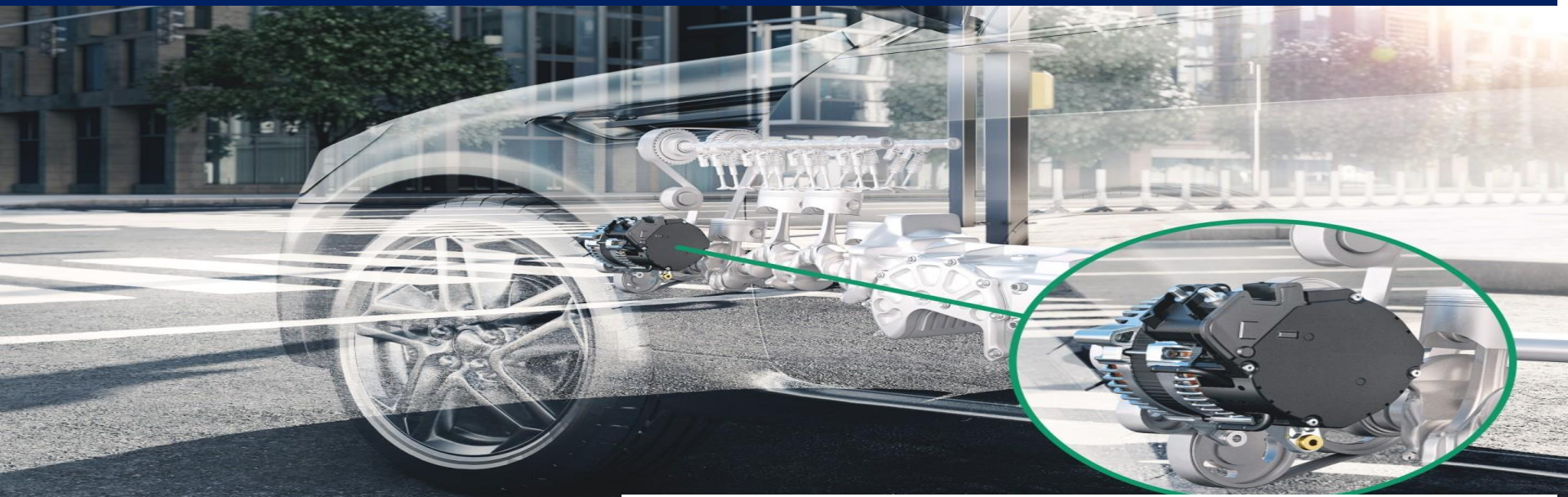
Introduction to Electric Vehicle Technology



Dr.Vasan prabhu Veeramani
Technical Head

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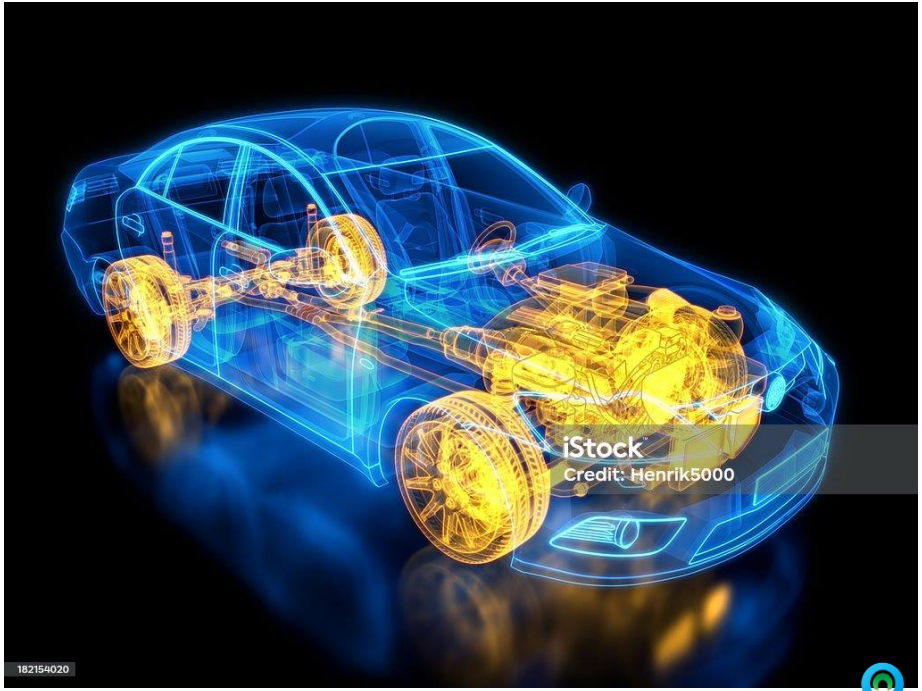
Agenda

- What is an Electric Vehicle (EV)
- EV vs. IC
- Why do we need
- EV Architecture
- Sub components in EV
- Motor Design
- V Model
- Data Analytics
- V2X
- Hardware



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What is an Electric Vehicle?

An electric vehicle (EV) is a type of vehicle that is powered by electricity stored in batteries or other energy storage devices, rather than by internal combustion engines that burn fossil fuels like gasoline or diesel. Electric vehicles use electric motors to drive the wheels and provide propulsion.

Electric vehicles offer several advantages, including reduced greenhouse gas emissions, lower operating costs (since electricity is generally cheaper than gasoline), quieter operation, and potential reductions in air pollution in urban areas.

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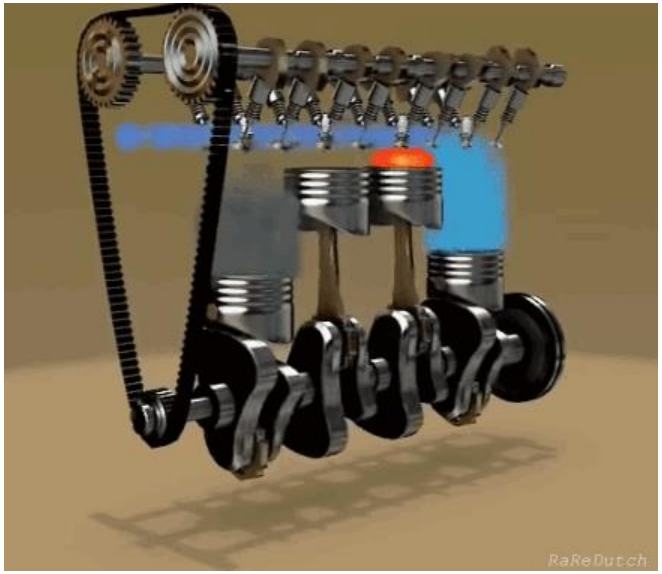
EV vs IC



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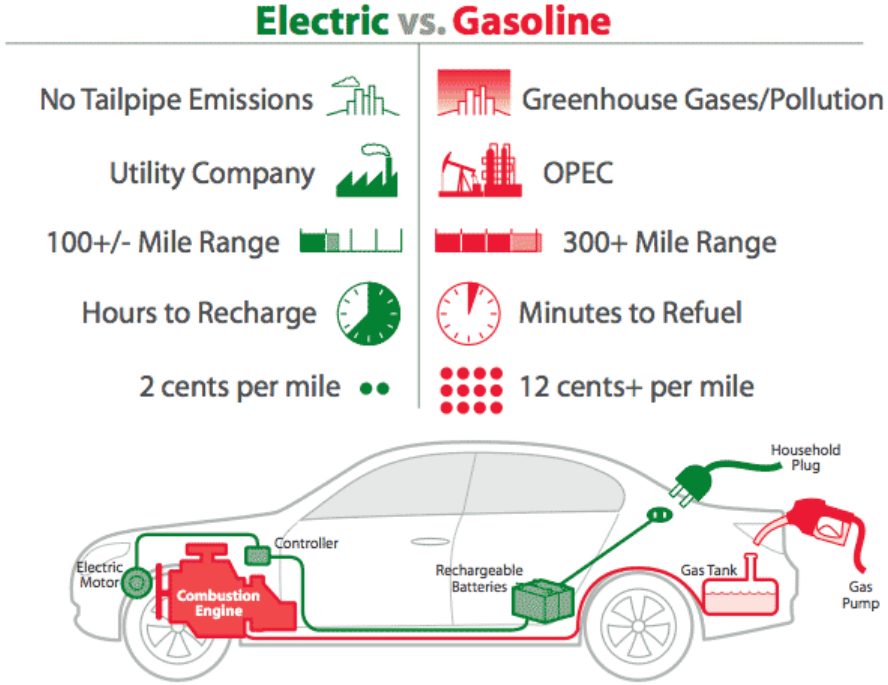
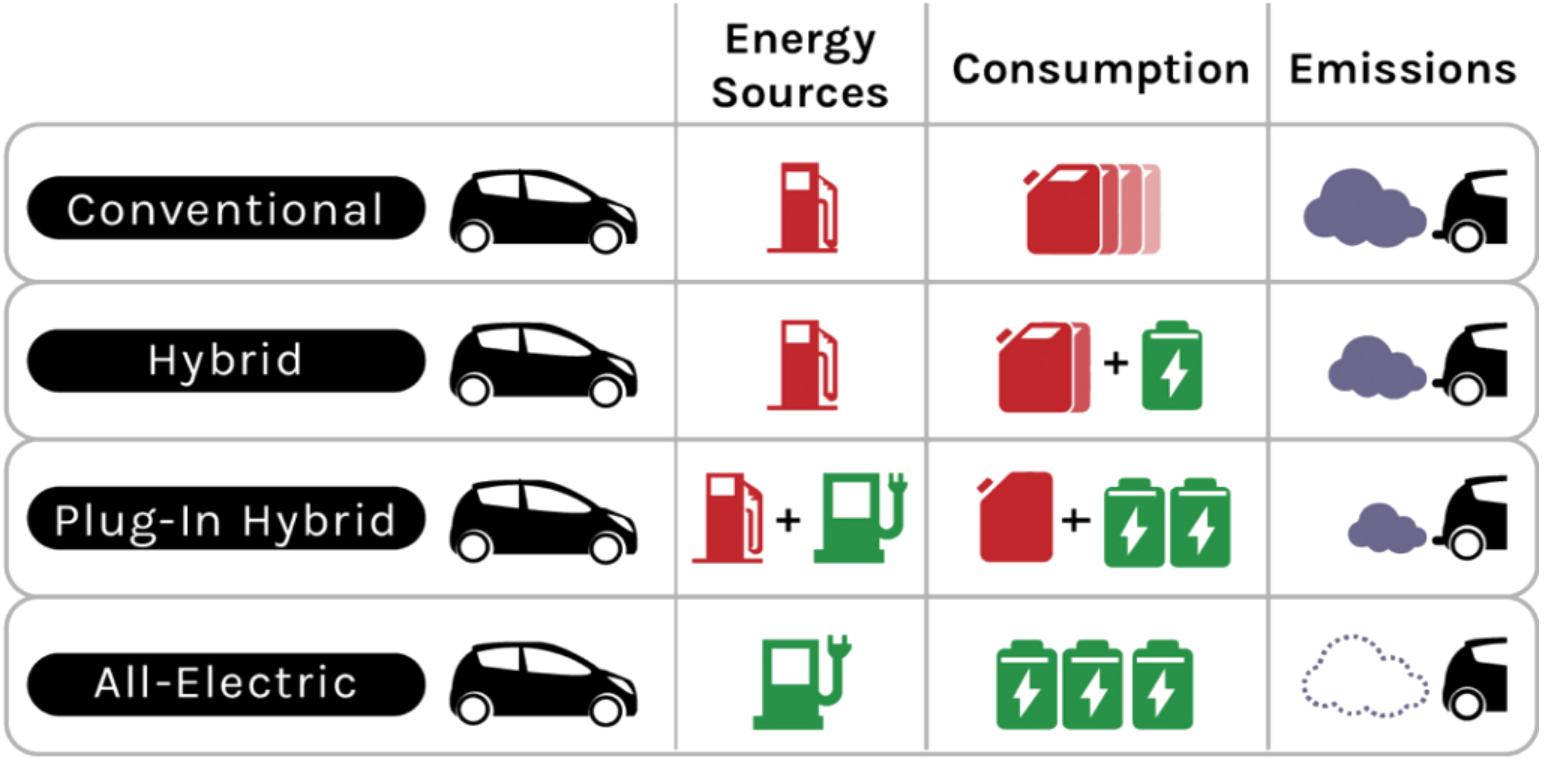
Electric Vehicle Vs IC Engine



Why do We need EV



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Promoting Energy Security

- **Reduced Oil Dependency**: Shifting away from oil-based fuels in transportation helps to reduce geopolitical risks and dependencies.
- **Local Energy Sources**: Renewable energy used in sustainable transportation often comes from local or regional sources, ensuring energy security.

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Social and Lifestyle Changes

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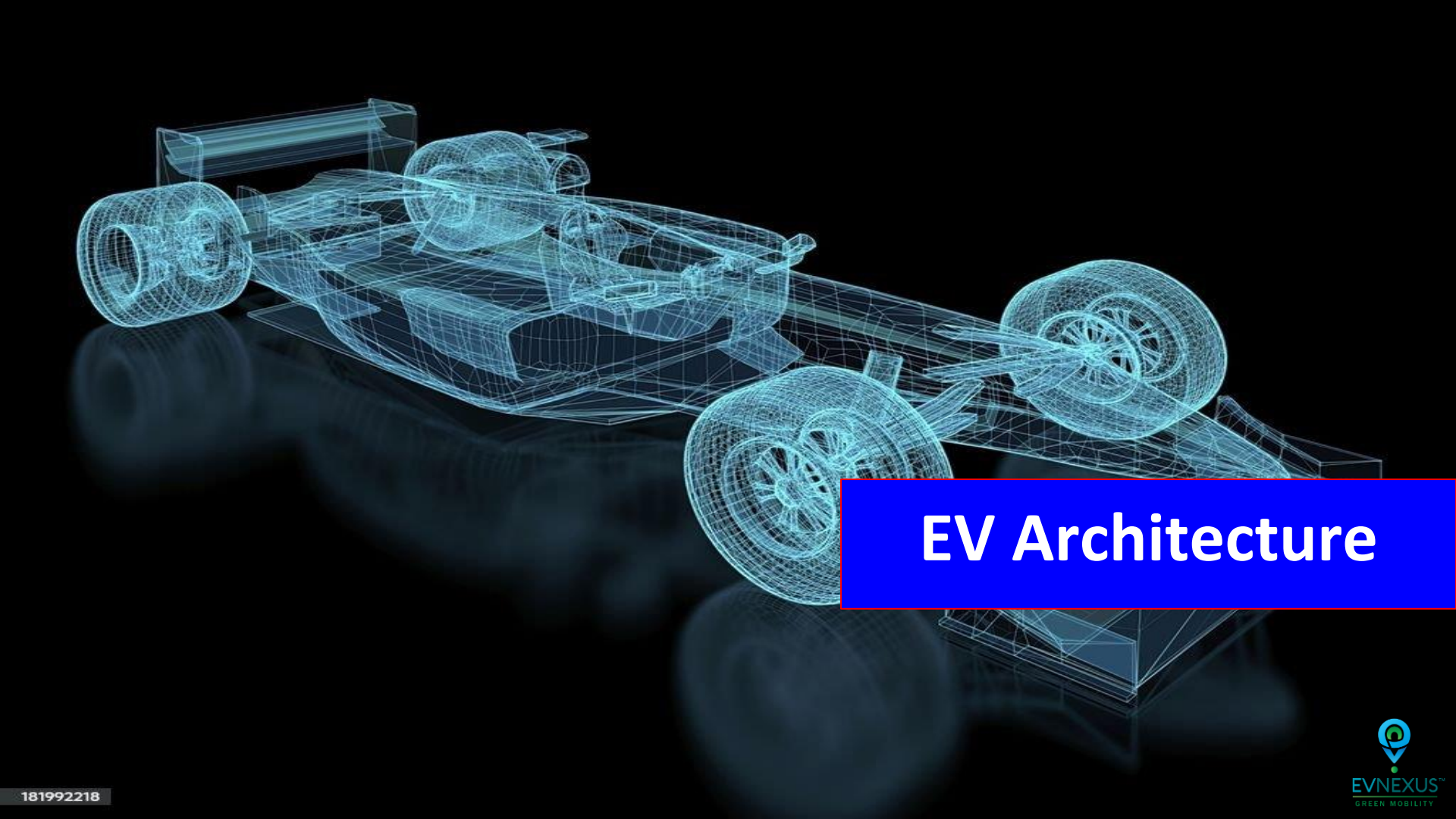

