- Power Cable.

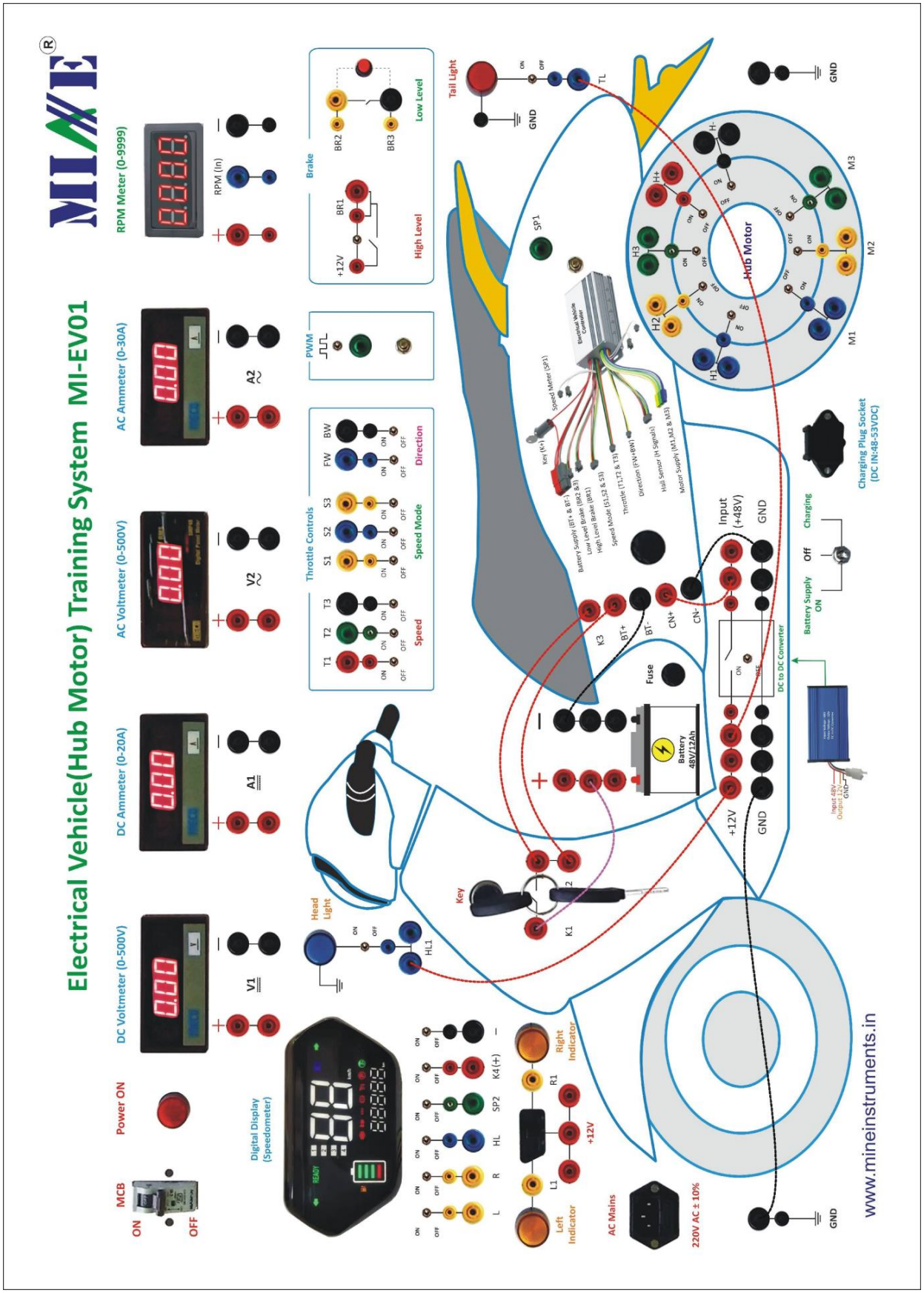
Theory: -

According to the Highway Code, the only valid use of flashing your headlights is to warn another road user of your presence. Flashing your headlights is useful when the horn wouldn't be heard, such as when driving at speed. Never flash your headlights to try and intimidate other road users, and never flash your headlights to give instructions. It is common for drivers to use the headlight flash as a signal to tell another road user that the way ahead is clear. However, it is advisable such signals are ignored. How you can be certain that the way ahead is clear or that this is what the flash was communicating? If you were to respond to flashing headlights this way or if you were to flash a driver to tell them that the way ahead is clear on your driving test would fail the test.

