ELECTRIC VEHICLE DESIGN USING MATLAB

Submitted in partial fulfilment of the requirements for the

Professional training – I of

Bachelor of Engineering Degree in

Electrical and Electronics Engineering

BY

PAVITHRA V (39140038)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS

SCHOOL OF ELECTRICAL AND ELECTRONICS

SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY

JEPPIAAR NAGAR, RAJIV GANDHI SALAI,

CHENNAI 600119. TAMILNADU

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Skill AP
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NAME Ms.PAVITHRA V

COLLEGE SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY

has Successfully Completed

MASTER CLASS ON EV DESIGN USING MATLAB(30 DAYS)

at Pantech e Learning Pvt Ltd, Chennai

From AUG 23,2021 To SEP 21,2021

Dr. Ravi Gujala Chief General Manager (Technical) APSSDC	Prof. Rama Koti Reddy Executive Director APSSDC	N Bangara Raju Managing Director APSSDC	M.Malaiappan Director Pantech e Learning

CONTENTS

ELECTRIC VEHICLE (EV)

- ✓ An EV is a shortened acronym for an electric vehicle. EVs are vehicles that are either partially or fully powered on electric power.

- ✓ Electric vehicles have low running costs as they have less moving parts for maintaining and also very environmentally friendly as they use little or no fossil fuels (petrol or diesel).

- ✓ There are 4 (four) types of electric cars, with the following outline:

- ✓ Battery Electric Vehicle (BEV)
- ✓ Hybrid Electric Vehicle (HEV)
- ✓ Plug-in Hybrid Electric Vehicle (PHEV)
- ✓ Fuel Cell Electric Vehicle (FCEV)

MATLAB MATRIX LABORATORY

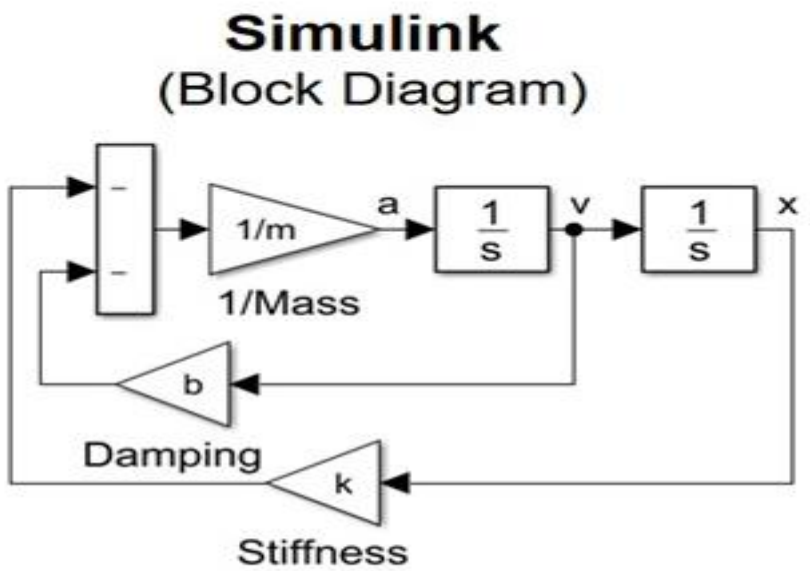
- MATLAB is a multi-paradigm programming language and numeric computing environment Tool MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.
- MATLAB® combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly. It includes the Live Editor for creating scripts that combine code, output, and formatted text in an executable notebook.

What Can we Do With MATLAB?

- Analyze data
- Develop algorithms
- Create models and application.

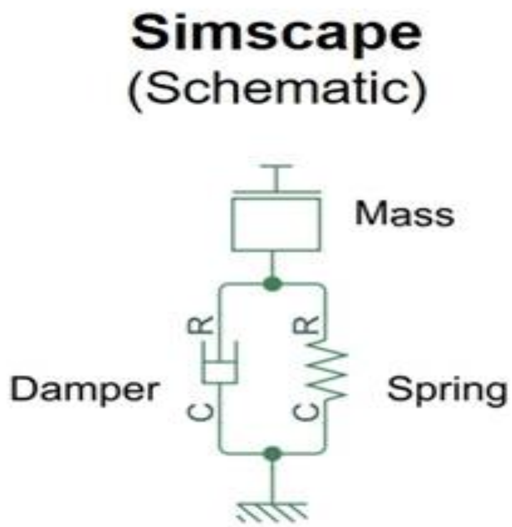
SIMSCAPE AND SIMULINK

- To create models of physical systems within the Simulink environment.
- Modeling and simulating multi-domain physical systems
- Elements for various physical domains
- Unit manager, data logging etc..,
- Simscape helps you develop control systems and test system-level performance.
- You can create custom component models using the MATLAB® based Simscape language, which enables text-based authoring of physical modeling components, domains, and libraries.
- You can parameterize your models using MATLAB variables and expressions, and design control systems for your physical system in Simulink.