EV Architecture

181992218

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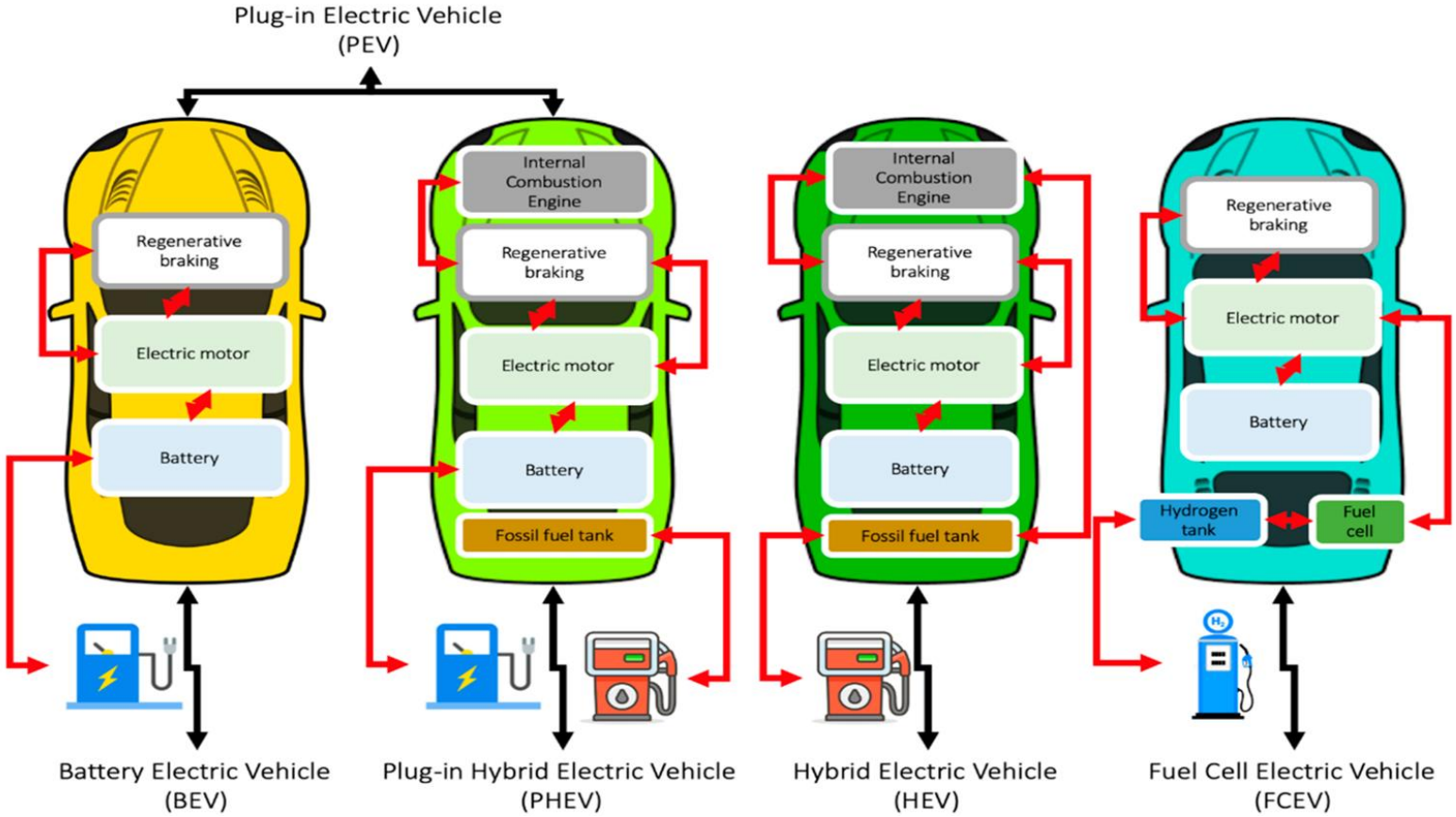

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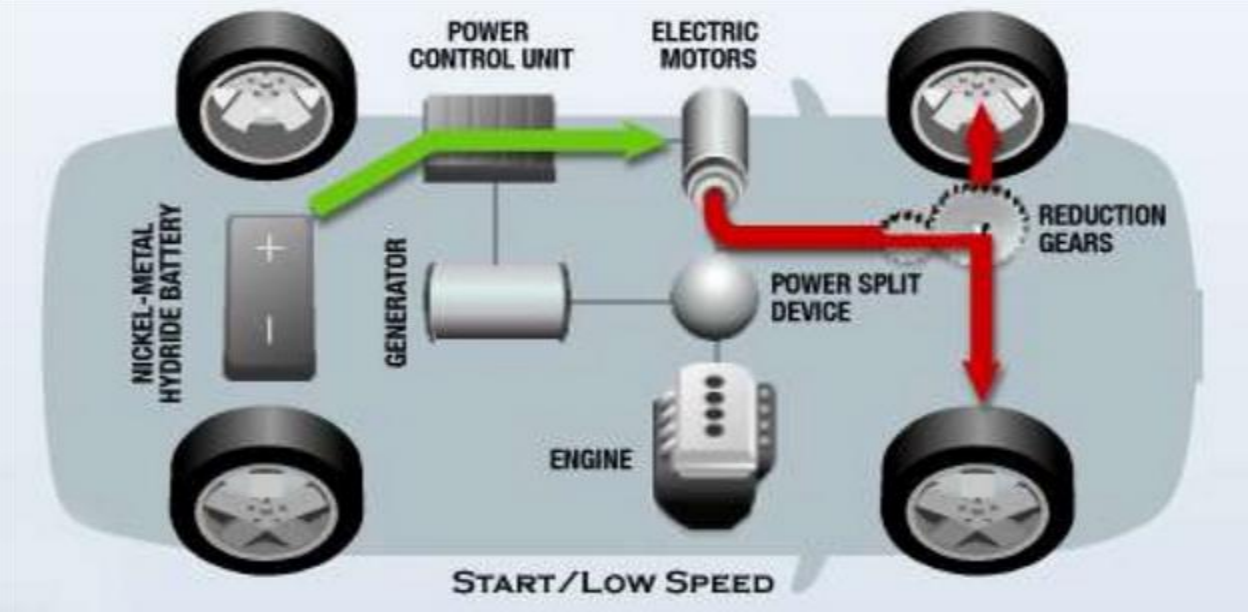
Hybrid Electric vehicle



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Degrees of Hybridization

	Micro Hybrid	Mild Hybrid	Full Hybrid	Plug-in Hybrid
Automatically stops/starts the engine in stop-and-go traffic				
Uses regenerative braking and operates above 60 volts				
Uses an electric motor to assist a combustion engine				
Can drive at times using only the electric motor				
Recharges batteries from a wall outlet for extended all-electric range				

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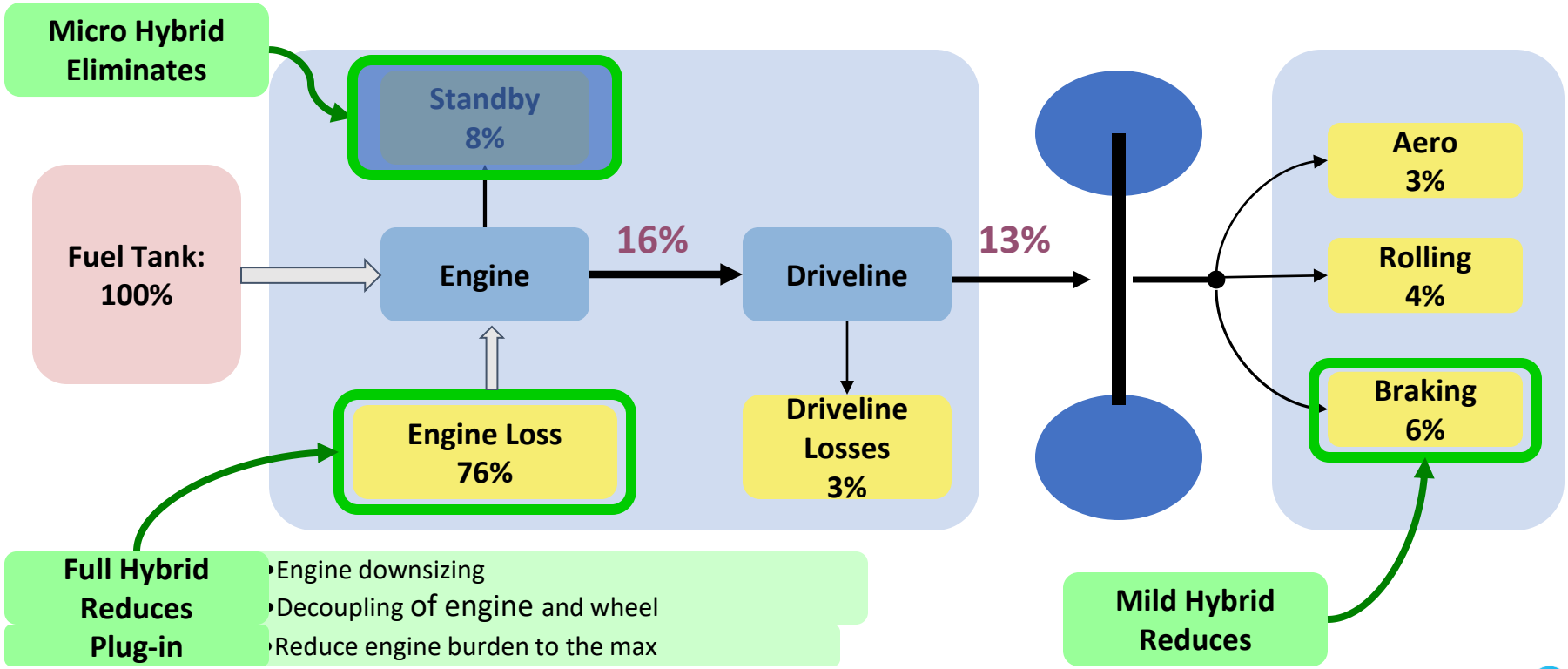
Energy Saving : Hybrid Systems



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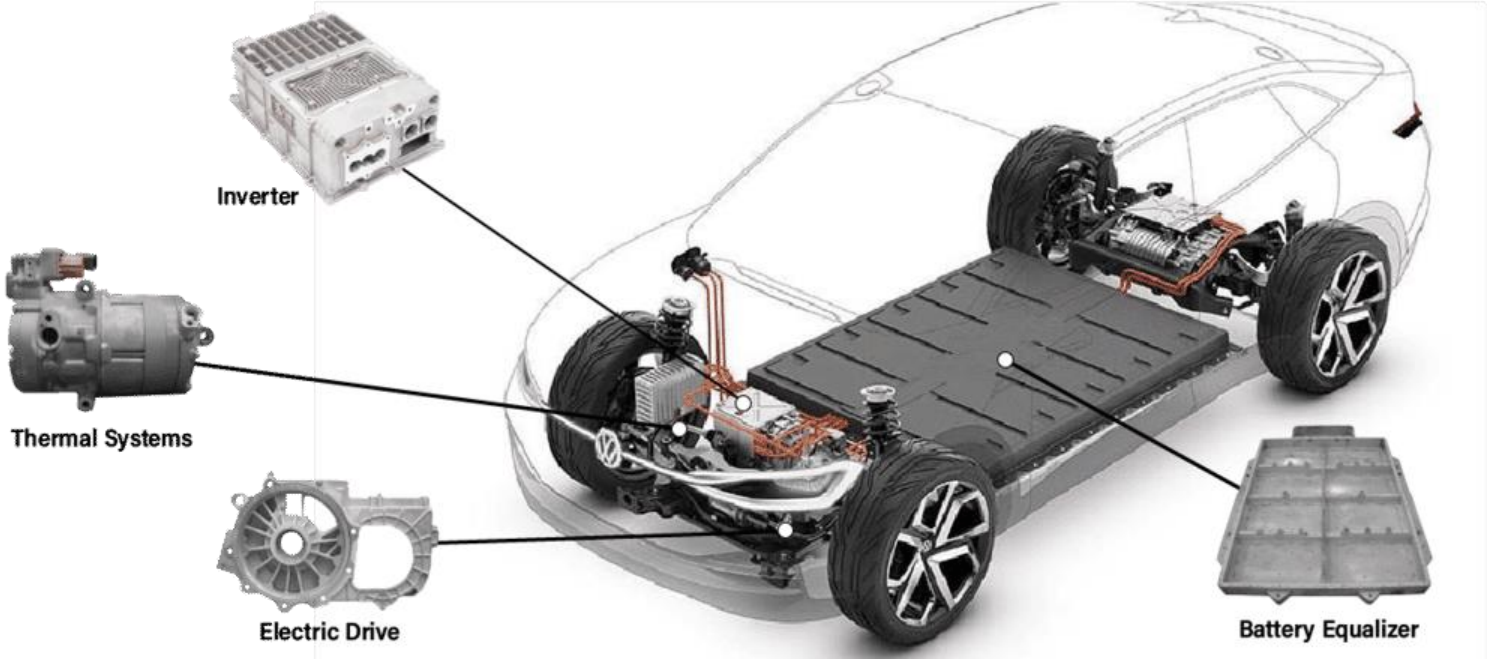
Sub Components