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection diagram of Head light & Tail light

Procedure:

- First of all, Connect the +12V of convertor to the headlight H1 terminal and Tail light TL terminal.
- Connect Key K1 to the Battery +V terminal.
- Connect Key K2 to the K3 of controller.
- Connect Battery K2 terminal to the BT+ of the controller.
- Connect Battery -V terminal to the BT- of the controller.
- Connect CN+ from controller to the +V input (48V) terminal of convertor.
- Connect CN- from controller to the GND terminal of convertor.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now Key turn from OFF to ON condition.
- Now Headlight & Tail light section is enabled for E vehicle.

Conclusion: As per Headlight experiment, we are able to see the light of headlight.

Experiment 8

Aim: - Study of Charging & Discharging of Battery in Electric Vehicle (Hub Motor) Training System.

Apparatus Required:

- Electric Vehicle (Hub Motor Training System) -(MI-EV01)
- Digital Multimeter
- Patch cords
- Power Cable

Theory: -

When Battery charge less than 48V Battery so charging is required and we use 48V 3A charger

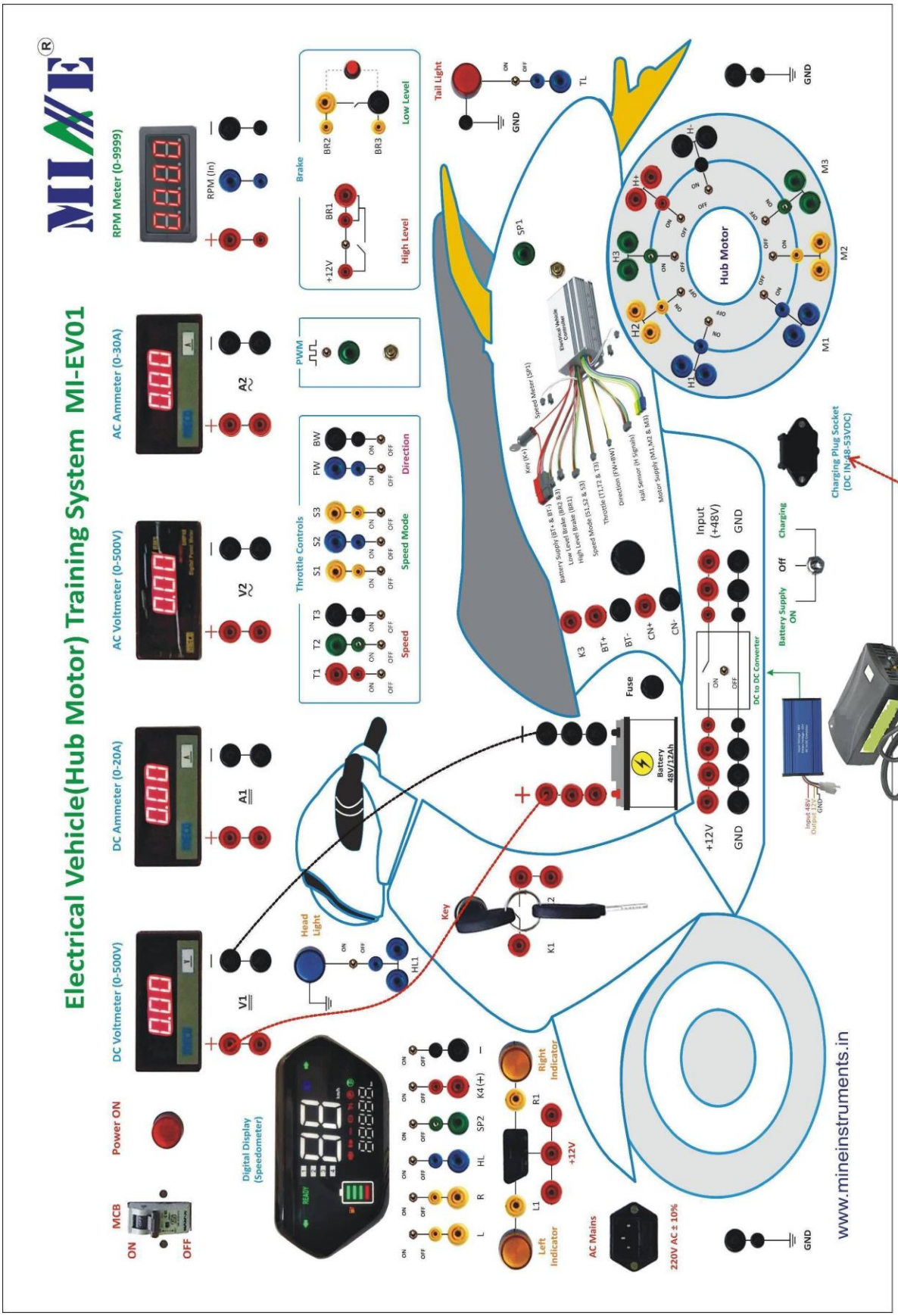
- Auto cut-off Voltage: 48-52V
- Charge Current: 6A
- Input Voltage: AC 230V
- Battery Pack: Lithium-ion phosphate
- High-Quality Charger