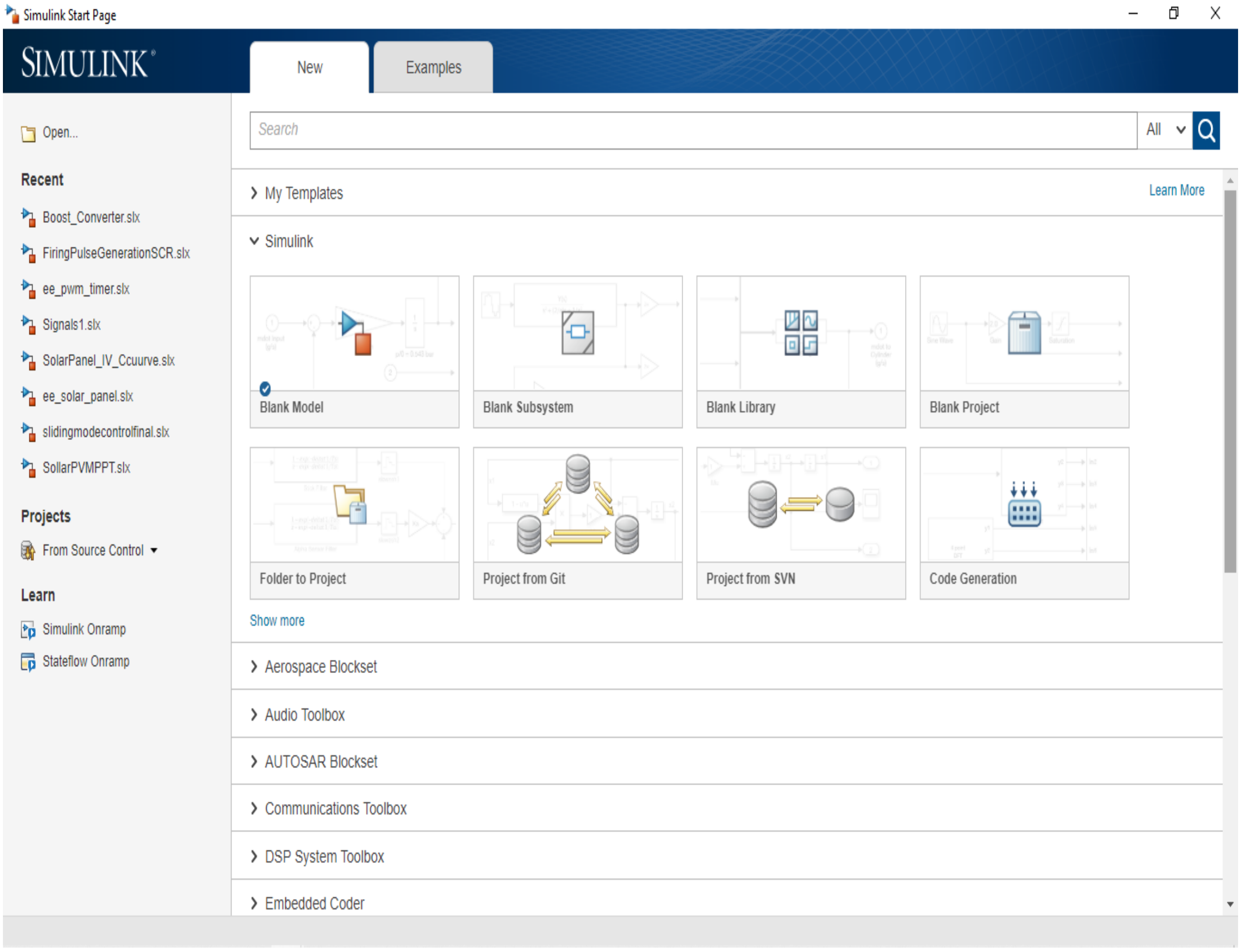


SIMULINK :-

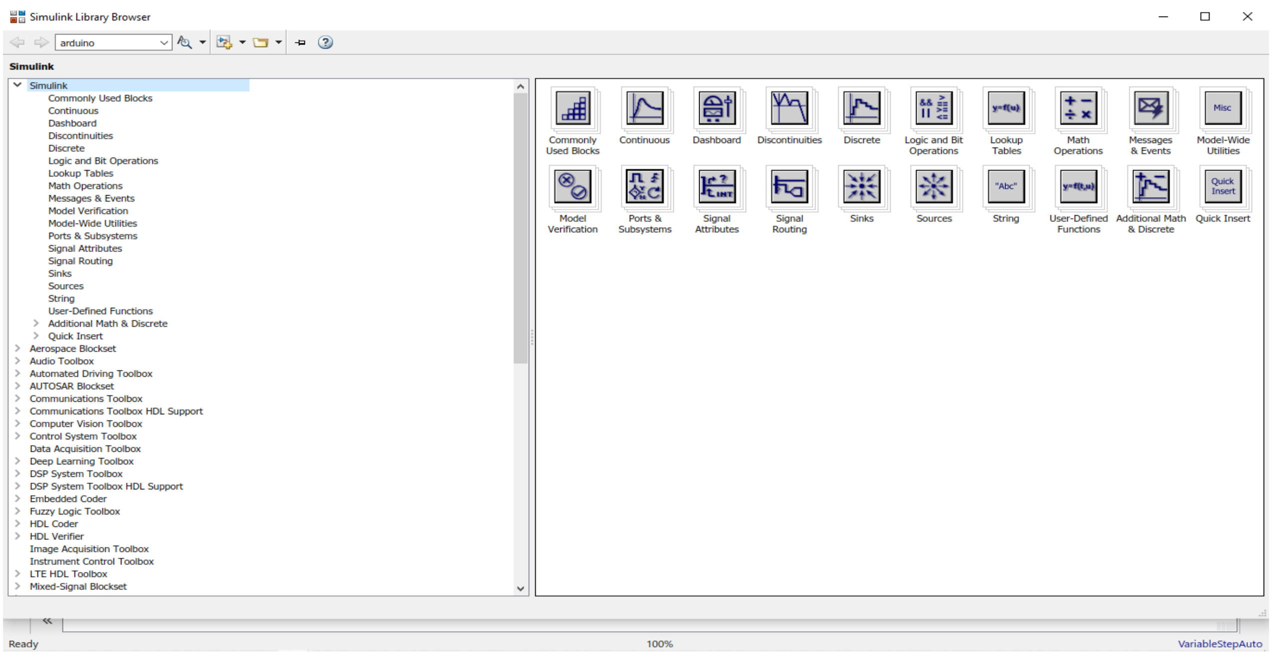
- Simscape helps you to develop control systems and test system-level performance.
- We can create custom component models using the MATLAB based on Simscape language, which enables text-based authoring of physical modeling components, domains, and libraries.



SIMULINK



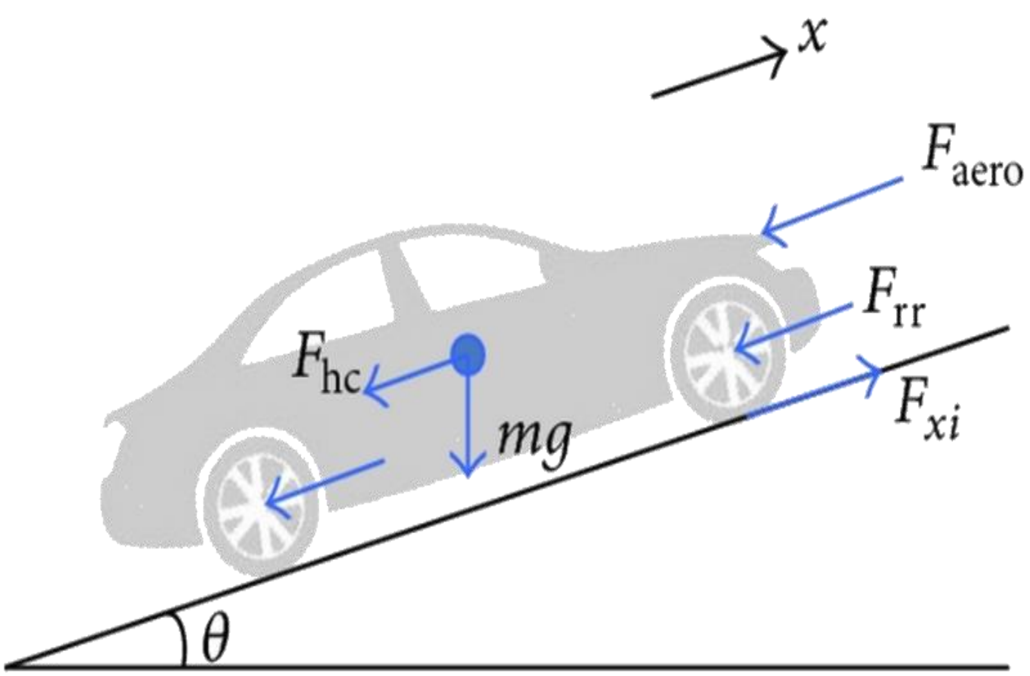
PROJECT WINDOW



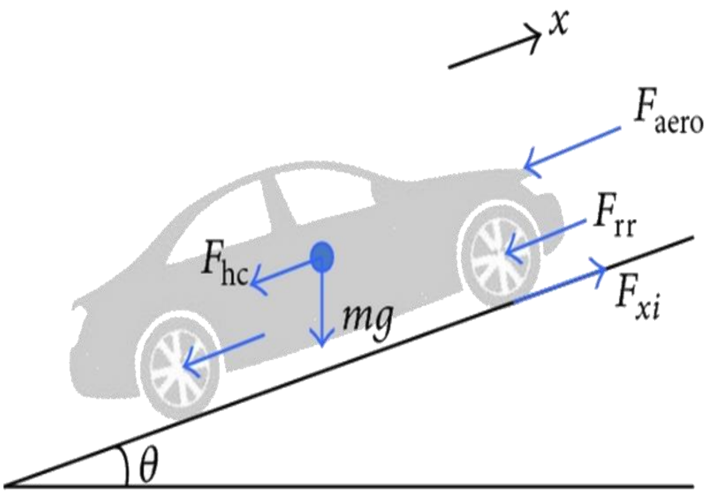
FORCES ON EV

Total Tractive Force

- Rolling Resistance Force(F_{rr})
- Aerodynamic drag force(F_{aero})
- Hill climbing Force(F_{hc})
- Acceleration Force(F_{xi})
    - Linear Acceleration Force
    - Angular acceleration force