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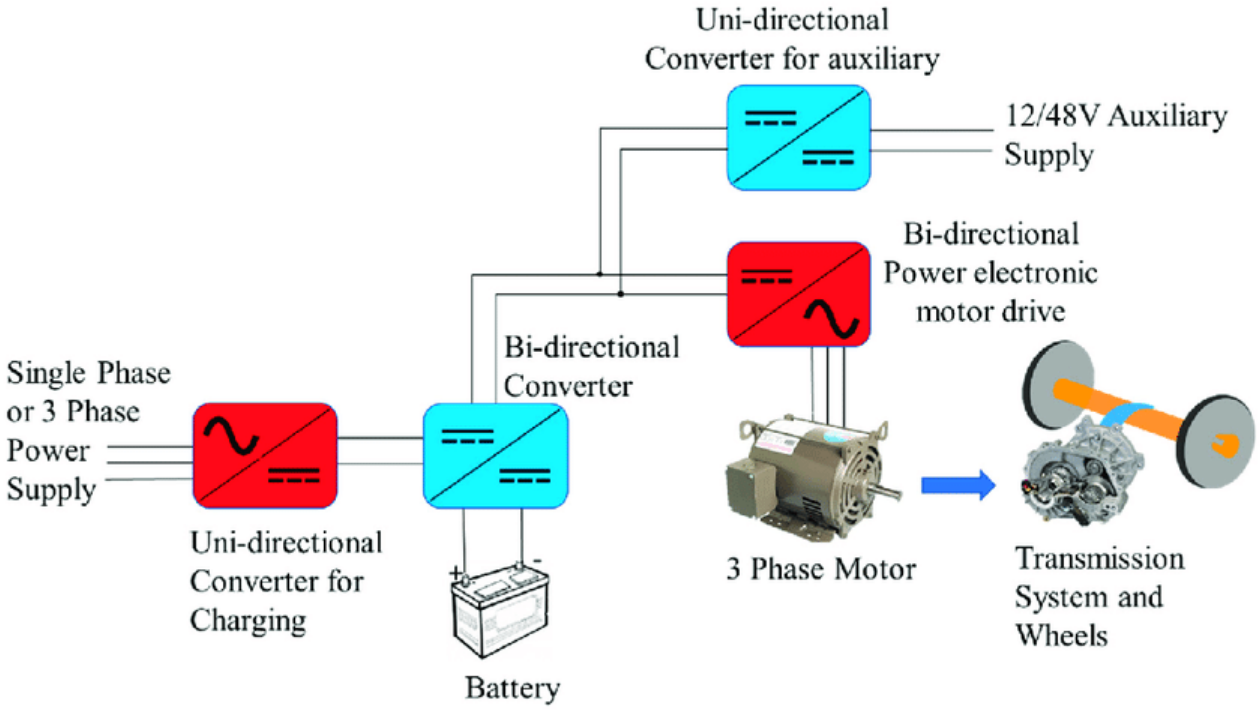
Sub Components



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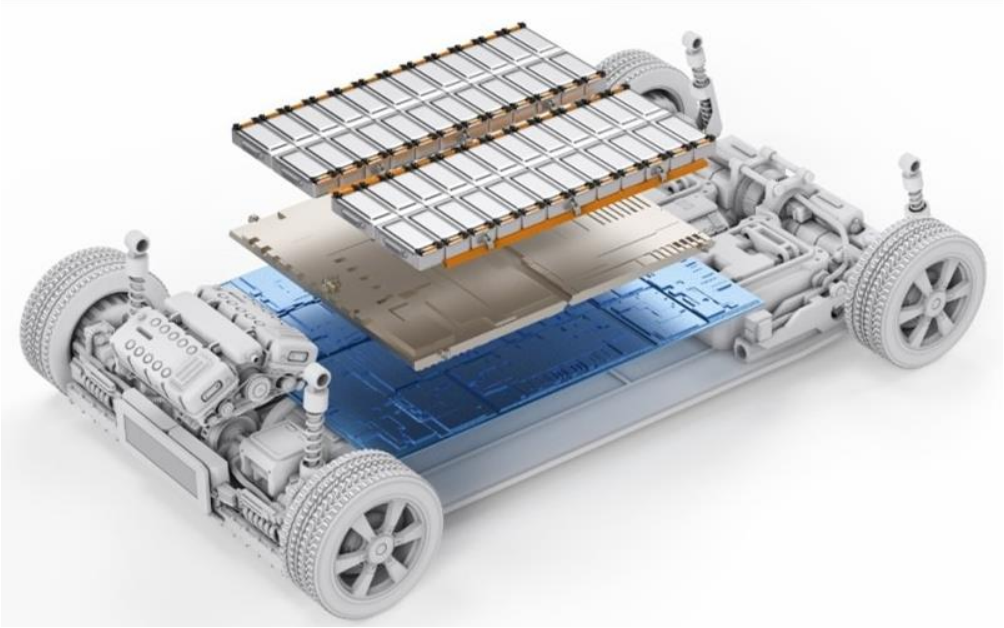
Battery



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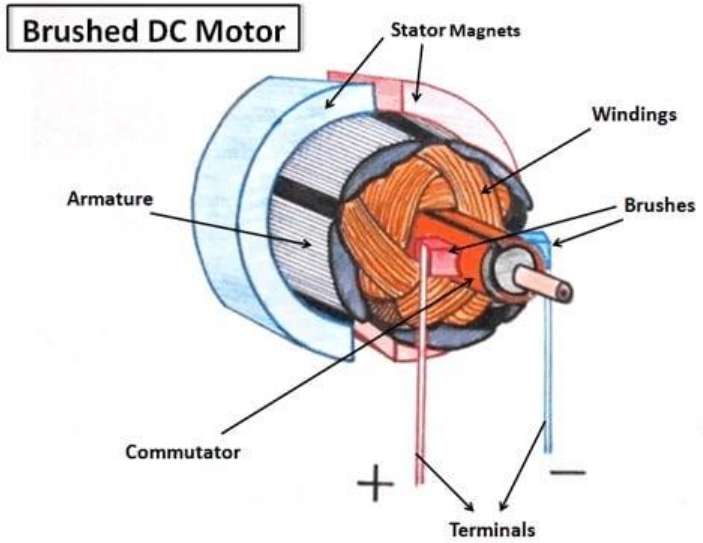
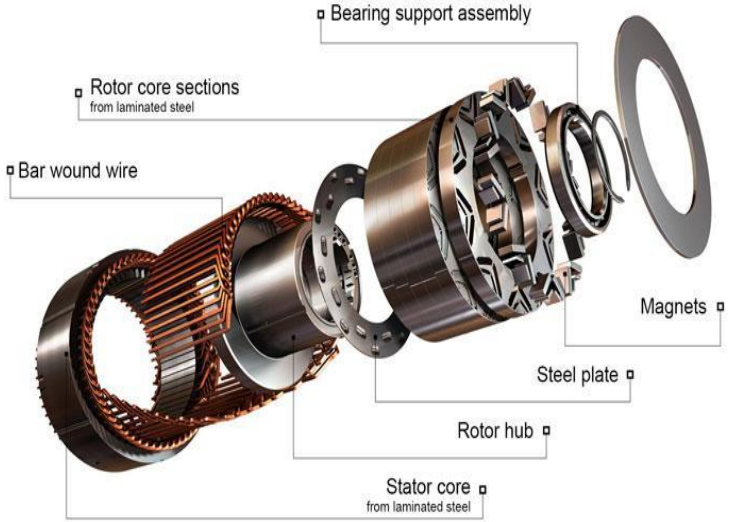
Motor





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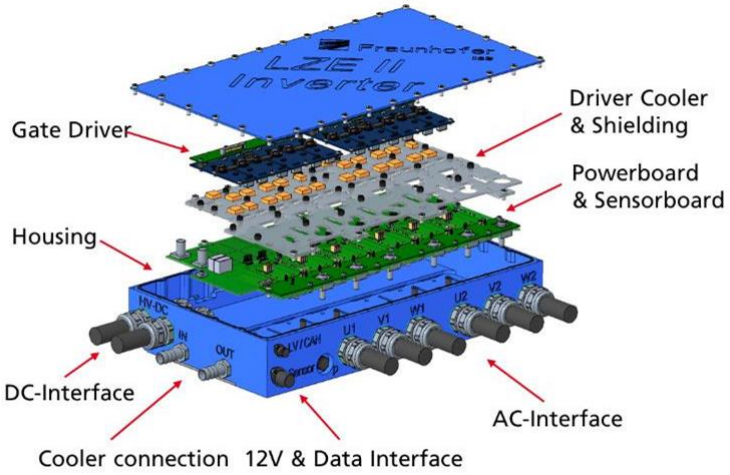
Power Electronics



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Charger

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Communication Channels

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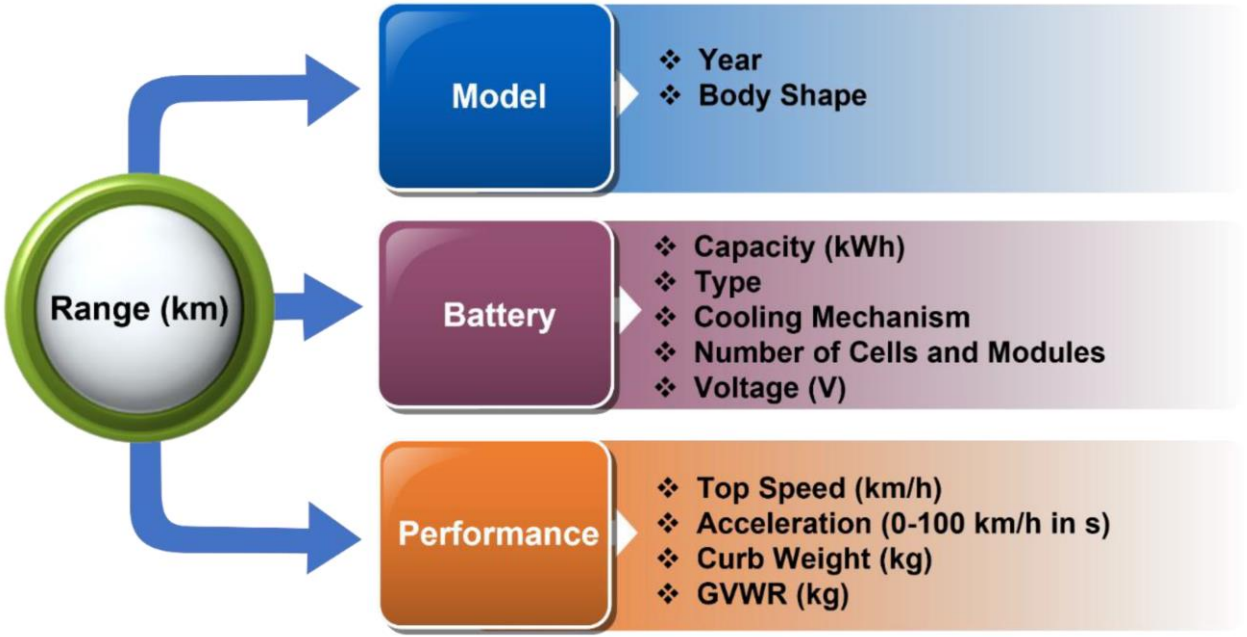
Range Estimation



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Motor Design

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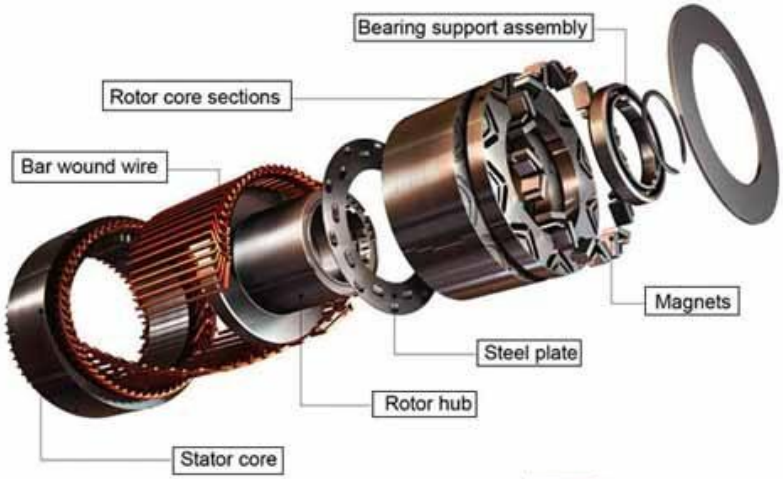
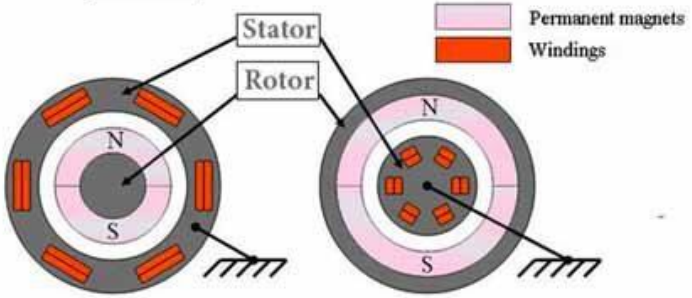
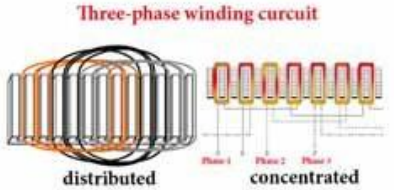
Permanent magnet synchronous motor construction







Innovation
Discoveries

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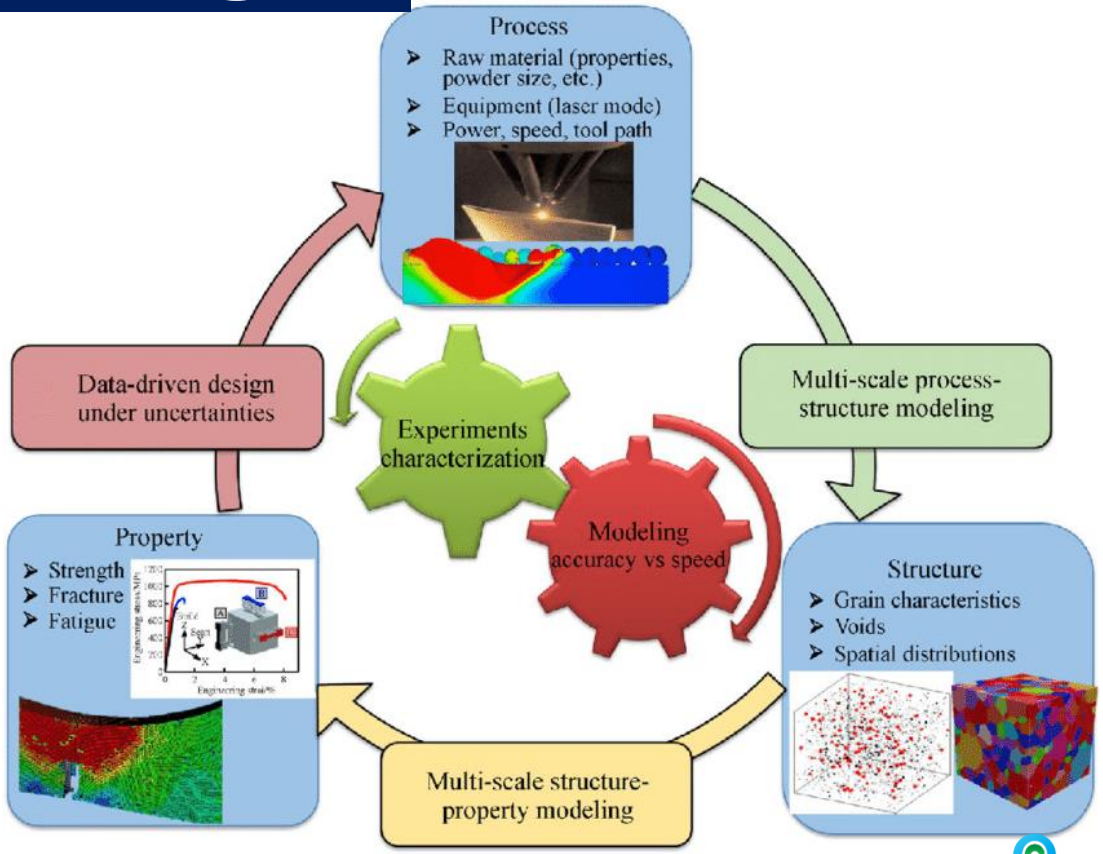
Multi-Physics Modeling

- Multi-physics modeling is a simulation approach that combines multiple physics disciplines to analyze complex systems.
- It involves the simultaneous solution of multiple partial differential equations that describe different physical phenomena occurring within a system.
- The different physics disciplines may include electromagnetism, heat transfer, fluid dynamics, mechanics, and acoustics, among others.
- The goal of multi-physics modeling is to provide a comprehensive understanding of the interactions and interdependencies between the different physical processes and their impact on the system behavior.