Applications- E-bike, Electric cycle Battery Charging Purpose.

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Connection diagram of Charging

Procedure:

- Connect charger to the Charging Plug Socket DC +48V.
- Connect +Ve & -Ve DC Voltmeter to the +Ve & -Ve battery terminal.
- While charging the Battery all the Bike Connections on Trainer EV01 are in Open condition.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.
- When Battery charger is measured by multimeter if Battery charge is less than 48V so charging is required.
- Additional, now connect the Battery charger plug to the Battery charging point and turn ON the switch of charging.

Conclusion: As per charging experiment we are able to see check the Battery is need to charge or not.

Experiment 9

Aim: - Study the N-T (Speed –Torque) characteristic, Input Power, Output Power & Efficiency.

Apparatus Required:

- Electric Vehicle (Hub Motor Training System) -(MI-EV01)
- Digital oscilloscope.
- Patch cords.
- Power Cable.

Theory:

When the load (torque) on the motor is constant, speed is directly proportional to supply voltage. And, when the voltage remains constant, an increase in the load (torque) on the motor results in a decrease in speed. When there is no load on motor and we will apply Constant PWM signal to controller we will get Higher Speed, while changing the load 0 to maximum the Speed & Current will be change as show in given fig below.

Torque is nothing but a momentary force developed at the time of force is applied to the motor. The unit of torque is Nm (Newton-meter). In other words, Torque $T_{(N.m)}$ is equal to the ratio between the electrical power $P_{(W)}$ in watts to the acceleration.

The total power rating of the motor details can be found from the motor's nameplate details. Absence of the power details, the power is equal to the product of the voltage and current for DC motor and for AC motor, the product of the voltage, current and power factor.

The speed of the motor can be found by using Speed measurement devices.