HILL CLIMBING FORCE



Rise / Run

F_{hc} = m.g.Sin θ

ACCELERATION FORCE :-

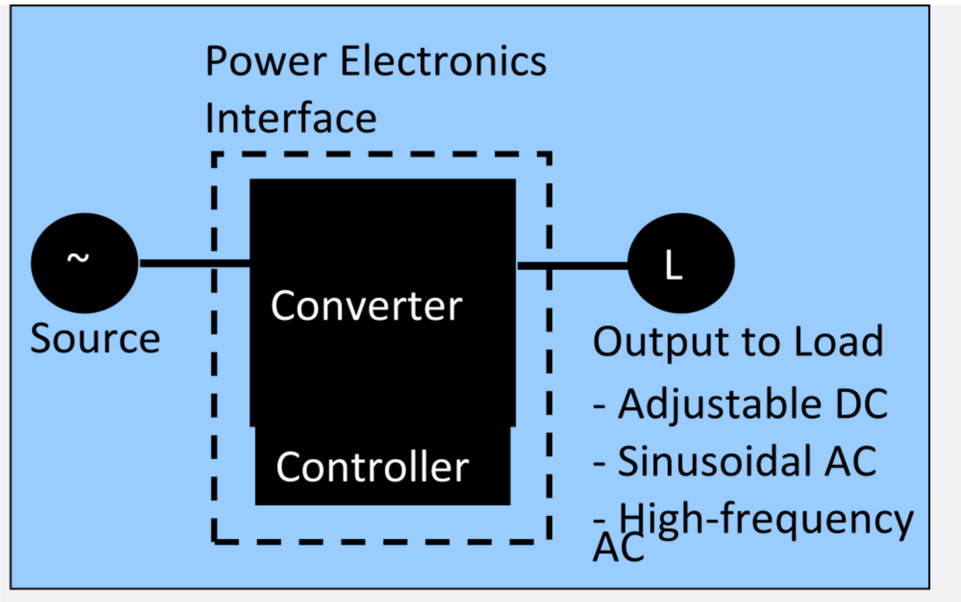
Linear Acceleration Force (F_{la}) = m.a

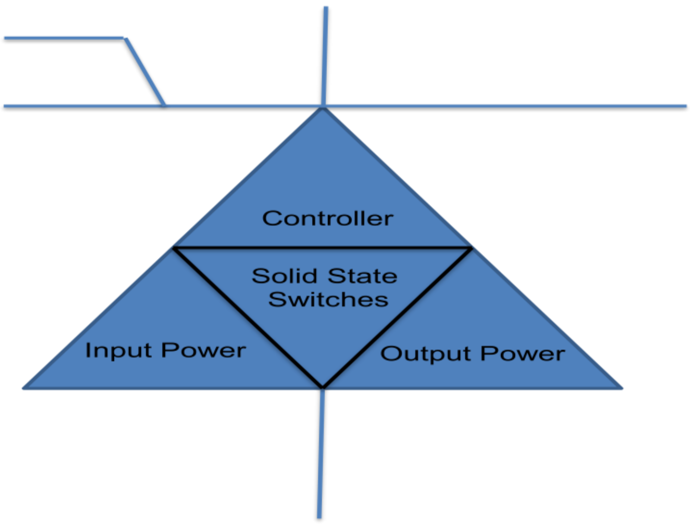
Angular Acceleration Force (F_{wa})

$$F_{\omega a} = \frac{IG^2\, a}{r^2\, \eta_q}$$

POWER ELECTRONICS

- Power electronics is the application of solid-state electronics to the control and conversion of electric power.
- Power electronics can be defined as the use of electronic devices to control and convert electric power.

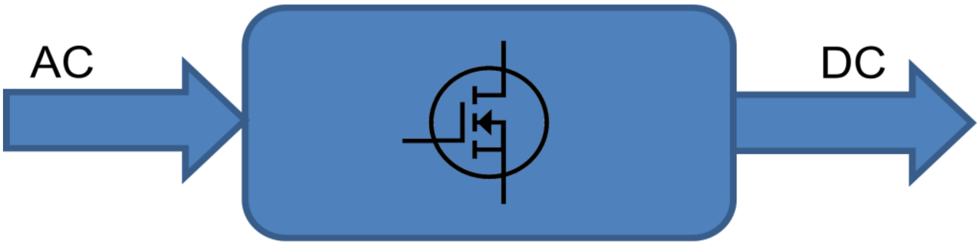




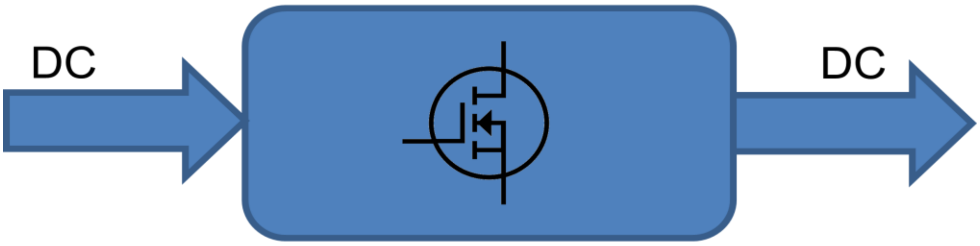
APPLICATION OF POWER ELECTRONICS IN EV:-

- Bidirectional Converter Topologies for Plug-In Electric Vehicles
- Bidirectional Battery Charger for an Electric Vehicle
- Bidirectional DC–DC Converter for Ultra-Capacitor Applications
- Integrated Bidirectional Converters for Plug-In HEV Applications
- Direct Conversion of an AC–DC Converter for Plug-In Hybrid Vehicles
- Resonant Converter for a Bidirectional EV Charger
- Isolated Bidirectional AC–DC Converter for a DC Distribution System
- Bidirectional T-Type Converter Topology for EV Applications
- Multilevel Two-Quadrant Converter for Regenerative Braking
- Multiphase Integrated On-board Charger for Electric Vehicle.