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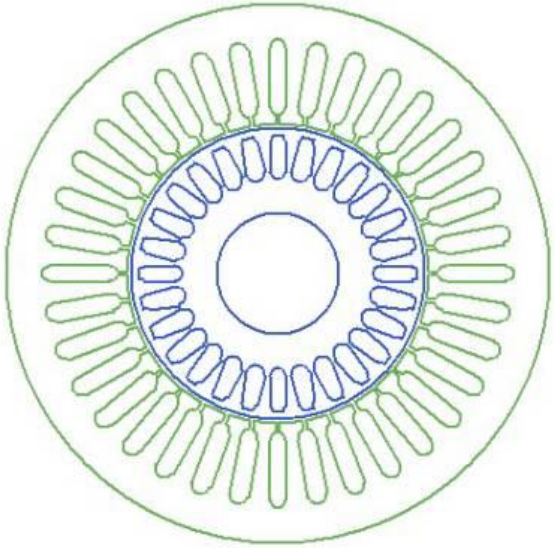
Ansoft Maxwell - Project7 - RMxprtDesign1 - Machine - [Project7 - RMxprtDesign1 - Machine]

File Edit View Project Machine RMxprt Tools Window Help

Project Manager

- Project7*
  - RMxprtDesign1 (Three Phase In
    - Machine
      - Stator
        - Slot
        - Winding
      - Rotor
        - Slot
        - Winding
      - Shaft
    - Analysis
      - Setup1
    - Optimetrics
    - Results
  - Definitions

Project



Main Diagram Winding Editor

Progress

Message

- Stator: Steel type is not assigned (11:20:36 вер 30, 2016)
- Stator/Slot: Hs0 must be greater than 0. (11:21:25 вер 30, 2016)
- Stator/Slot: Bs0 must be greater than 0. (11:21:25 вер 30, 2016)
- Stator/Slot: Bs1 must be greater than 0. (11:21:25 вер 30, 2016)

Ready

NUM

EVNEXUS™

РУС 23:25

Motor Modeling Softwares

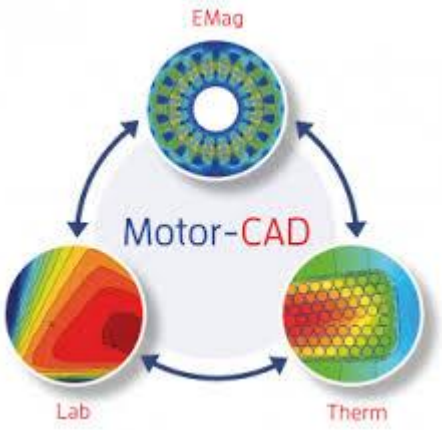
Ansys MAXWELL

COMSOL

Simcenter MAGNET

Simcenter Motorsolve

Altair



JMAG

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JMAG- Express Online

No installation required.

JMAG-Express Online can be used for free after creating an account.

Start using JMAG-Express Online

Create an free account

- Software License Agreement
- Terms of Use

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- Requirement
- Input
- Parametric
- Design Case Table
- Graph
- Characteristics Ta...
- Map
- Thermal

Thermal Considering

Targeted Value

- [x] Rated Power, kW
- [x] Maximum Torque, Nm
- [x] Rated Revolution Speed, rpm
- [x] Maximum Revolution Speed, rpm

Sizing Parameter

- [x] Number of Poles
- [x] Number of Slots
- [x] Power Supply Voltage(RMS), V
- [x] Maximum Current(RMS), A
- [x] Maximum Outer Diameter of Motor, mm
- [x] Maximum Motor Height, mm
- [x] Winding
- [x] Magnet

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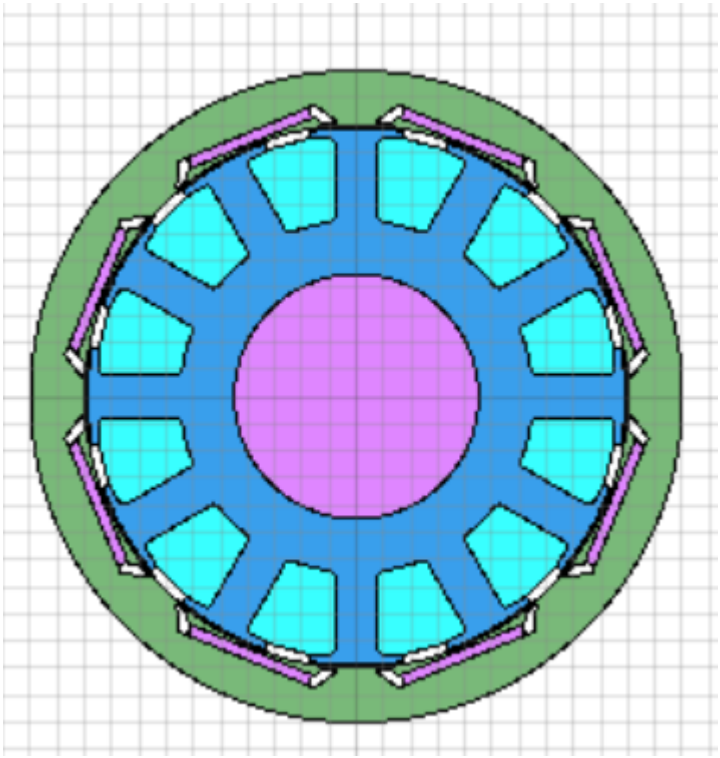
JMAG- Motor Model



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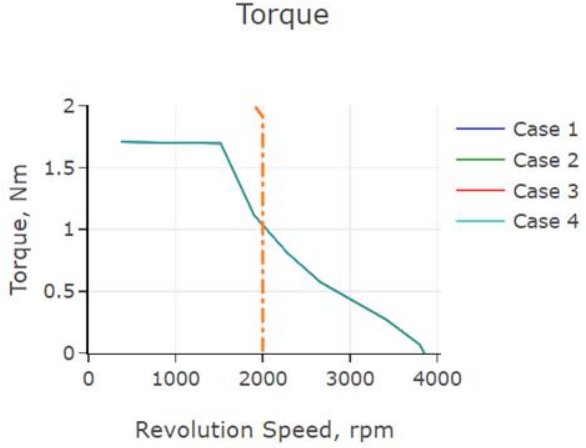
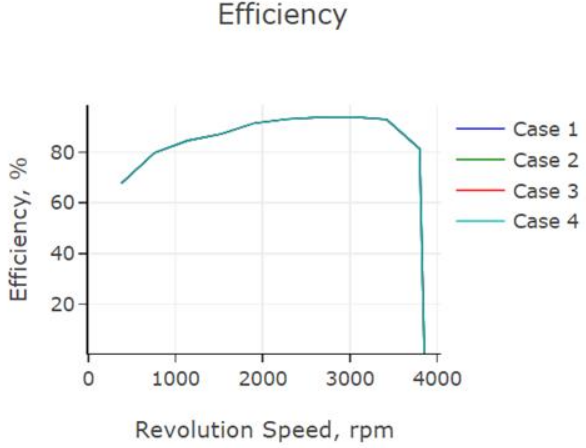
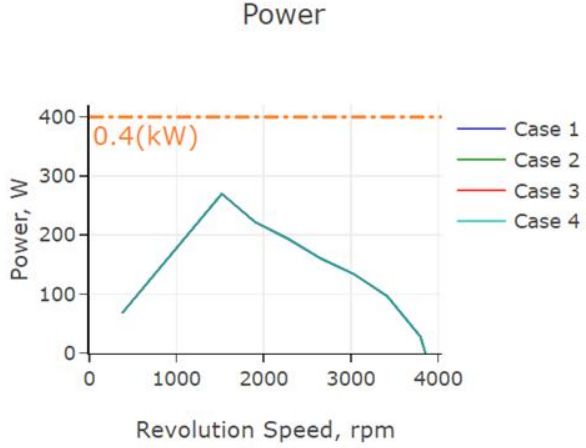
JMAG- Results







EVNEXUS™
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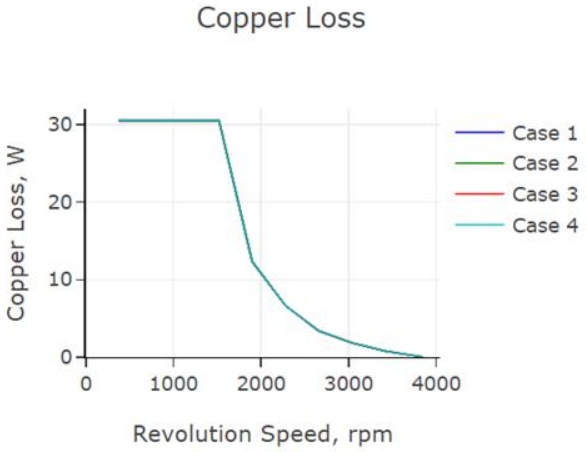
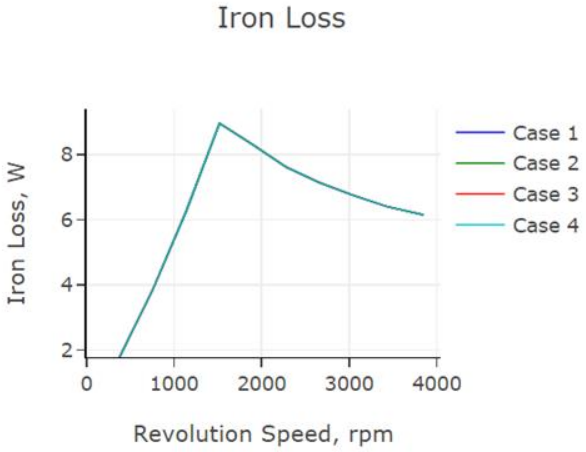
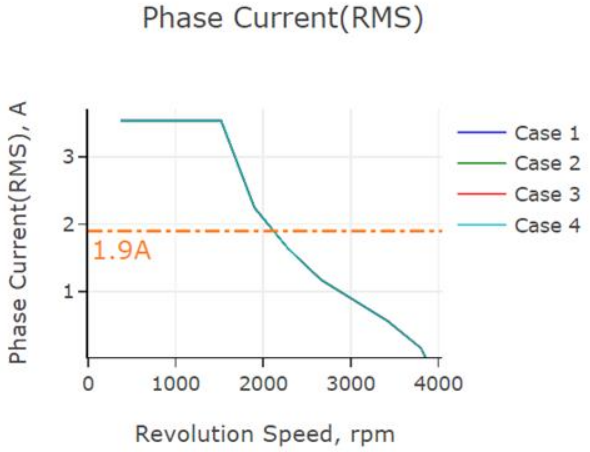
JMAG- Results







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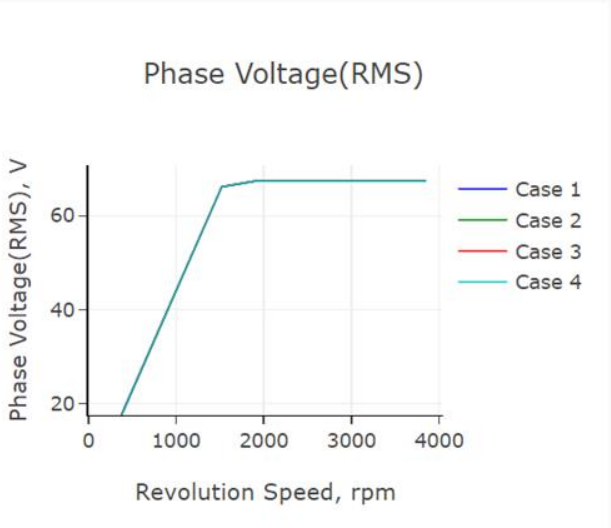
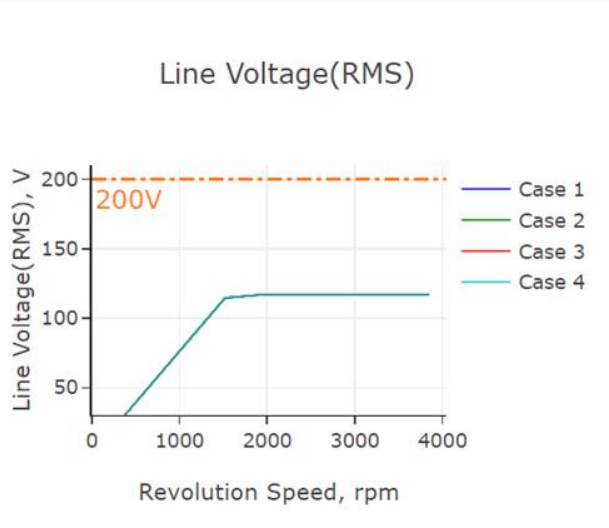
JMAG- Results





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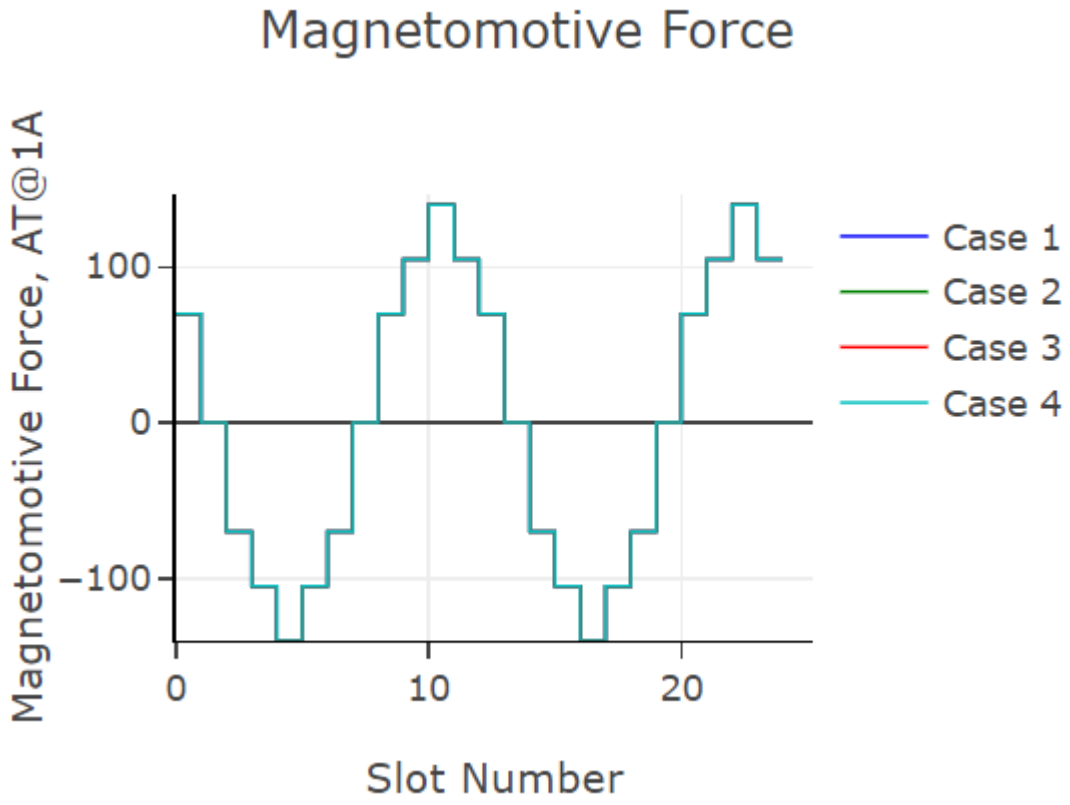
JMAG- Results