Hence motor torque $T = P / \omega$

Here omega ω is equal to $2 \times pi \times N_{(rpm)} / 60$

For DC Motor torque Formula:

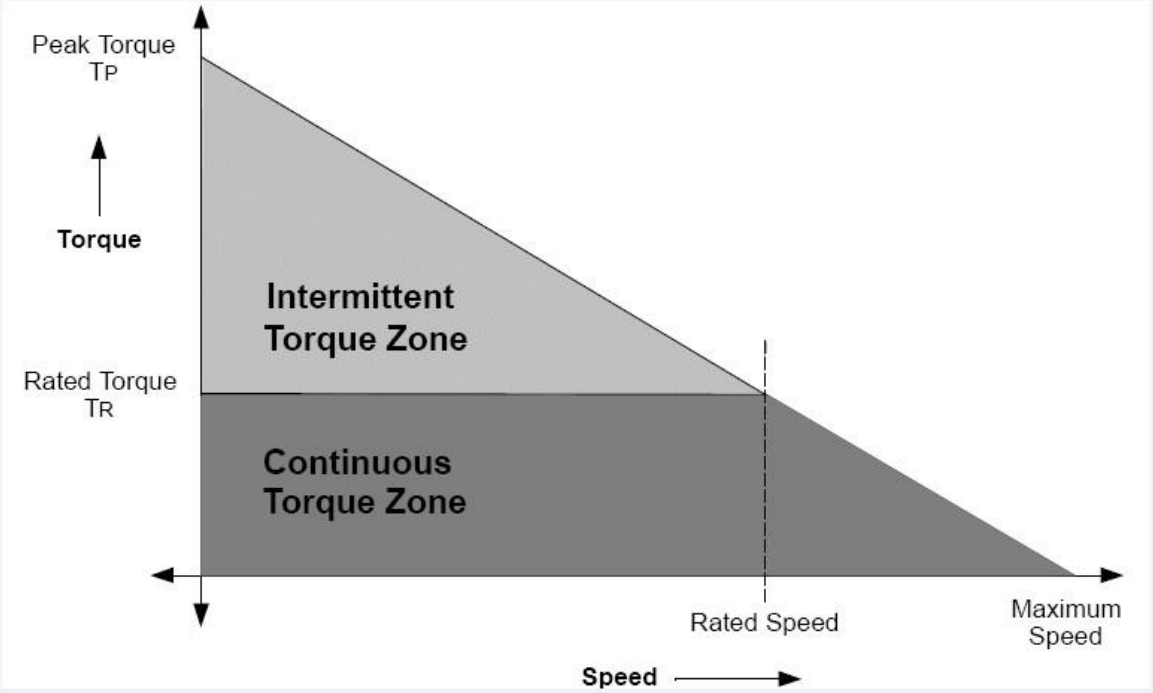
For Calculating, Torque for DC motor

$T = V \times I / (2 \times pi \times N_{(rpm)} / 60)$

$N_{(rpm)}$ is the speed of the motor