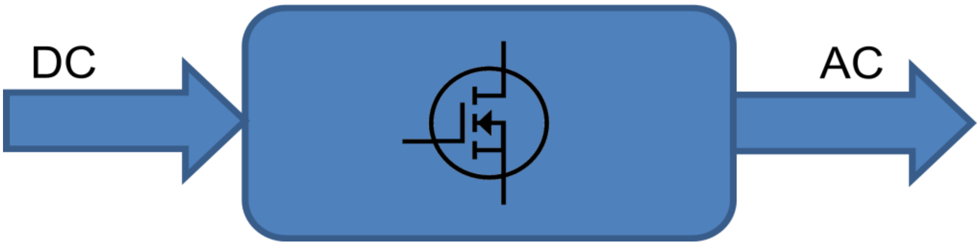
POWER ELECTRONICS CONVERTERS



Rectifier



Chopper or DC-DC Converter



Inverter

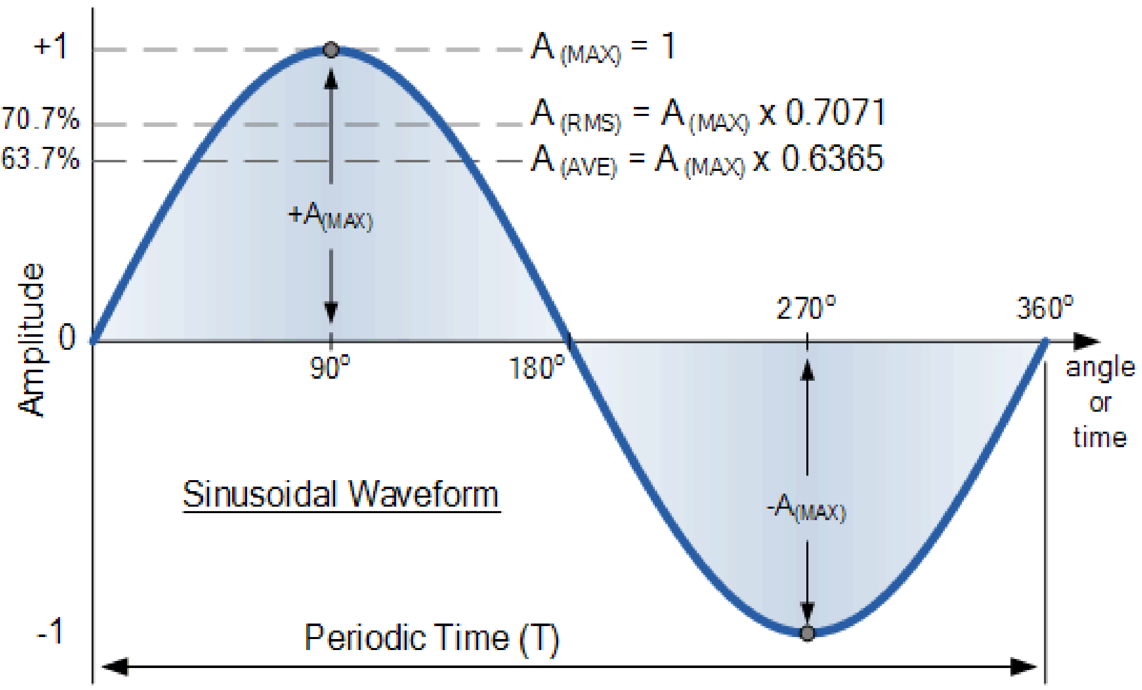
Solid State Switches:-

- Diode
- SCR – Thyristor
- MOSFET, IGBT, GTO.

RECTIFIERS:-

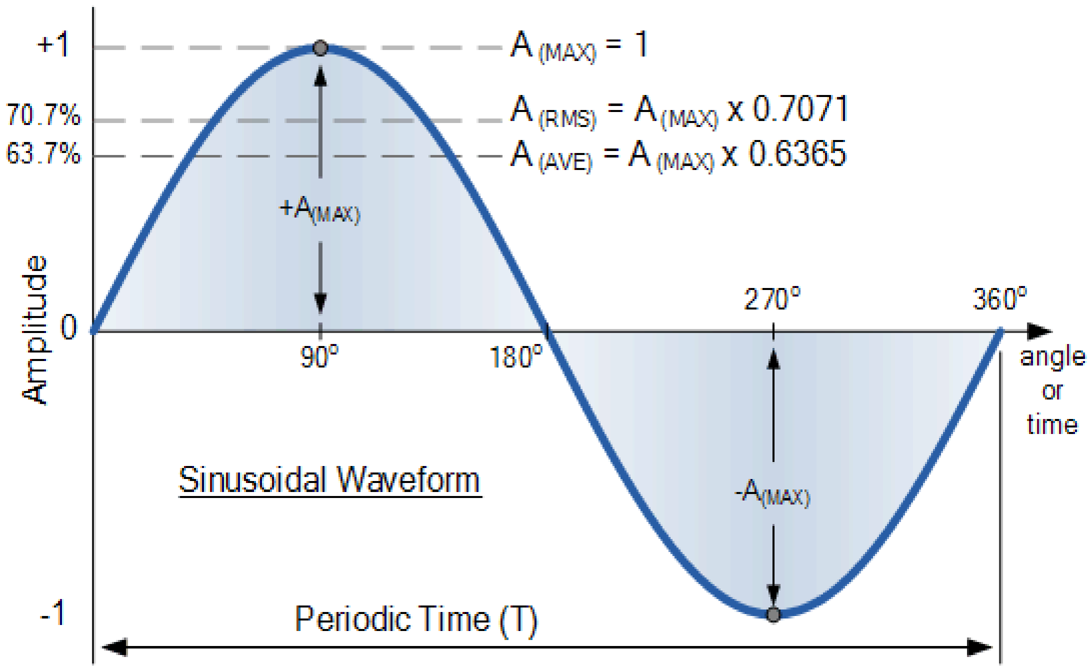
- ✓ Uncontrolled Rectifier
- ✓ Controlled Rectifier
    - Half wave controlled Converter
    - Full wave controlled Converter
    - Single Phase/Three Phase Converter

SINEWAVE:-



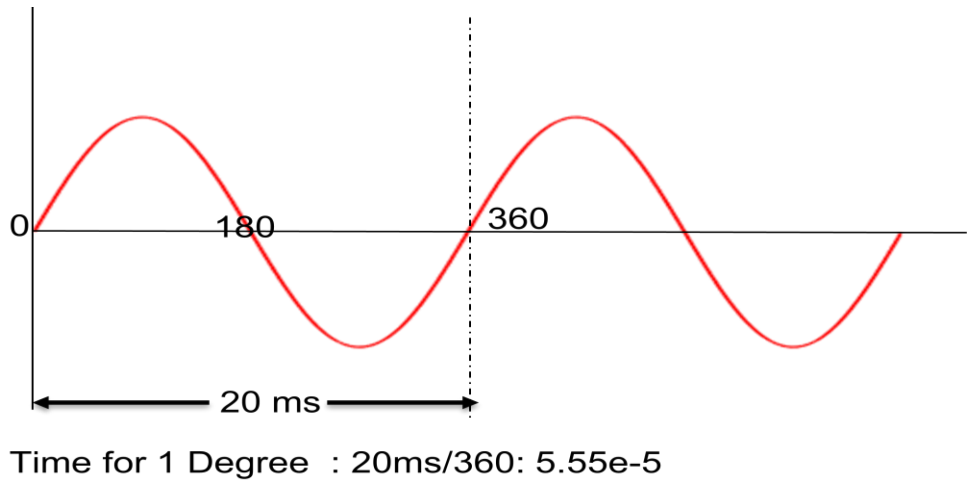
Frequency: 50Hz, Time Period: 1/F= 1/50Hz, (20ms)

SINE WAVE ANALYSIS:-



Frequency: 50Hz, Time Period: 1/F= 1/50Hz, (20ms)