Parameter Initialization

DC Link Voltage	$V_{dc} = 12$ [Volt]
Number of pole pairs	$P = 1$
phase resistance	$R = 0.1$ $[\Omega]$
self inductance	$L = 2$ $[mH]$
Mutual inductance	$M = 0.5$ $[mH]$
Moment of inertia	$J = 0.002$ $[kg.m^2]$
Damp coefficient	$B = 0.0002$ $[N.m.s.rad^{-1}]$
Rate of rotating speed	$n = 600$ $[rpm]$
Factor of EMFs	$k_e = 0.025$
Sliding Mode Parameters	$\lambda_2 = 10, \lambda_1 = 0.01, \lambda_3 = 0.03$
saturation bound of output	± 20
sampling period	$T_s = 0.001$ $[s]$
Frequency of carrier	$f_z = 3000$ Hz
Torque Load	$T_L = 0.1 \square 0.5$ $[N.m]$

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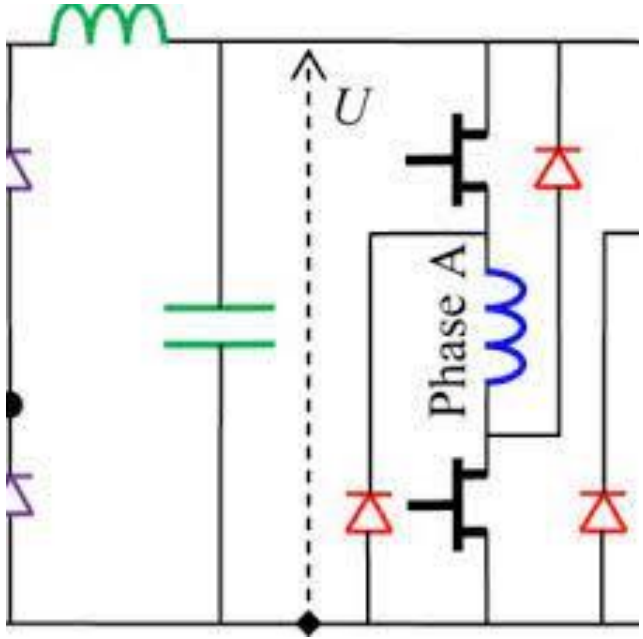
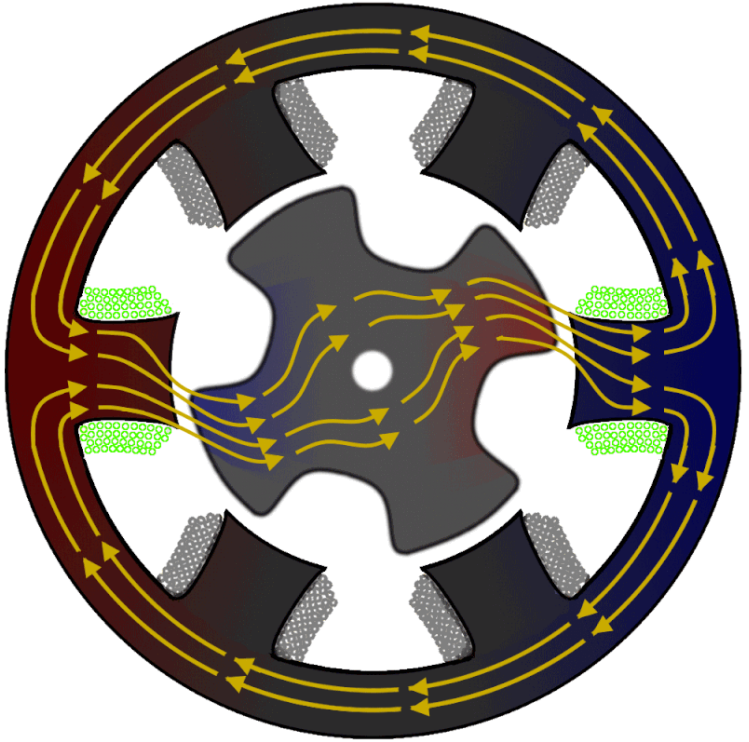
Switched Reluctance Motor





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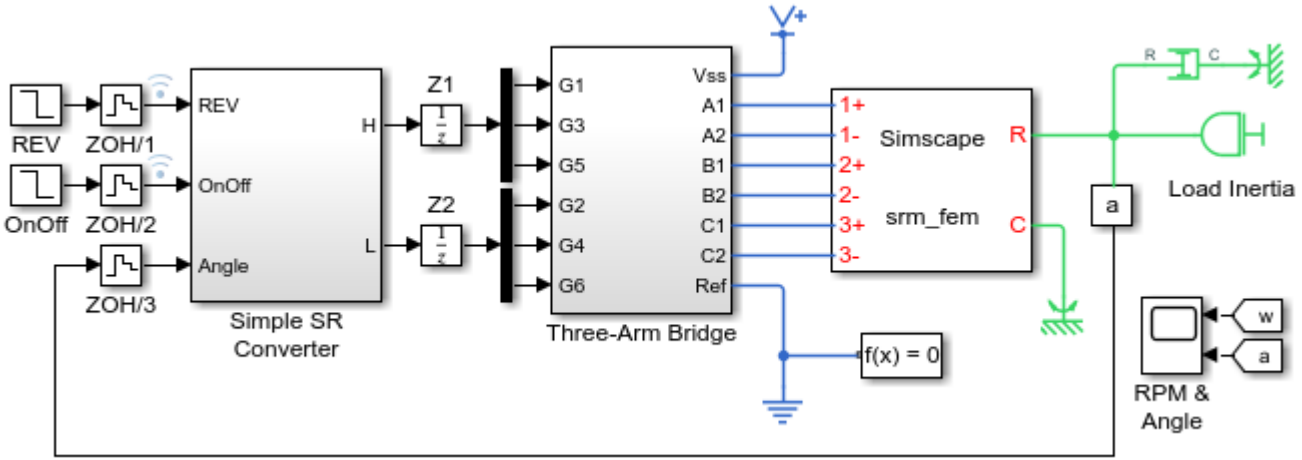
Switched Reluctance Motor Parameterized with FEM Data



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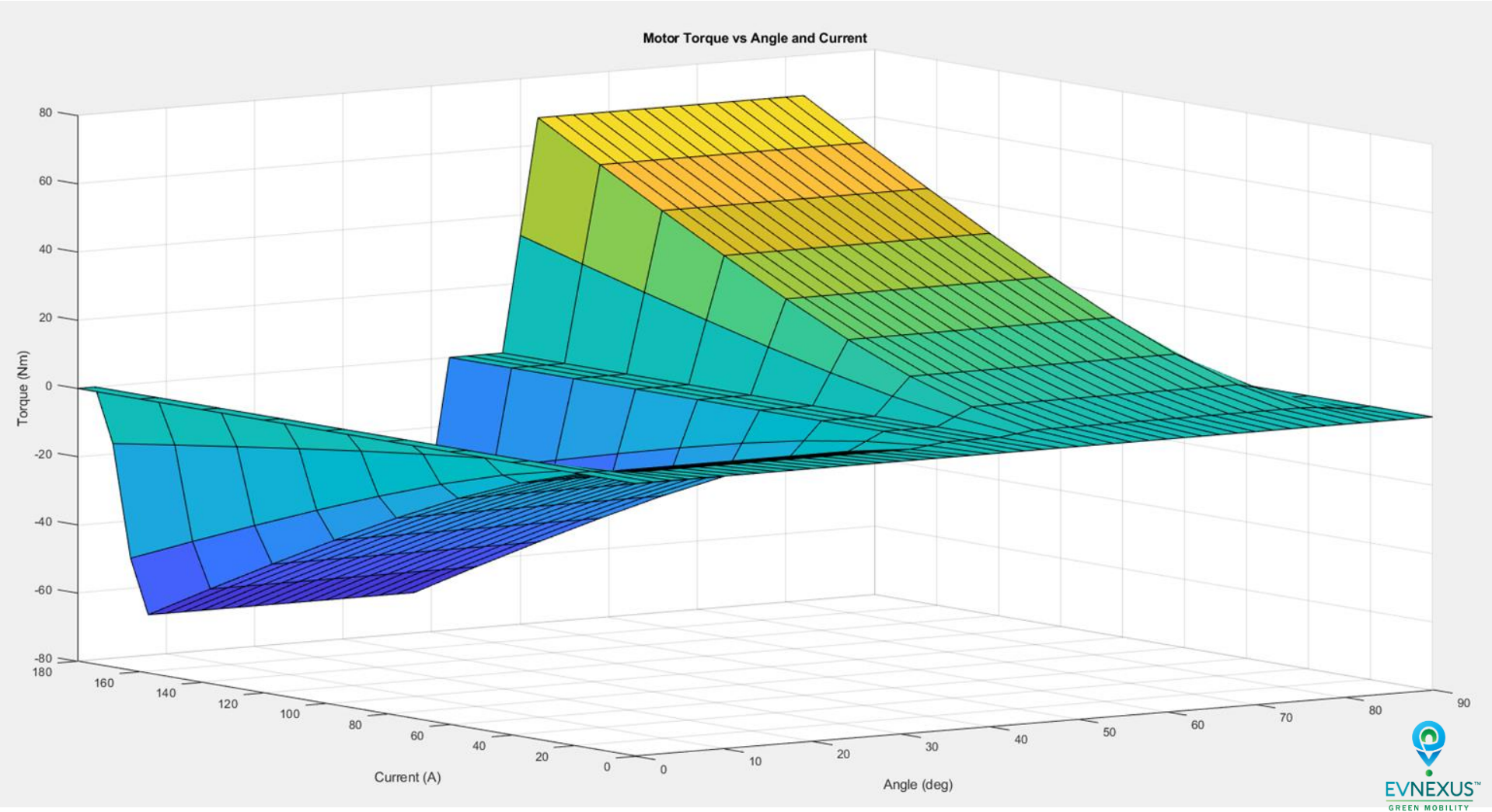
Motor Torque vs Angle and Current
Torque (Nm)
80
60
40
20
0
-20
-40
-60
-80
Current (A)
180
160
140
120
100
80
60
40
20
0
Angle (deg)
0
10
20
30
40
50
60
70
80
90
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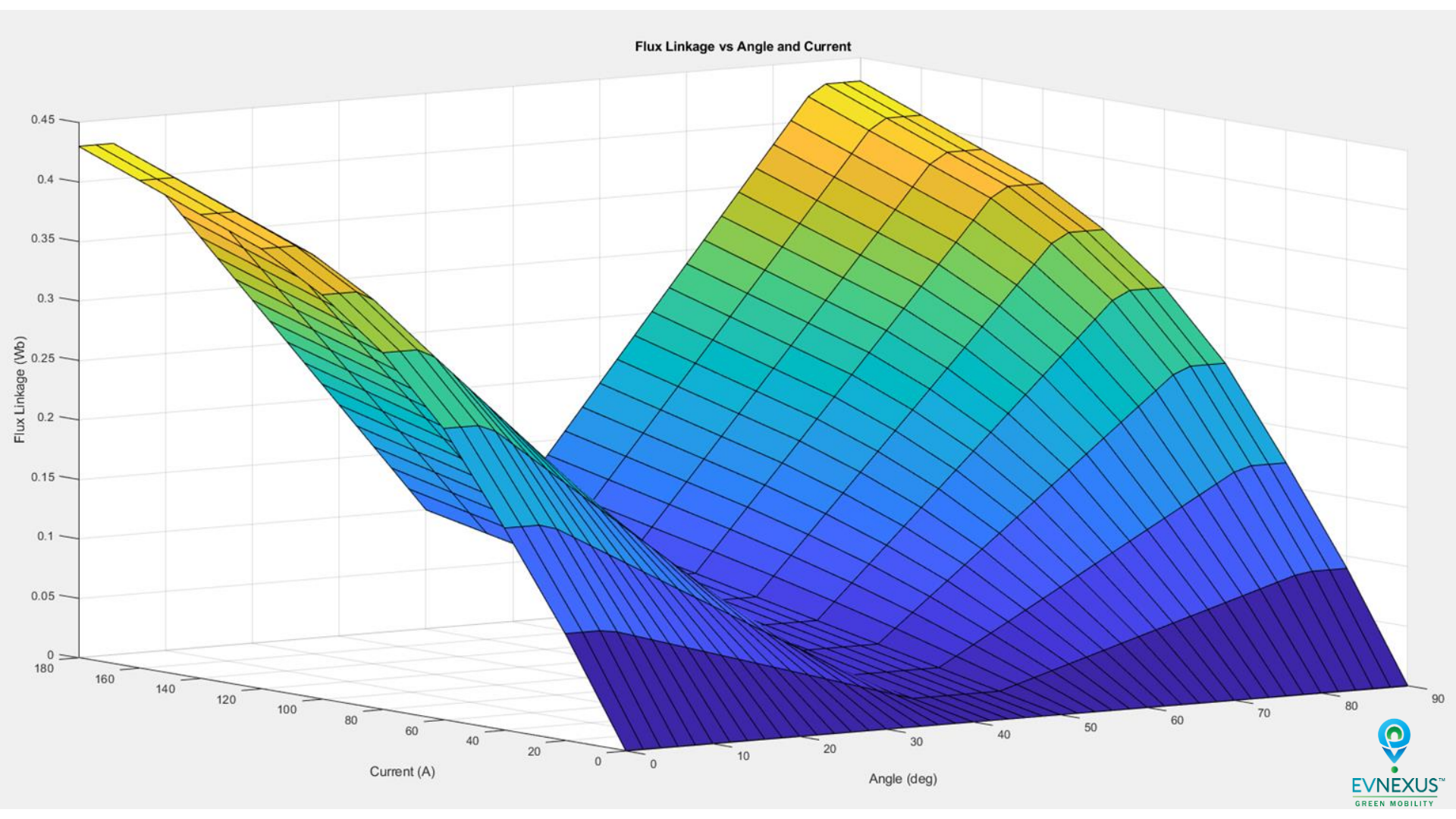
Flux Linkage vs Angle and Current
Flux Linkage (Wb)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Current (A)
180
160
140
120
100
80
60
40
20
0
Angle (deg)
0
10
20
30
40
50
60
70
80
90
EVNEXUS™
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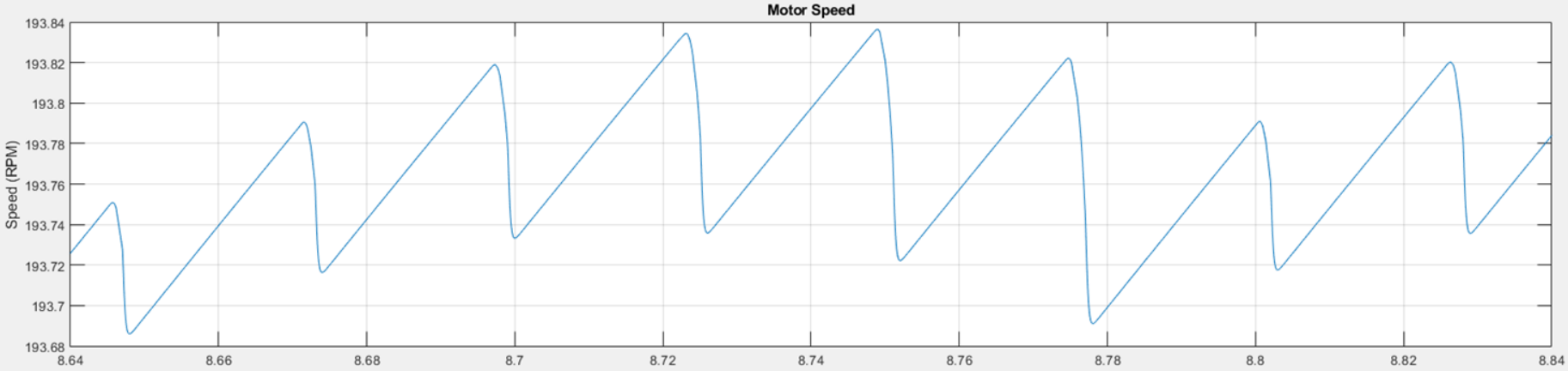