V = Input DC Voltage

I = Input DC Current

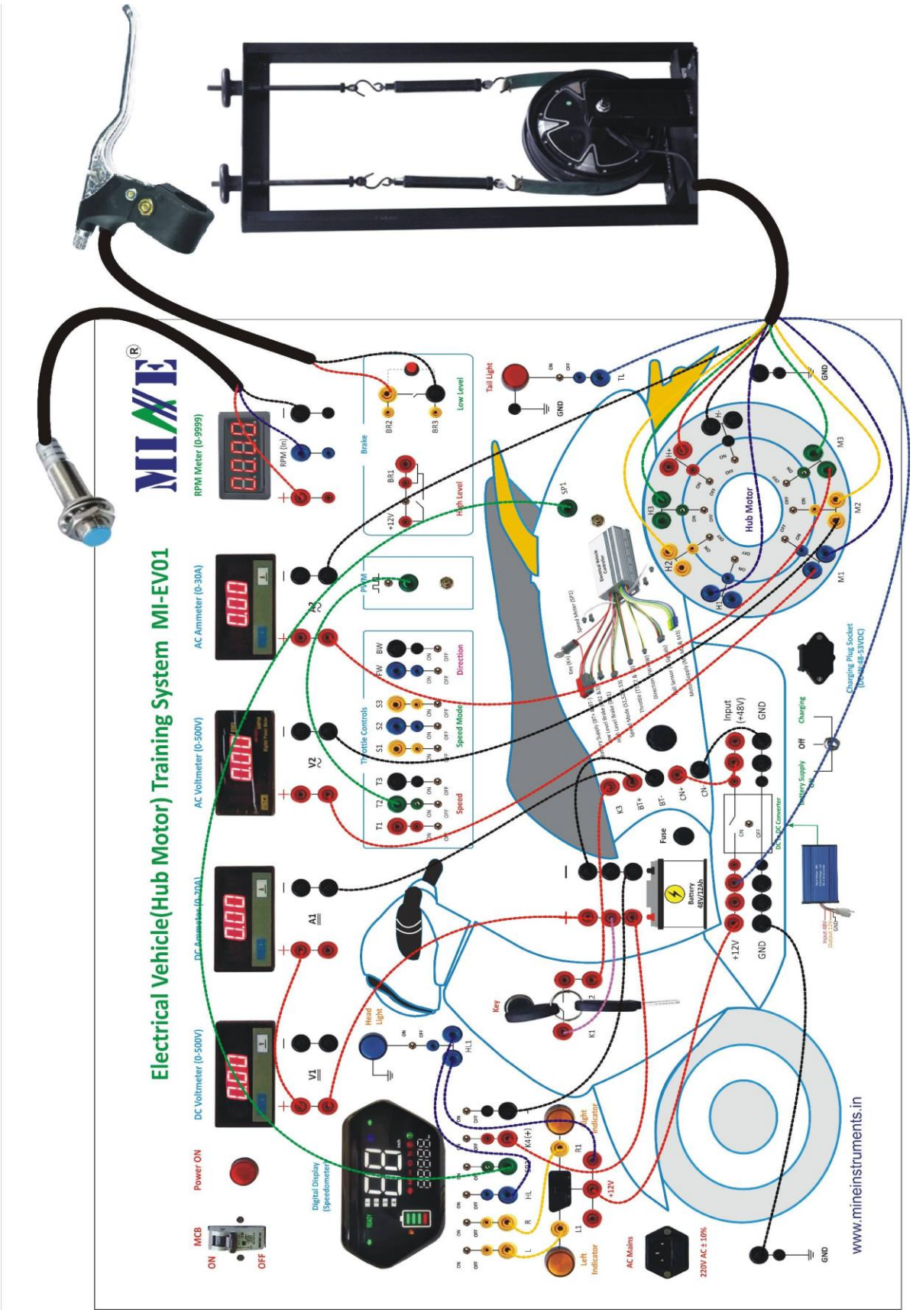


N-T (Speed –Torque) characteristic

Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



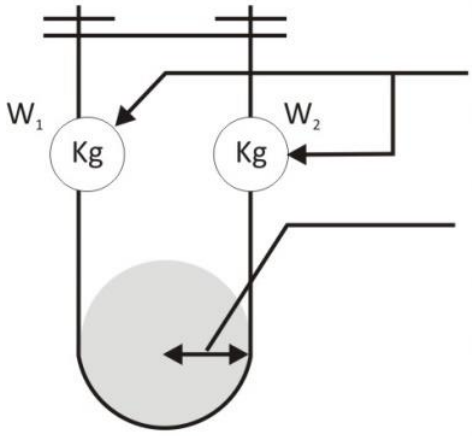
Connection diagram of Speed & Torque

Procedure:

- First of all, connect Key K1 to the Battery +V and K2 to K3 of Controller.
- Connect Battery +V Terminal to the +V terminal of DC Voltmeter and Battery –V terminal to the -V terminal of DC Voltmeter and connect DC Ammeter +V terminal to the +V of Battery terminal and –V DC ammeter to the BT +of Controller and also connect Battery -V terminal to Controller BT- terminal.
- Connect the Hub motor three phase wire and meter to controller M1(Blue) terminal to AC Voltmeter + V terminal and M2 (Yellow) terminal of Controller connect to AC Voltmeter –V terminal and Controller M3 terminal connect to AC Ammeter to +V terminal and-V terminal of AC Ammeter connect to Hub Motor Green wire and connect M1 & M2 terminal to the Hub motor Blue & Yellow wire. 5 pin Hall sensor H1 (Blue), H2 (Yellow), H3(Green) H+(Red) & H- (Black) to the panel of Hub motor.
- Connect PWM terminal to the T2 terminal of speed section.
- Connect RPM sensor output to RPM meter terminals and Break wire connect to BR2 (Yellow) and BR3 (Black) GND in Brake section.
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.
- We can control speed of Hub Motor by PWM for getting speed-torque characteristics we will apply a constant PWM signal to Controller by which out motor will run at a constant speed on no load condition.
- Now note the Speed in RPM meter, also Voltage & Current read by DC Voltmeter and DC Ammeter.
- After that apply the load by tight the load belt by rotate the dial on motor setup and take the reading of both balances connected to load.
- Put on the given formula

How to Calculate Torque from Applied Load

Torque= Force x Perpendicular Distance
= (mass x g) x Perpendicular Distance



Differential reading of Spring Balance (W_1 ~W_2) = mass

Radius of the pully (r)
= Perpendicular Distance

Gravitational Acceleration (g) = 9.8 N/m^2

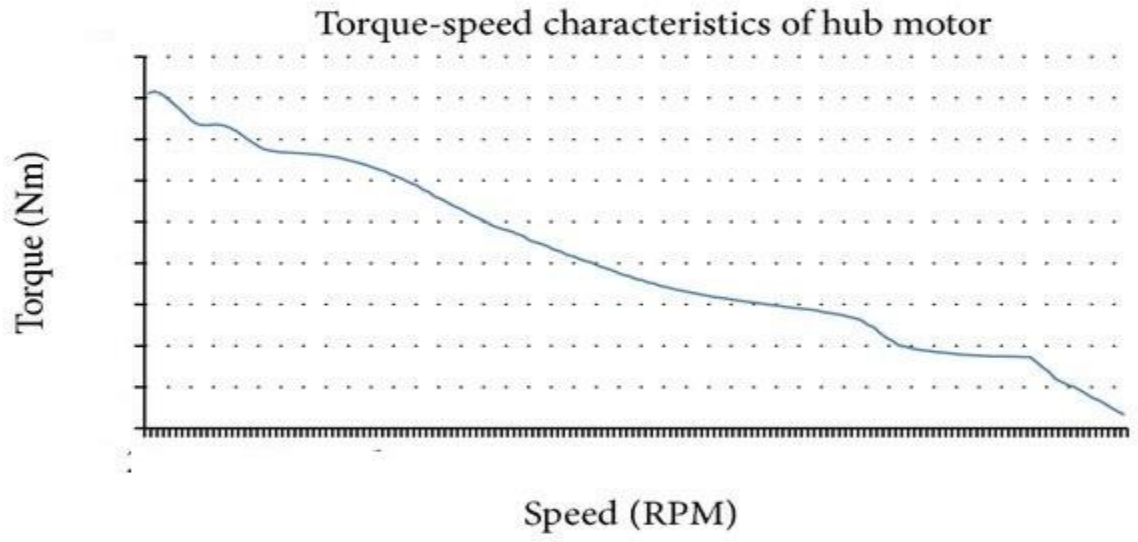
Torque (T) = (W1 - W2) x R x 9.81 Nm
W1 = Weight at Balance 1
W2 = Weight at Balance 2
R = Radius
G = 9.81
Input Power (Pi) = VI Watts
V= input Voltage
I = Input Current
Out Power (Pm) = Watts
$P = T\omega$
$\omega = 2\pi N/60$
N= Speed in RPM
T = Torque

$$\text{Efficiency \%} = \frac{\text{Out put Power}}{\text{Input Power}} \times 100\ \%$$

Output = Input - Losses

S. No	Voltage V(volts)	Current A(Amps)	Spring Balance Reading W1(Kg)	W2(Kg)	Speed N(RPM)	Torque T(Nm)	Output Power Pm (Watts)	Input Power Pi (Watts)	Efficiency ή %

- After putting the Values in Table Plot the Graph Between N-T (Speed –Torque).