TIME PERIOD:-



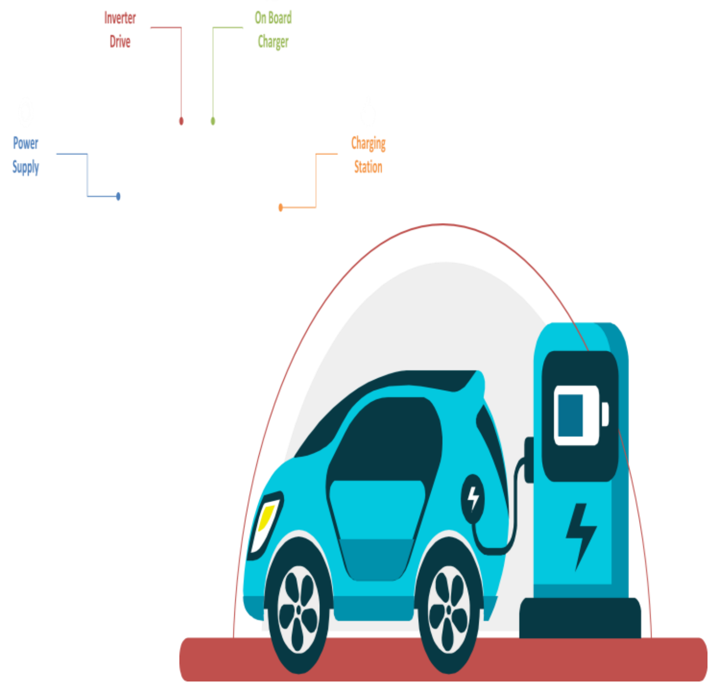
POWER CONVERTER DESIGN:-

- Power Converters for Electric Vehicles gives an overview, topology, design, and simulation of different types of converters used in electric vehicles (EV).
- It covers a wide range of topics ranging from the fundamentals of EV, Hybrid EV and its stepwise approach, simulation of the proposed converters for real-time applications.
- **Power Factor Correction (PFC)**:-
  - Power Factor Correction (PFC) shapes the input current of the power supply to be in synchronization with the mains voltage, in order to maximize the real power drawn from the mains.
  - In a perfect PFC circuit, the input current follows the input voltage as a pure resistor, without any input current harmonics.
  - **OBSERVATIONS:-**
  - Power factor correction is essential to minimizing the total apparent power consumed from the grid.
  - Regions around the world recognize this need and have implemented voluntary or mandatory requirements depending on the class of electronic equipment.

- **Design Procedure**
  - Specifications
  - Efficiency
  - Range of Input
  - % of Accuracy

- **Specifications:**
  - Power: 2KW
  - Output Voltage: 400V/5A
  - Efficiency : 90%
  - Input Voltage regulation 15% of Input
  - Op Voltage ripple 20%

APPLICATIONS OF POWER ELECTRONICS IN EV:-

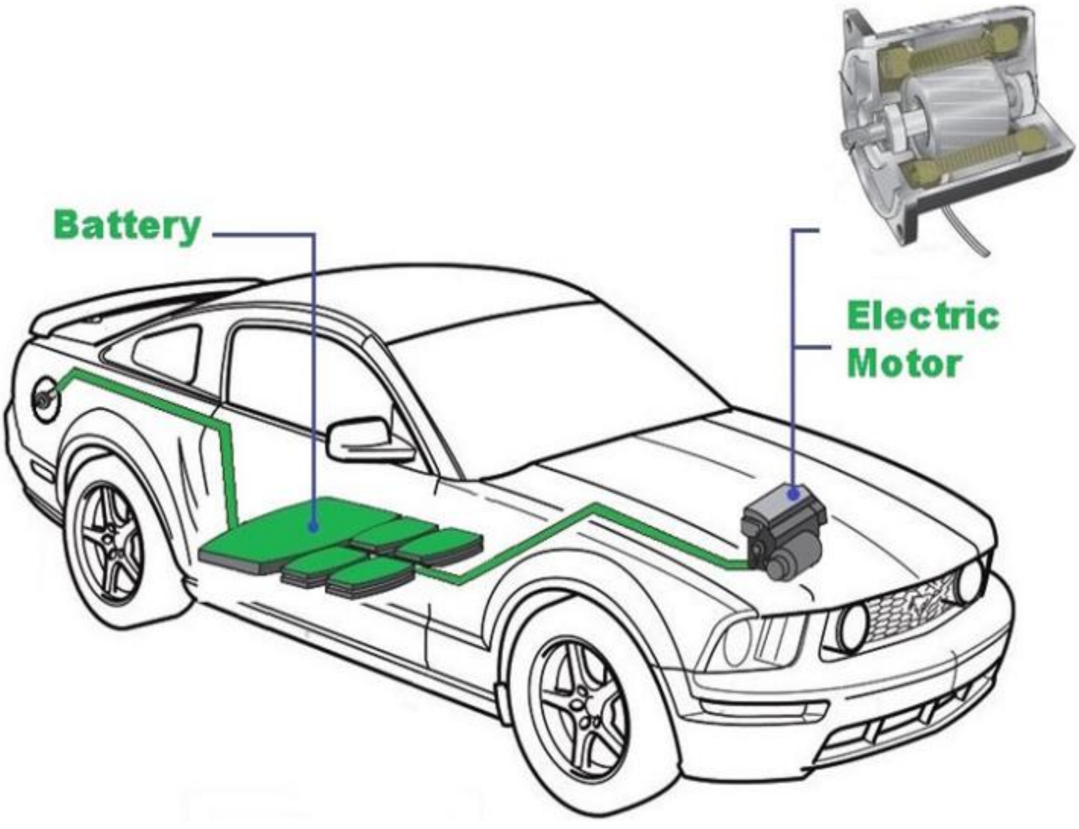


SCOPE OF ELECTRIC VEHICLE:-

- Automakers from all around the world are sighting a keen eye on Indian markets.
- With world’s largest electric vehicle manufacturer, Tesla coming into to the Indian electric automotive spectrum, it is not futile to say that India got a new lease for becoming the future hub for electric vehicles.
- However, the pandemic has slowed the growth speed of India by leaps and bounds.
- In April 2019, NITI Aayog, the federal think tank, published a report titled “India's Electric Mobility Transformation”, which pegs EV sales penetration in India at 70 percent for commercial cars, 30 percent for private cars, 40 percent for buses, and 80 percent for two- and three- wheelers by 2030.
- As electric vehicle manufacturing is becoming popular every day, its market share is also expected to rise greatly.
- India's GDP is expected to grow by an amazing 25% by 2022. The best part is that, apart from reducing environmental pollution, EVs can lower oil import by about $60 Billion by 2030.