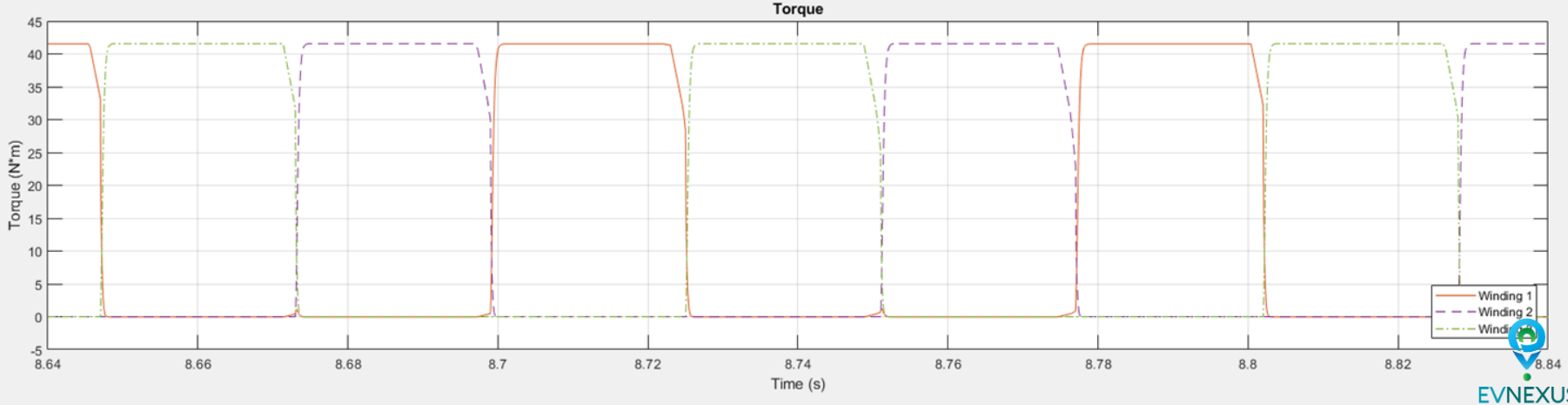

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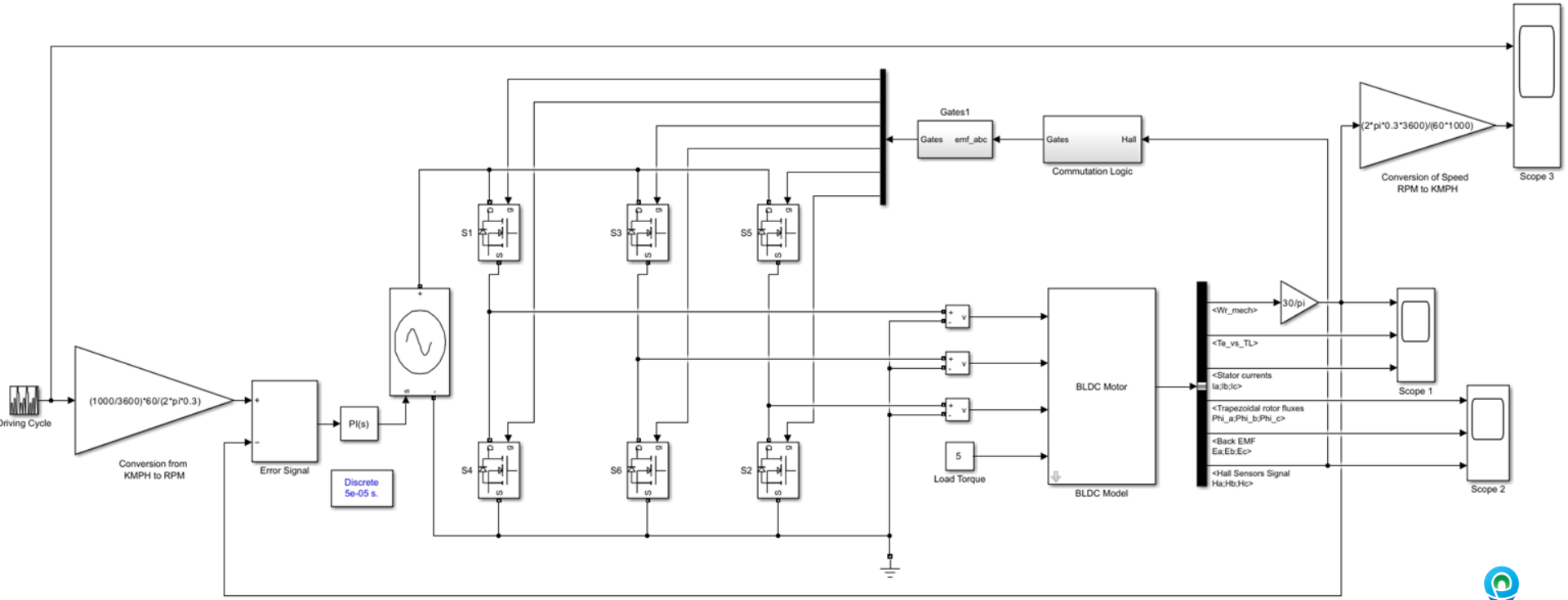
BLDC Model in MATLAB



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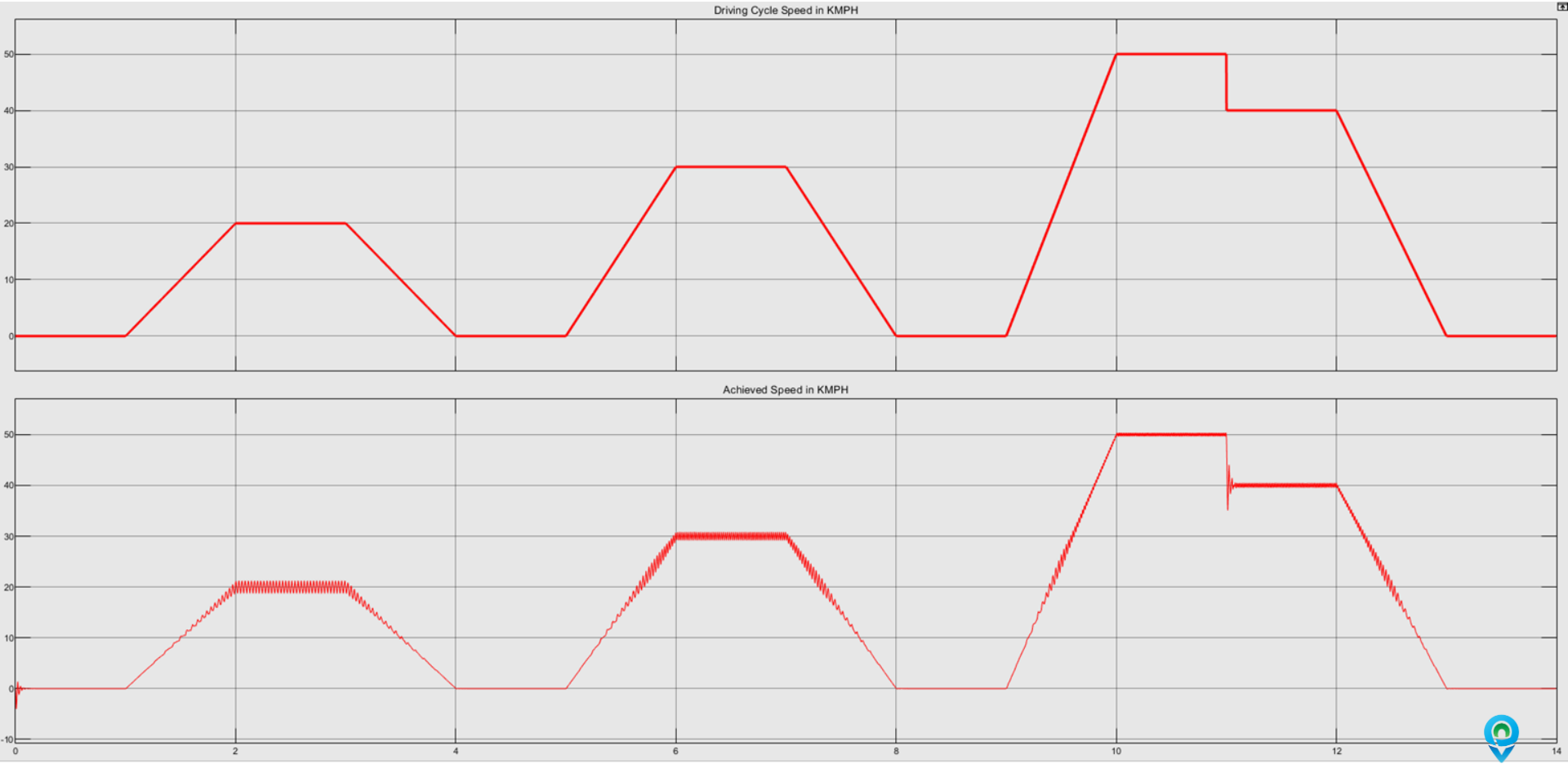

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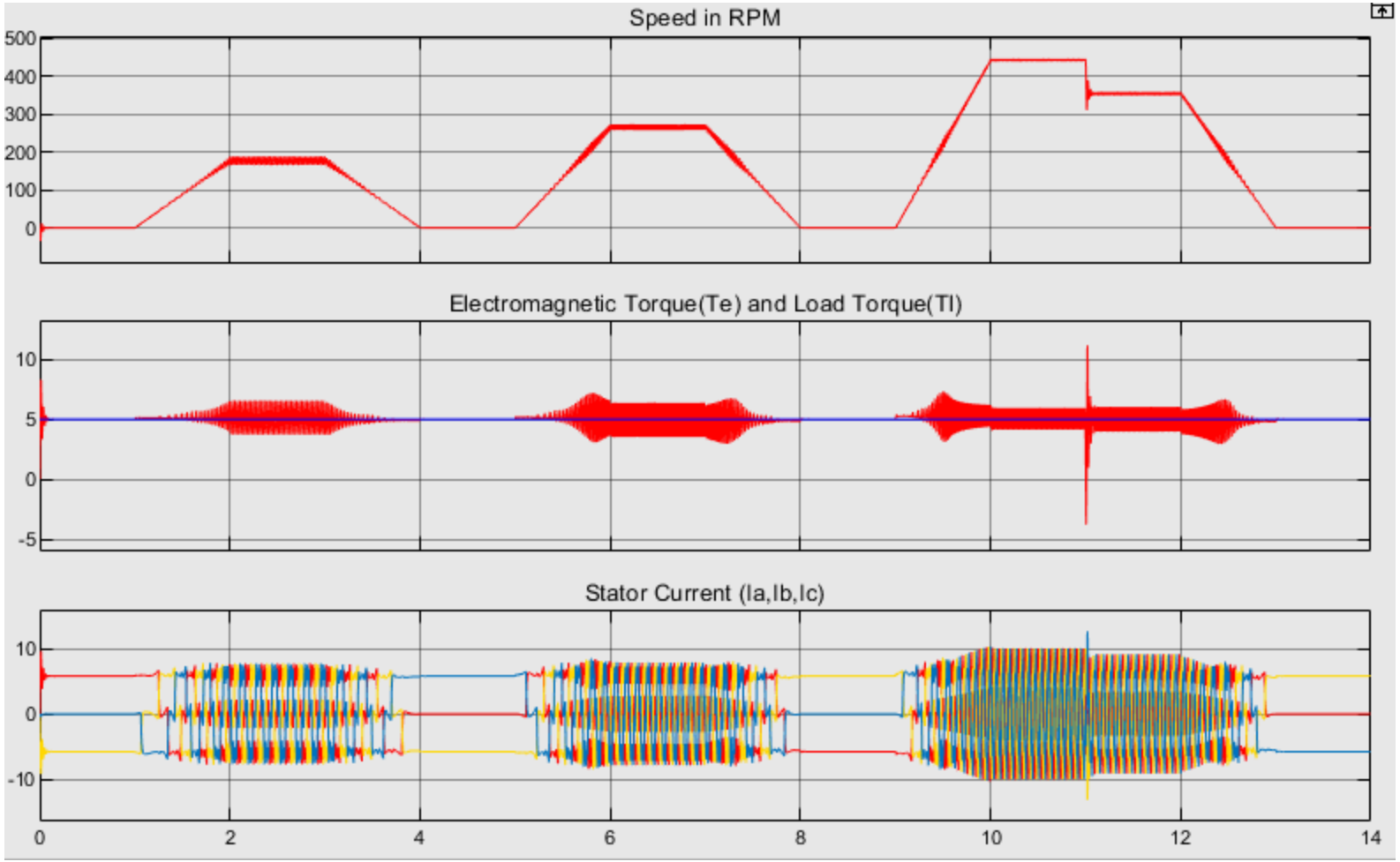

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Modelling Techniques

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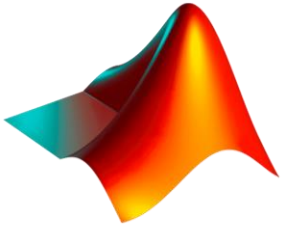
MATLAB Modelling techniques:

- Differential Equations (ODEs and PDEs)
- Simulink Modelling
- State-Space Modeling
- Simscape Modeling
- Machine Learning Models
- SimEvents for Discrete Event Simulation
- Data-Driven Modeling
- Finite Element Analysis (FEA)
- Custom Scripting for Specific Models
- Hybrid Modeling