Conclusion: Understand N-T (Speed –Torque) characteristic, Input Power, Output Power & Efficiency.

Experiment 10

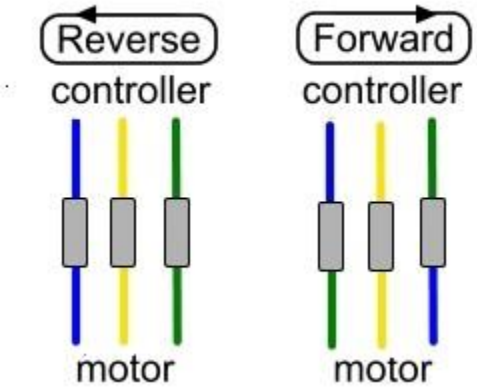
Aim: - Study of running Hub (BLDC) Motor in Forward & Reverse direction.

Apparatus Required:

- **Electric Vehicle (Hub Motor Training System) -(MI-EV01)**
- Digital oscilloscope**.**
- Patch cords**.**
- Power Cable**.**

Theory: -

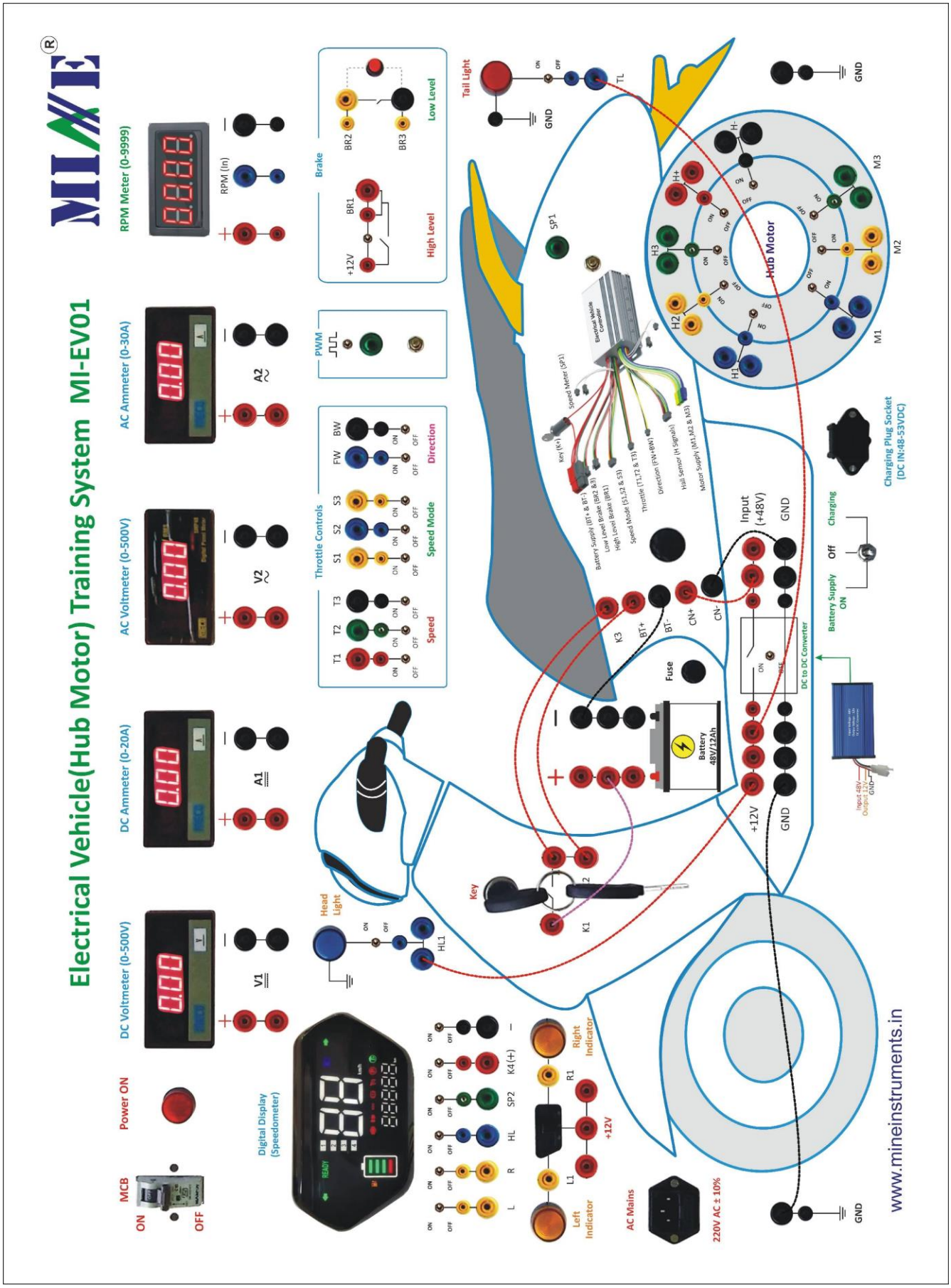
Forward and Reverse Control of Hub (BLDC) Motor By changing the logic relationship of the switch tubes of the inverter, the turn-on sequence of each phase of the armature winding is changed to realize the forward and reverse rotation of the motor. In order to produce the maximum average electromagnetic torque in both forward and reverse rotations of the motor to ensure symmetrical operation, the mutual positional relationship between the rotor position sensor and the main magnetic pole of the rotor and each phase