TYPES OF MOTORS:-

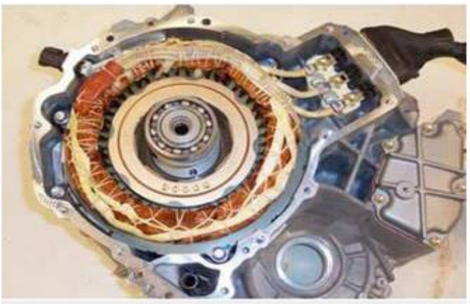
1) DC Motor
2) Permanent Magnet Brushless DC Motors (PMBLDC)
3) Induction Motors
4) Permanent Magnet Motor
5) Switched Reluctance Motor (SRM)



ELECTRIC MOTOR

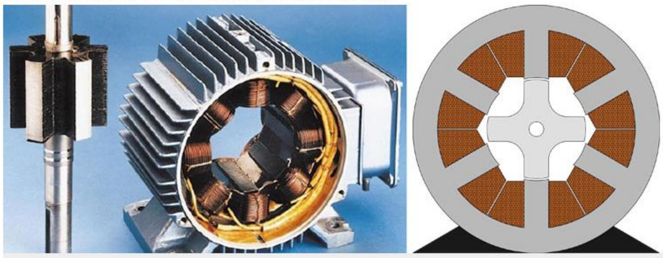
BLDC In-runner type used in Ather Scooter

BLDC MOTOR



AC INDUCTION MOTOR

market, it can replace the PMSM and Induction motors in the future.



SRM MOTOR

SPEED CONTROL:-

DC SPEED CONTROL

- When a wire carrying electric current is placed in a magnetic field, a magnetic force acting on the wire is produced.
- The force is perpendicular to the wire and the magnetic field.
- The magnetic force is proportional to the wire length, magnitude of the electric current, and the density of the magnetic field.
- Magnetic Force $F = BIL$
- Torque $T = BIL\ Cos\alpha$
- α − angle between the coil plane and magnetic field
- F= Force, B = magnetic flux density, I = current

ADVANTADE OF SPPED CONTROL:-

- High Torque
- Simple Control
- Low Cost

DIS-ADVANTAGE OF SPEED CONTROL:-

- High Maintenance cost
- Poor Efficiency.

BLDC MOTOR SPEED CONTROL:-

Brushed DC Commutation

- The windings in the armature are switched to the DC power by the brushes and armature.
- Each winding sees a positive voltage, then a disconnect, then a negative voltage.
- The field produced in the armature interacts with the stationary magnet, producing torque and rotation.

DC Motor Bridge

- The DC motor needs four transistors to operate the DC motor.
- The combination of transistor is called an H-Bridge, due to the obvious shape.
- Transistors are switched diagonally to allow DC current to flow in the motor in either direction.
- The transistors can be Pulse Width Modulated to reduce the average voltage at the motor.

Three-Phase Bridge to Drive BLDC Motor:-

- Six-step Commutation
- The Brushless DC motor is really a DC motor constructed inside-out, but without the Brushes and Commutators
- The mechanical switches are replaced with transistors
- The windings are moved from the armature, to the stator

- Types of BLDC Motor based on Magnet Arrangement

1.One Pole Pair
2.Two Pole Pair
3.Four Pole Pair

Advantages:

- Simple and rough construction
- Affordable and low maintenance
- High reliability and highly proficient
- No requirement of additional starting motor and necessity not be synchronized.

Applications:

- Large capacity exhaust fans
- Driving lathe machines
- Oil extracting mills
- Electric Sewing Machine
- Drilling machines

INDUCTION MOTOR SPEED CONTROL:-

- AC Motor
- Asynchronous Motor
- Synchronous Motor
- Three Phase
- Single Phase
- Wound Rotor
- Squirrel Cage
- Speed Control Methods
- (Note: For Squirrel Cage Motors)

- **PMSM SPEED CONTROL:-**

  - Permanent Magnet Synchronous Motors (PMSM) are similar to Brushless DC motors (BLDC).

  - PMSM are rotating electrical machines that have a wound stator and permanent magnet rotors that provide sinusoidal flux distribution in the air gap, making the BEMF inform a sinusoidal shape.

  - **Classification of PMSM with the Rotor Design**
    - Surface Mount PMSM
    - Interior Mount PMSM

- **SRM MOTOR SPEED CONTROL:-**

- 1830-1850 SRM Concept Evolved
- Due to Tesla Invented AC Induction Motor in Late 1800’s, the entire market diverted
- Technology development in Power Electronic Circuit, the SRM again capture the Market (1960s).

- **SR Drive:**

- 6/4 Pole Switched Reluctance Motor
- Converter Design
- Gate Pulse Generation
- Current Control.