MATLAB®

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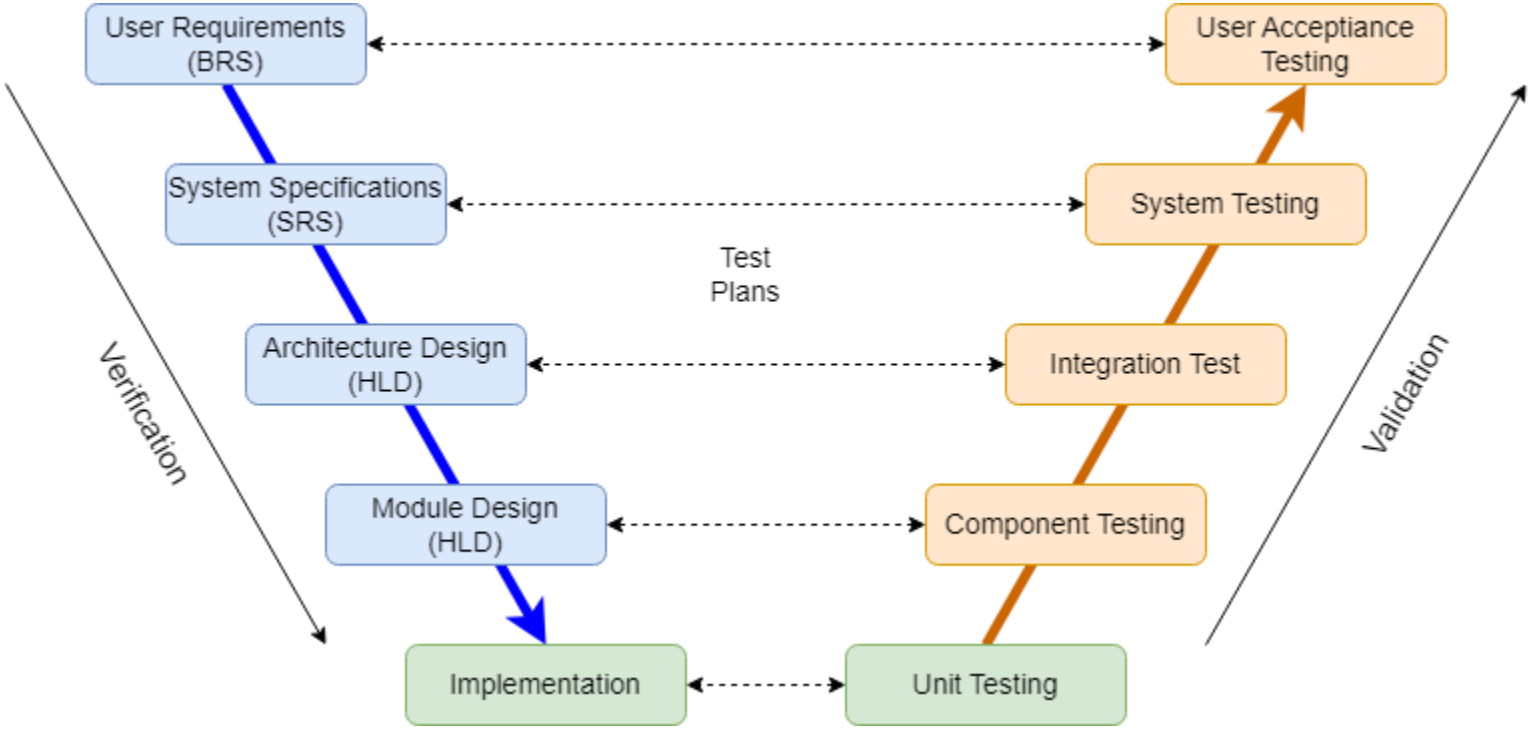
V Model



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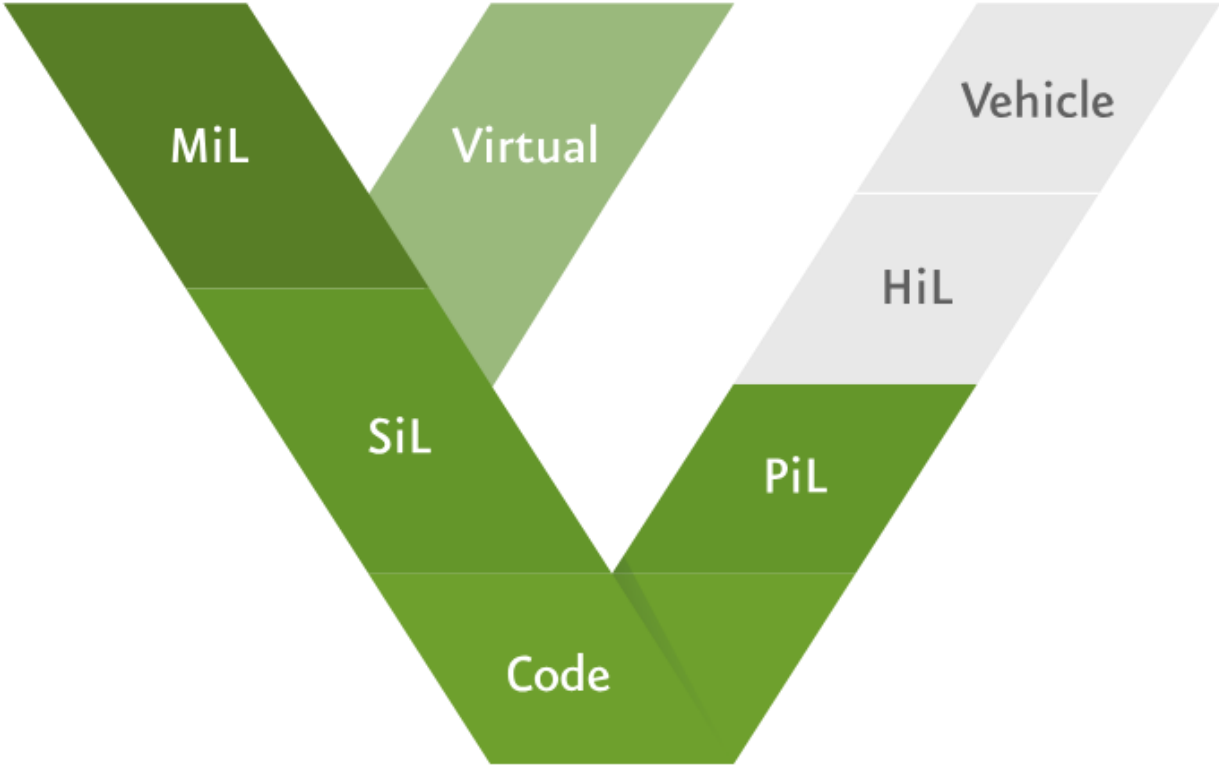

Typical application areas

Braking	Steering	Battery Management	Body Controller	ADAS	Comfort Functions

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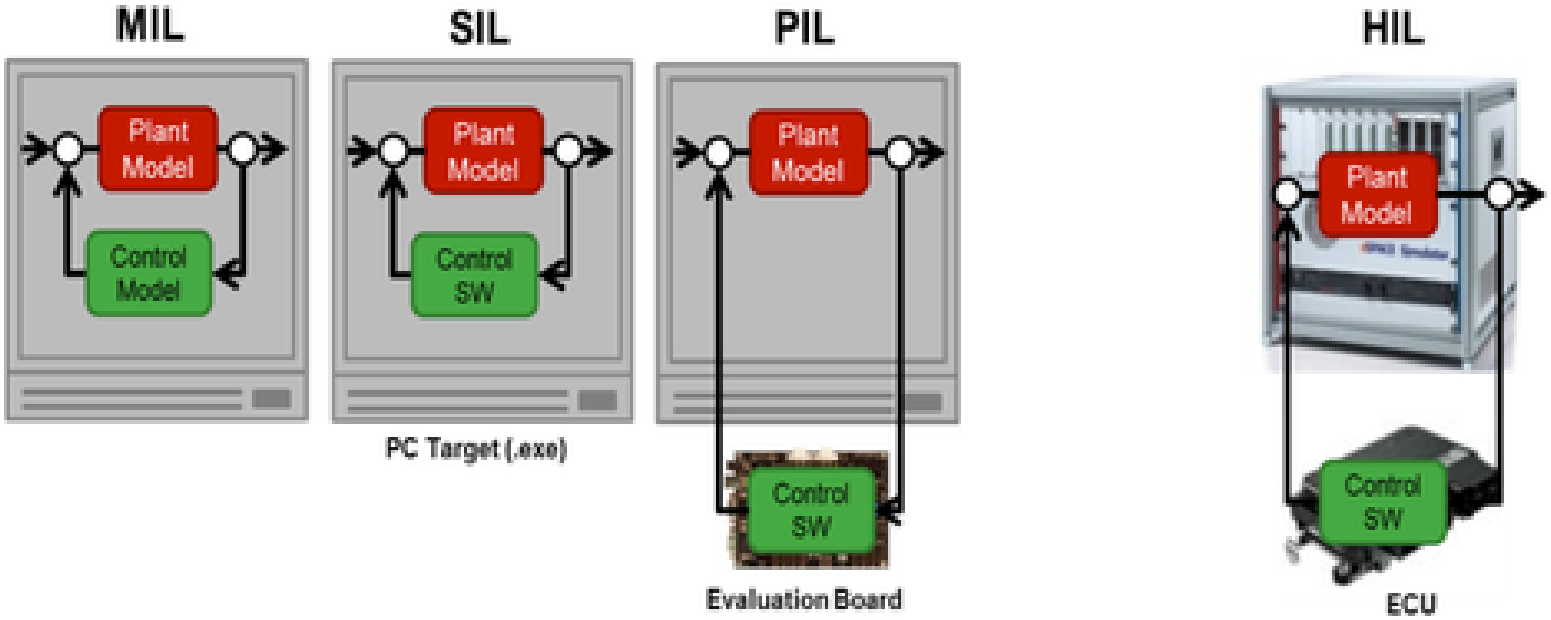
MIL-SIL-PIL-HIL



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Tools

1.Electric Vehicle Simulation Tools: AVL CRUISE, **MATLAB/Simulink**, Simcenter Amesim, Ricardo IGNITE

2.Battery Management System (BMS) Software: **MATLAB/Simulink** (A123 Systems BMS, LG Chem BMS, Tesla BMS)

3.Data Analytics and Big Data: **Tableau, Power BI**, **MATLAB**, Python (with data analysis libraries like pandas and NumPy)

4.Firmware and Software Updates: (Tesla OTA Updates, Ford Software Update, BMW Connected Drive)

5.Telematics and Connectivity: (Geotab, Verizon Connect, Fleet Complete, TomTom Telematics)

6.Vehicle Diagnostic Software: Bosch KTS, Delphi DS, Launch X431, Autel MaxiSYS

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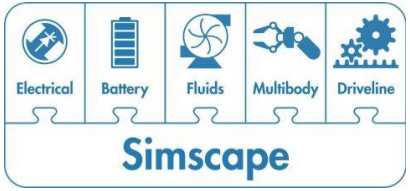

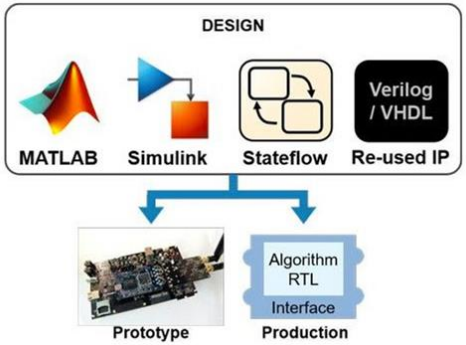

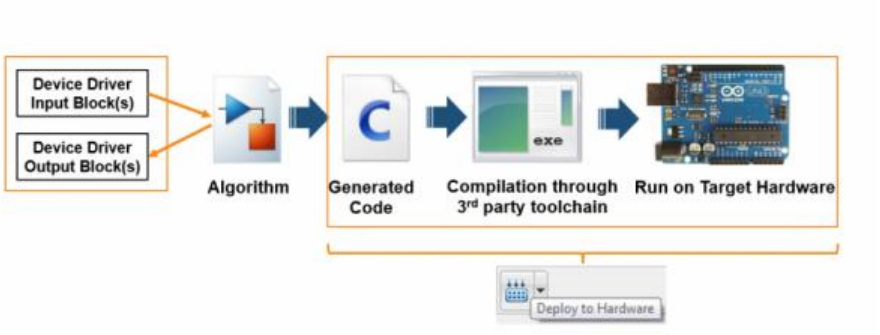

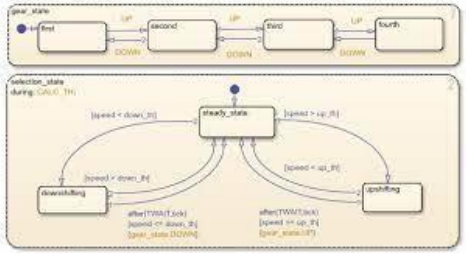

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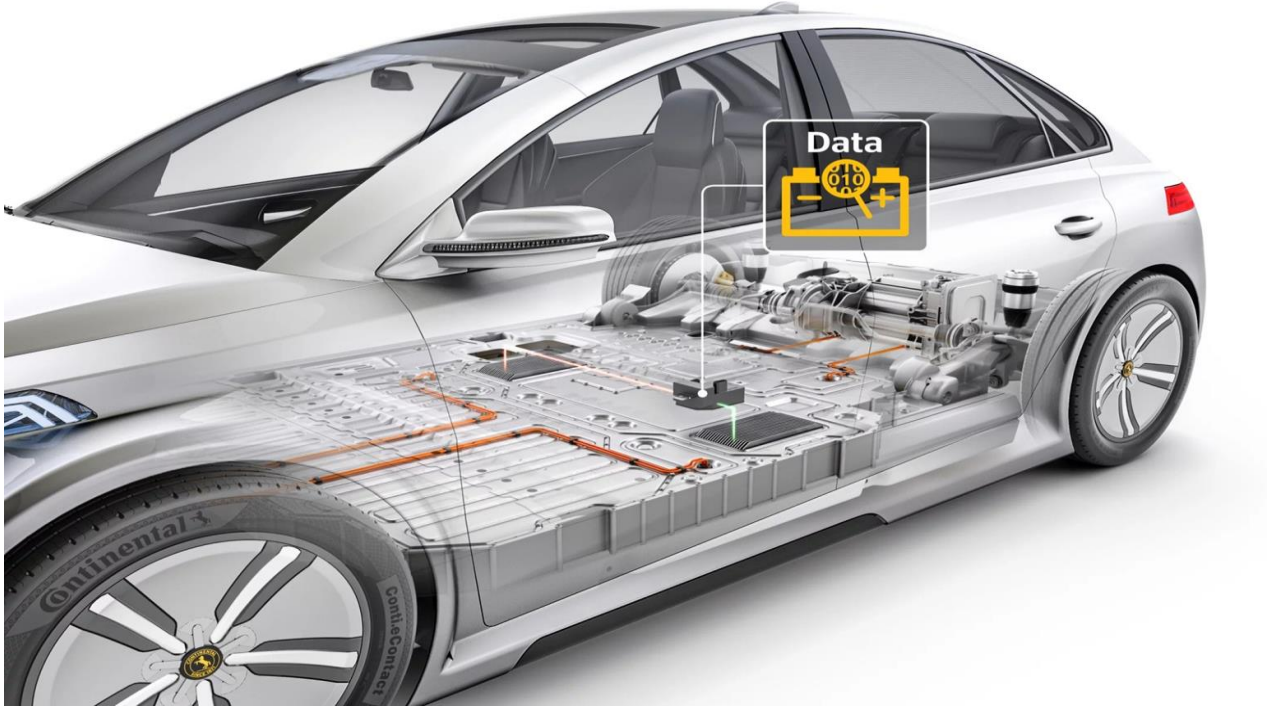
Data



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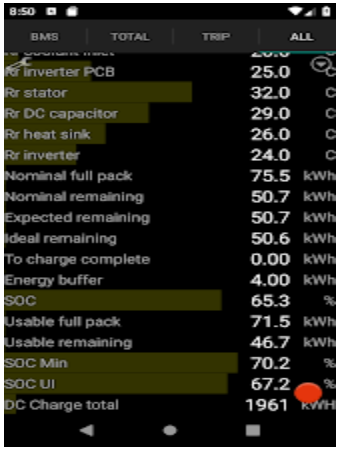
Data Analytics

- **Energy Consumption**: Advanced algorithms can analyze the data to provide insights into optimal driving speeds and conditions for maximizing battery life.
- **User Behavior**: IoT technology can analyze driver behavior patterns, suggesting more energy-efficient driving techniques.