Safety Precaution:

- Please make sure your power cable is connected properly to the trainer.
- Please make connections properly as mentioned.
- Do not apply any external high voltage or current source by which trainer get damaged.
- Do not touch motor pulley when motor is running condition.
- Make sure the loading arrangement is on no load condition when motor will start.

Connection Diagram:



Procedure:

- First of all, connect Key K1 to the Battery +V and K2 to K3 of Controller.
- Connect Battery +V Terminal to the +V terminal of DC Voltmeter and Battery –V terminal to the -V terminal of DC Voltmeter and connect DC Ammeter +V terminal to the +V of Battery terminal and –V DC ammeter to the BT +of Controller and also connect Battery -V terminal to Controller BT- terminal.
- Connect the Hub motor three phase wire and meter to controller M1(Blue) terminal to AC Voltmeter + V terminal and M2 (Yellow) terminal of Controller connect to AC Voltmeter –V terminal and Controller M3 terminal connect to AC Ammeter to +V terminal and-V terminal of AC Ammeter connect to Hub Motor Green wire and connect M1 & M2 terminal to the Hub motor Blue & Yellow wire. 5 pin Hall sensor H1 (Blue), H2 (Yellow), H3 (Green) H+(Red) & H- (Black) to the panel of Hub motor.
- Connect RPM sensor output to RPM meter terminals and Break wire connect to BR2 (Yellow) and BR3 (Black) GND in Brake section.
- Connect Throttle cable to Panel throttle section. (RED T1, GREEN T2, BLACK T3 are Throttle Speed Control and YELLOW S1, BLUE S2, YELLOW S3 are Speed mode change control)
- Connect RPM sensor output to RPM meter terminals and Break switch output wire to Break input,
- Connect AC mains to EV01 Trainer board.
- Make sure all toggle fault switches are in OFF condition.
- After connecting Battery terminals and mains AC plug put toggle and MCB switch ON for supply.
- Now key turn from OFF to ON condition.

For Forward & Reversing Motor:

- For forward motor rotating firstly press the F (Forward) button of handle in forward mode so motor run-in forward direction.
- If you change the mode from forward to reverse so motor run-in reverse direction.
- After doing this Follow the Procedure: for Run Hub Motor, direction will change

Conclusion: Capable of running motor in reversing & forwarding direction.