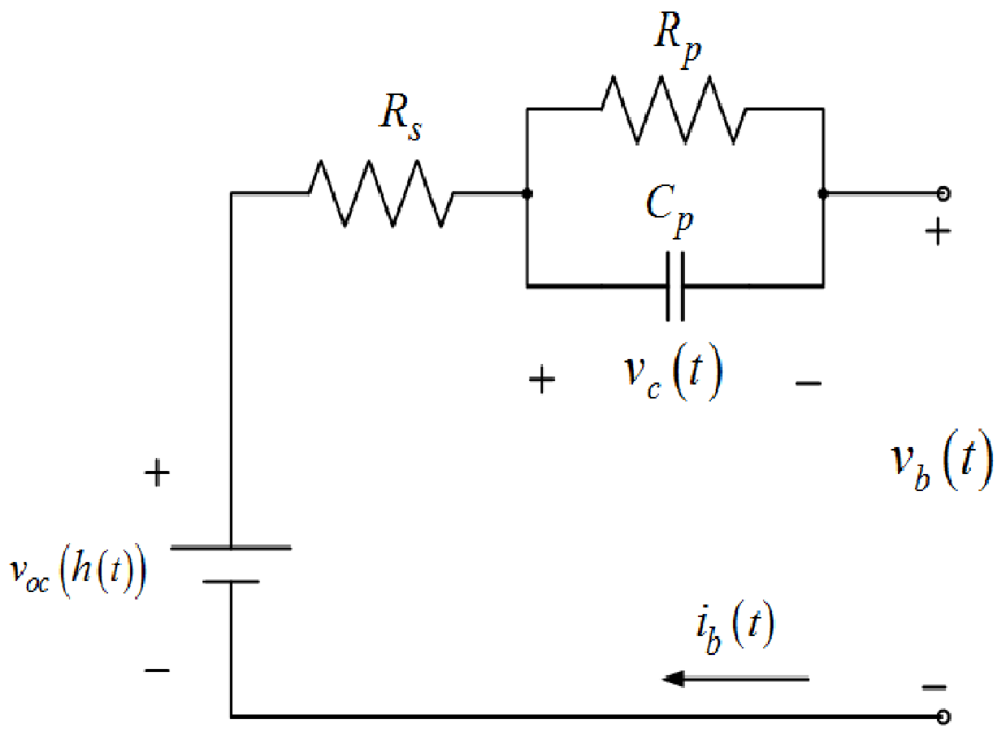
- **Applications :-**

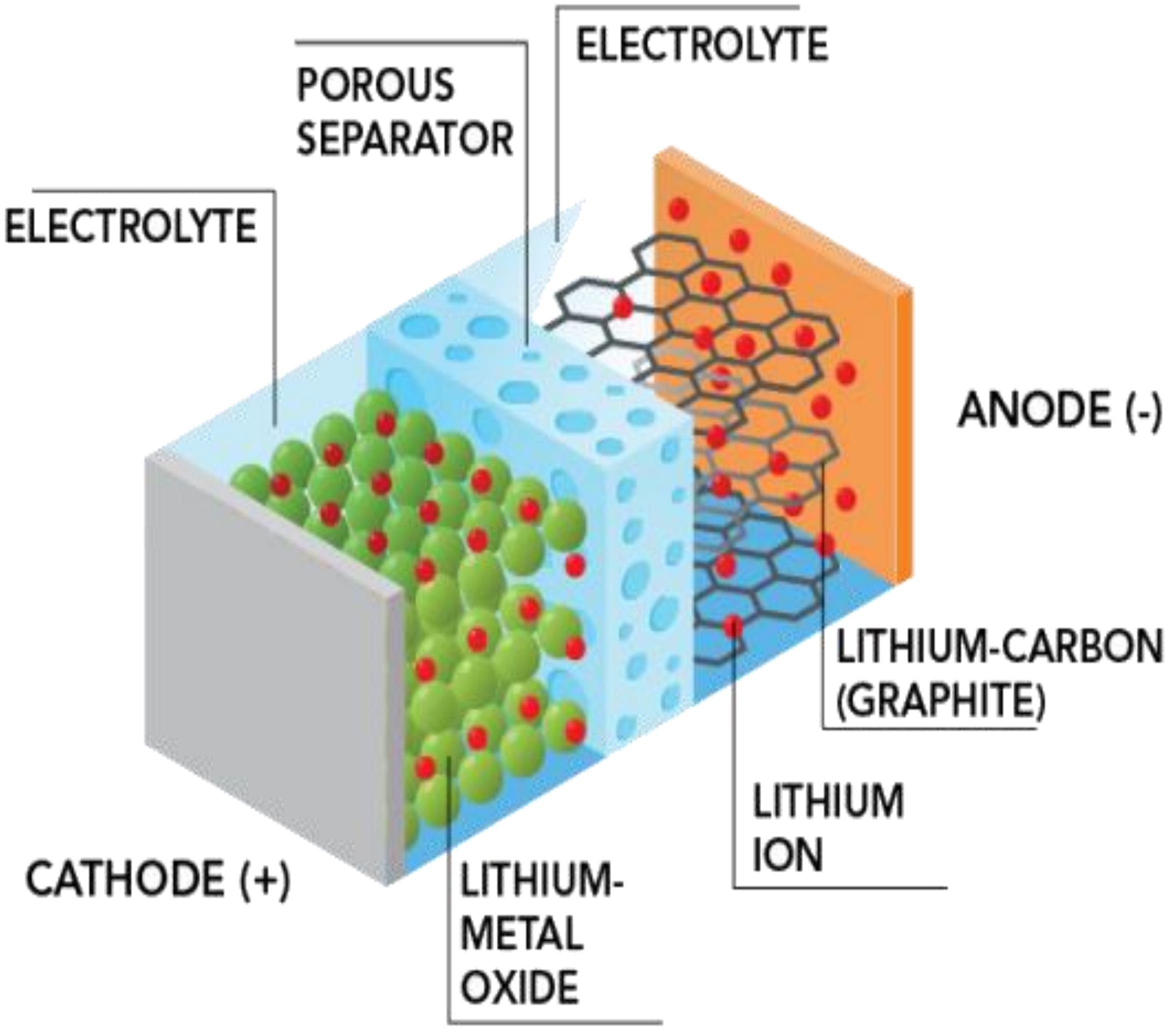
- AC Drives
- Automated Guided Vehicles
- Heating, ventilation and air conditioning
- Robots.

BATTERY MANAGEMENT SYSTEMS:-

- It's a device to convert Chemical Energy to Electrical Energy**.**
- Types of EV Battery
- Lithium-ion
- Lithium Phosphate
- Nickel-metal hydride batteries
- Lead-acid batteries.

Battery Equivalent Circuit:-





Battery Parameters Battery SOC:

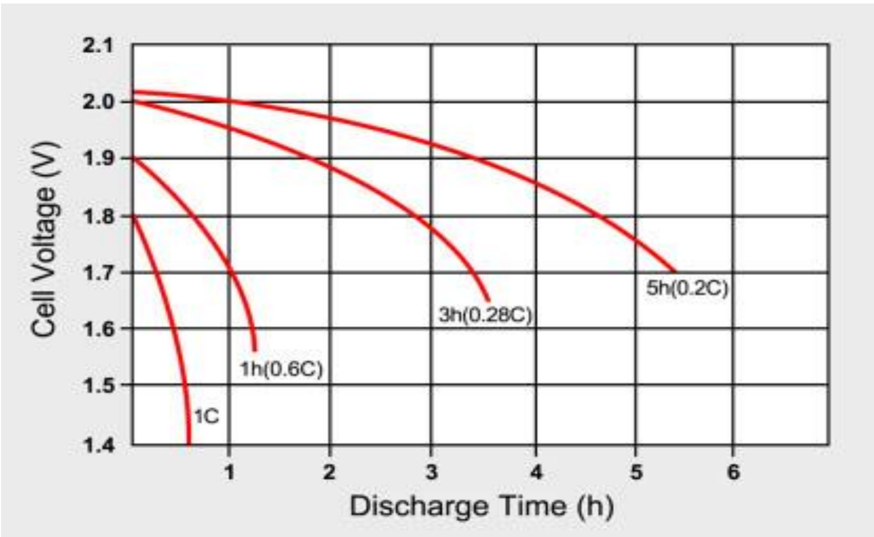
- The fraction of the total energy or battery capacity that has been used over the total available from the battery.

Shows the remaining capacity of the battery while in use.

Model	Battery	Charge Times
Toyota Prius PHEV	4.4kWh Li-ion, 18km all-electric range	1.5h at 230VAC 15A
Chevy Volt PHEV	16kWh, Li-manganese/NMC, liquid cooled, 181kg (400 lb), all electric range 64km	4h at 230VAC, 15A
Mitsubishi iMiEV	16kWh; 88 cells, 4-cell modules; Li-ion; 109Wh/kg; 330V, range 128km	7h at 230VAC 15A
Smart Fortwo ED	16.5kWh; 18650 Li-ion, driving range 136km	3.5h at 230VAC, 15A
BMW i3 Curb 1,365kg	Since 2019: 42kWh, LMO/NMC, large 60A prismatic cells, battery weighs ~270kg (595 lb) driving range: EPA 246 (154 mi); NEDC 345km (215 mi); WLTP 285 (178 mi)	11kW on-board AC charger; ~4h charge; 50kW DC charge; 30 min charge.
Nissan Leaf*	30kWh; Li-manganese, 192 cells; air cooled; 272kg, driving range up to 250km	8h at 230VAC, 15A; 4h at 230VAC, 30A
Tesla S* Curb 2,100kg (4,630 lb)	70kWh and 90kWh, 18650 NCA cells of 3.4Ah; liquid cooled; 90kWh pack has 7,616 cells; battery weighs 540kg (1,200 lb); S 85 has up	9h with 10kW charger; 120kW Supercharger, 80% charge in 30 min

	to 424km range	
Tesla 3 Curb 1,872 kg (4072 lb)	Since 2018, 75kWh battery, driving range 496km ; 346hp engine, energy consumption 15kWh /100km (24kWh/mi)	11.5kW on-board AC charger; DC charge 30 min
Chevy Bolt Curb 1,616kg; battery 440kg	60kWh; 288 cells in 96s3p format, EPA driving rate 383km; liquid cooled; 200hp electric motor (150kW)	10h at 230VAC, 30A 1h with 50kWh
MG EV ZS	44.5KW Lithium Ion	394V
TATA NEXON EV	30.2 Lithium Polymer	320V

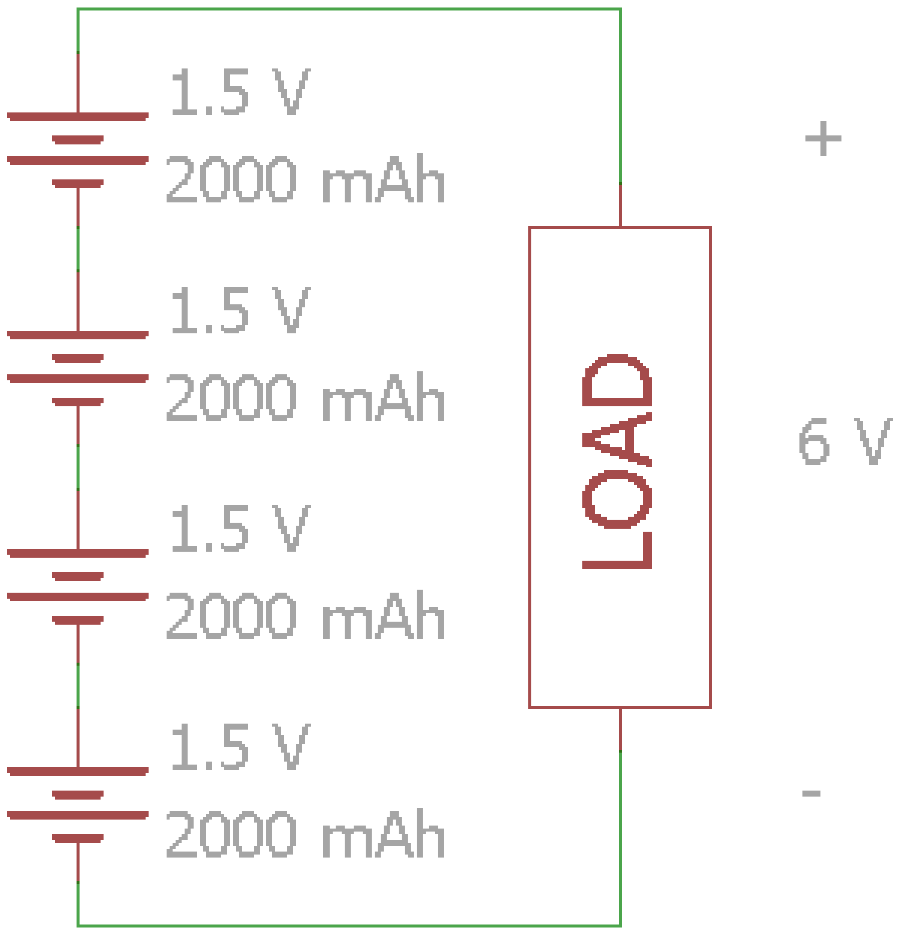
STATE OF HEALTH:-



MATLAB DEMO:-

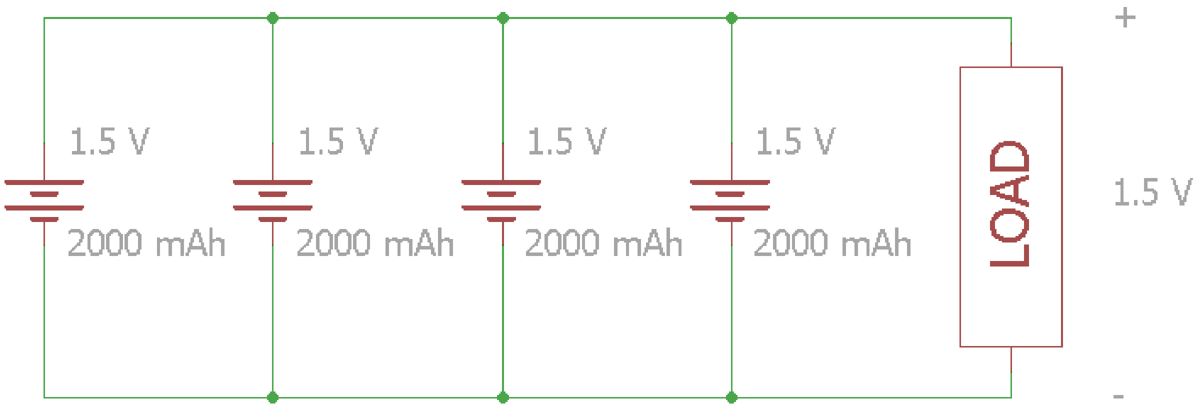
- Series
- Parallel
- Series-Parallel

SERIES CONFIGURATION:-



- 1.5+1.5+1.5+1.5 = 6V/2000mA

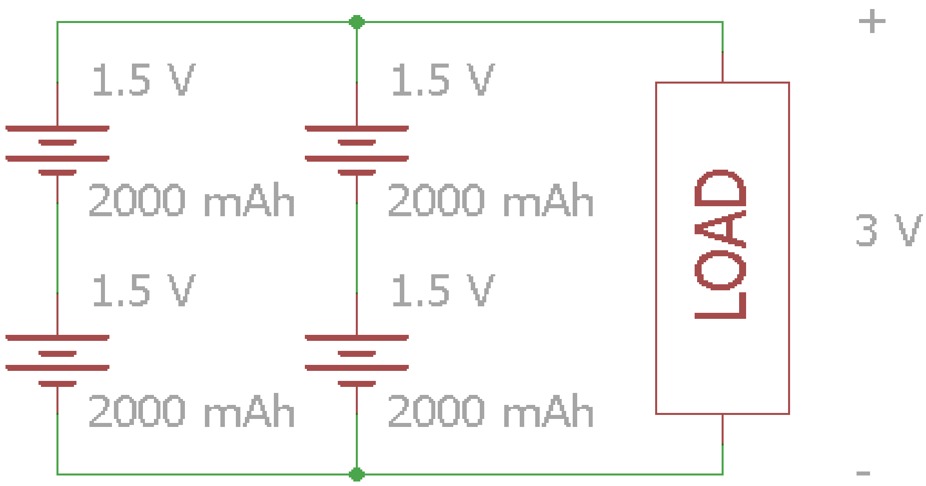
PARALLEL CONFIGURATION:-



1.5V/ (2000 + 2000+ 2000+ 2000)

= 1.5V/8000mA

SERIES PARALLEL CONFIGURATION:-



(1.5+1.5) / (2000+2000)

= 3V/4000mA

CONCLUSION

- The global electric vehicle market size is projected to grow from 4,093 thousand units in 2021 to 34,756 thousand units by 2030, at a CAGR of 26.8%.
- India has already shown its keen interest to be a major part of this automotive paradigm shift.
- Countries like, The UK, France, Norway and Germany have even brought in legislation to ban the sales of non-electric vehicles as early as 2025
- . India has already shown its keen interest to be a major part of this automotive paradigm shift.
- Adding to that, India has already put forward the desire to become the biggest hub for electric vehicles in the future. Price of electricity as fuel could fall as low as Rs 1.1/km, helping an electric vehicle owner save up to Rs. 20,000 for every 5,000km traversed.
- Finally, electrification will help reduce vehicular emissions, a key contributor to air pollution which causes an average 3% GDP loss every year, reports suggest.

REFERENCE:-

MATLAB SIMULATION FILES

C:\Users\91900\Downloads\Download-Day-3-PPTs1\Download Day 4 simulation\d4exp2.

THANK YOU