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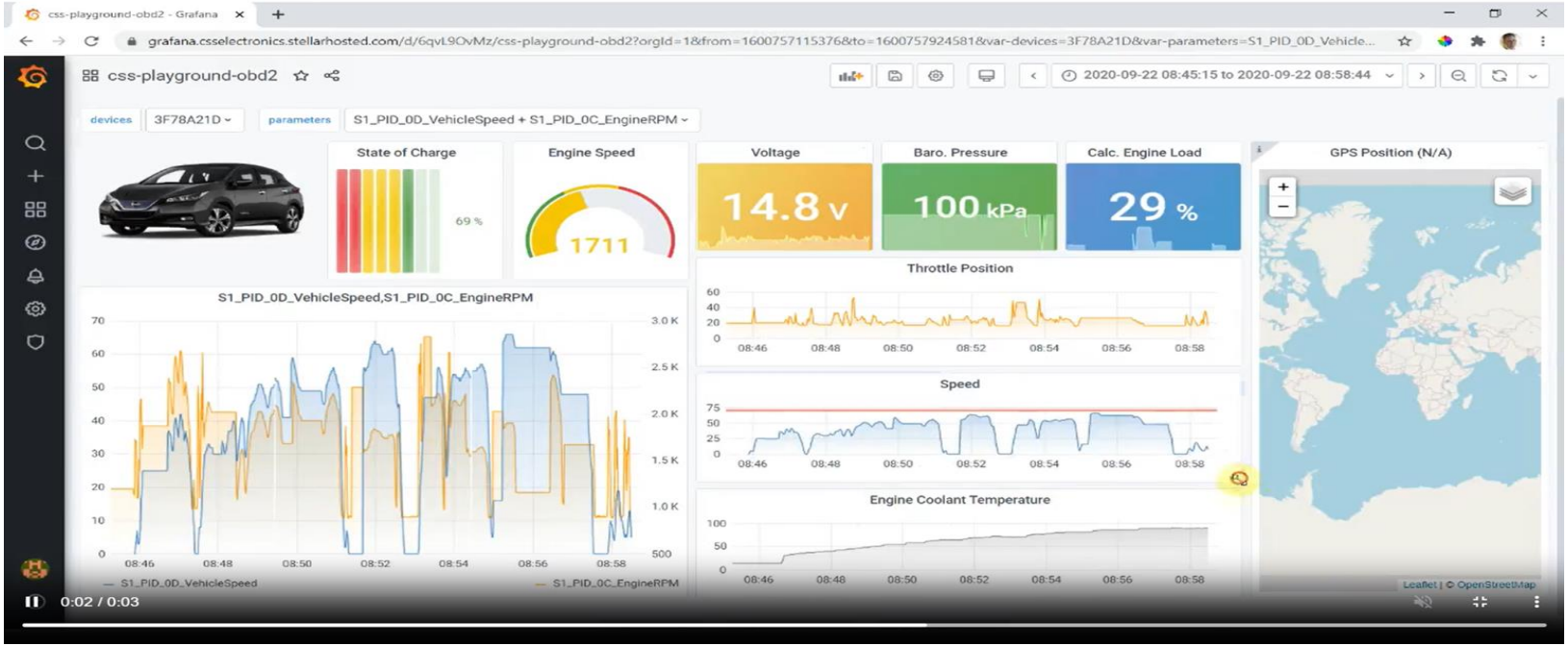
BMS data Logger



https://www.csselectronics.com/pages/electric-vehicle-data-logger-cloud-battery-telematics#dashboard

https://grafana.csselectronics.stellarhosted.com/d/yBc5x90nk2/css-playground-kia-ev6?orgId=1

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An Overview of IoT-based Applications in Evs

- The Internet of Things (IoT) has revolutionized various industries, including automotive and transportation. When it comes to Electric Vehicles (EVs), IoT technology plays a pivotal role in enhancing both vehicle performance and sustainability measures.

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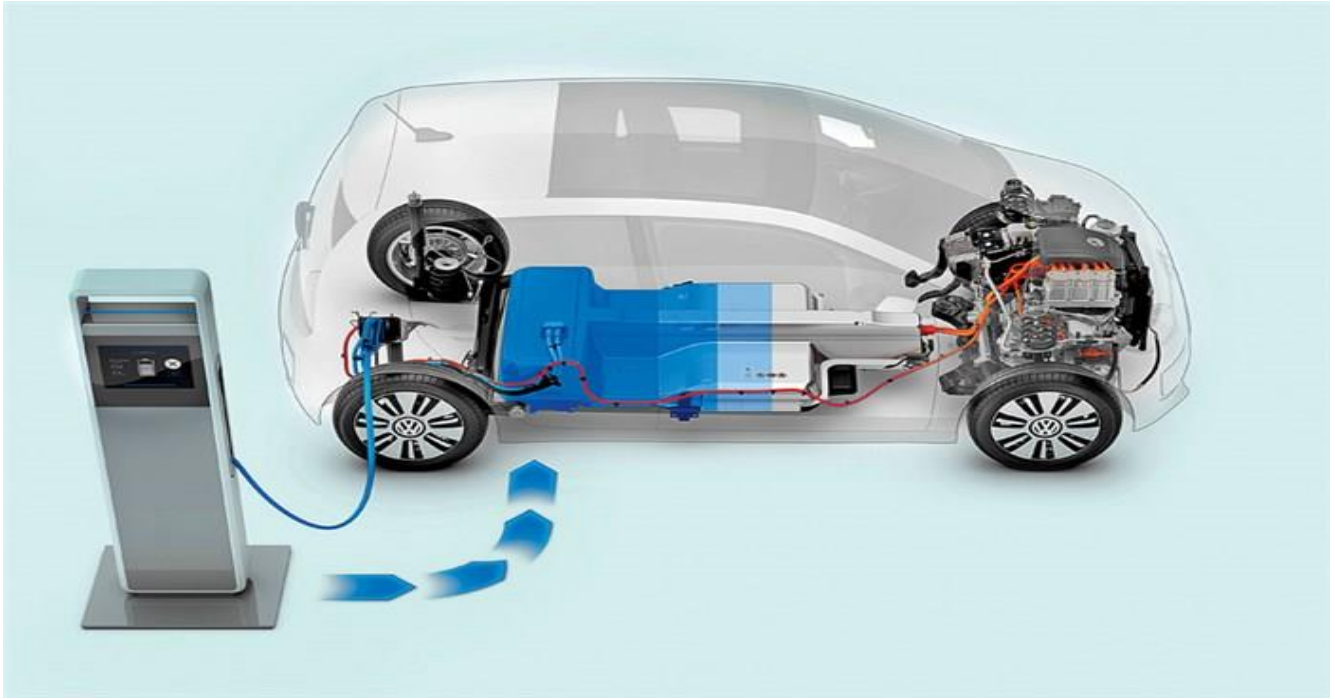
V2X



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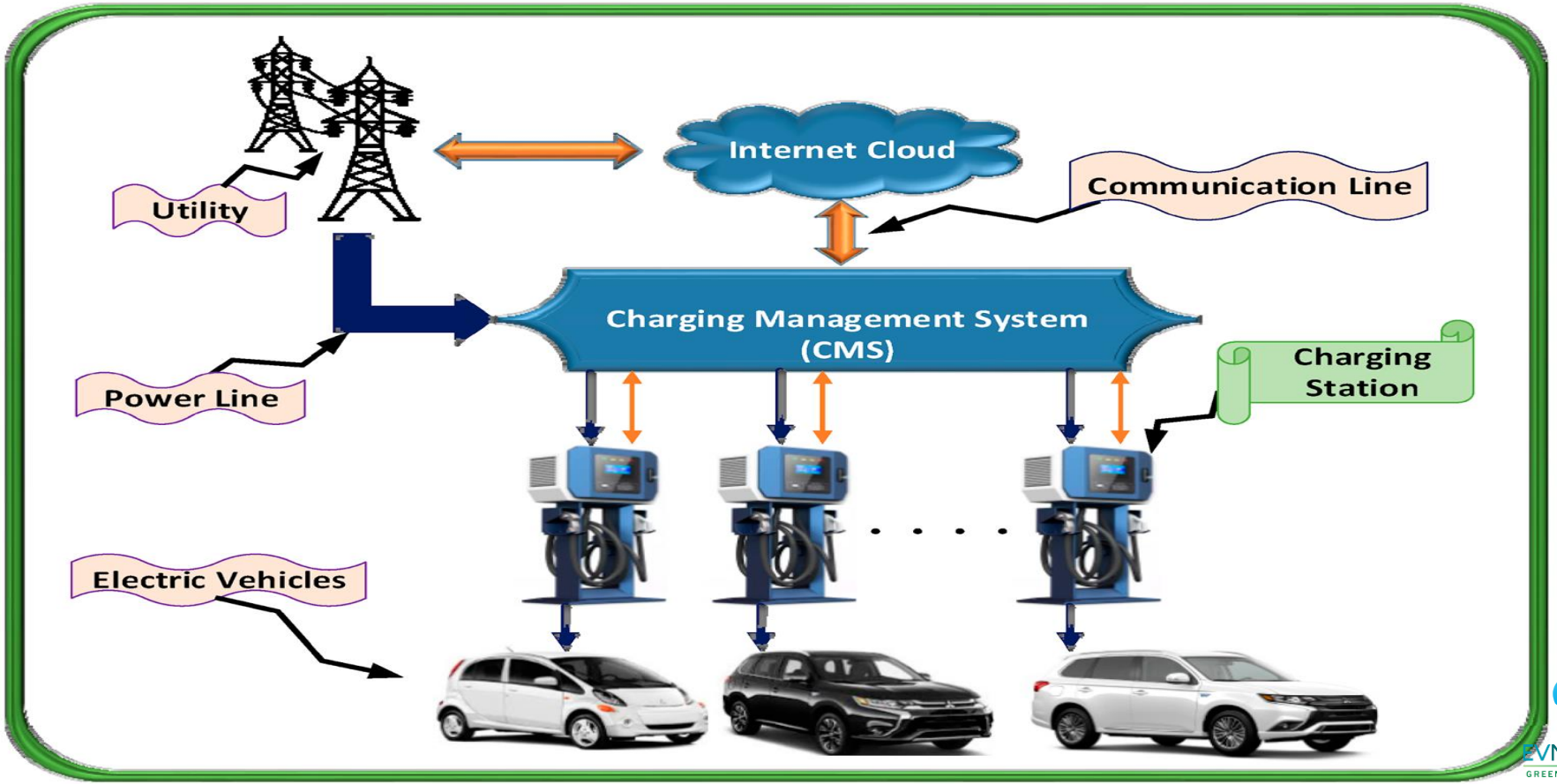
Utility
Internet Cloud
Communication Line
Charging Management System (CMS)
Power Line
Charging Station
Electric Vehicles


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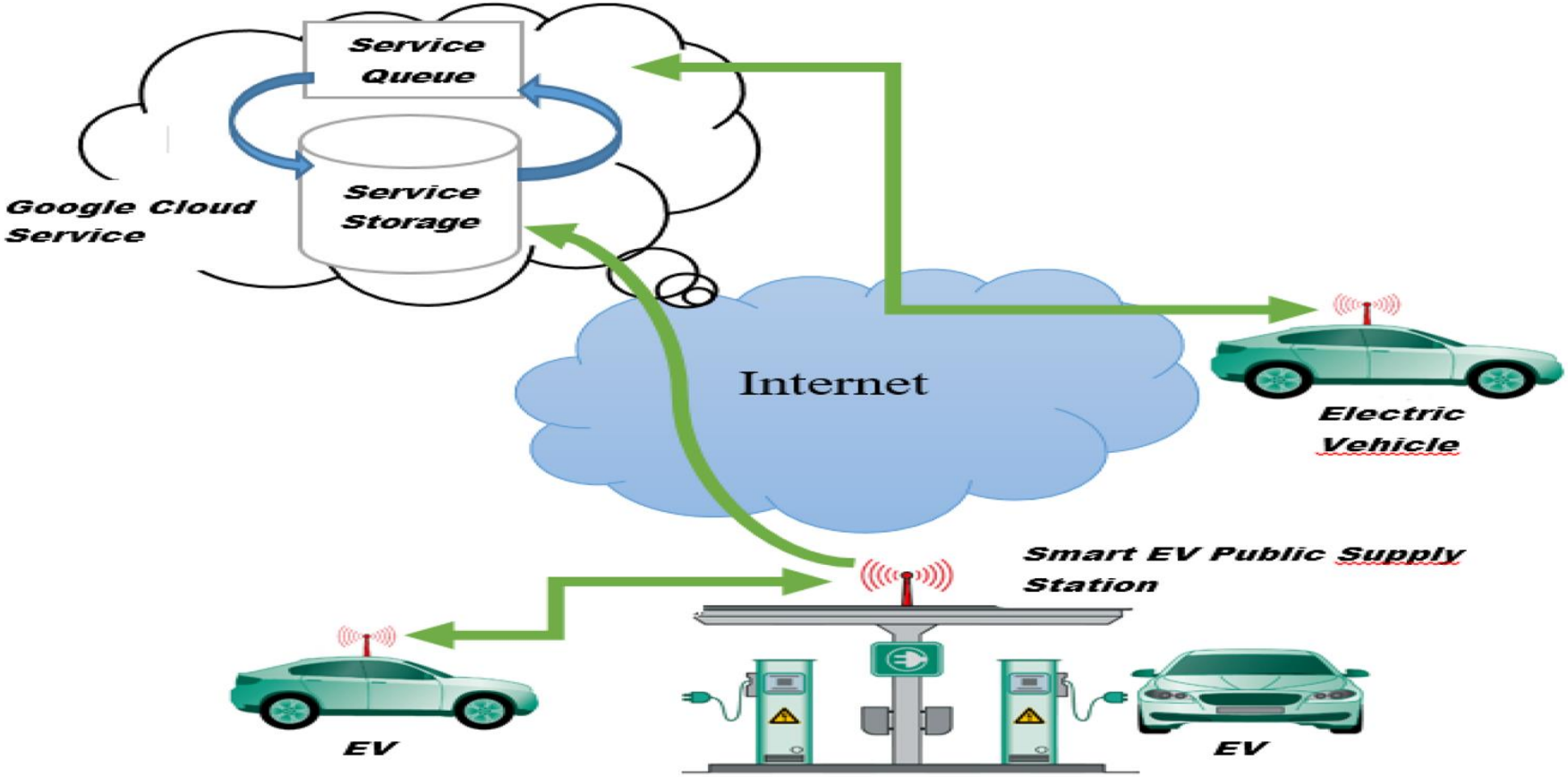

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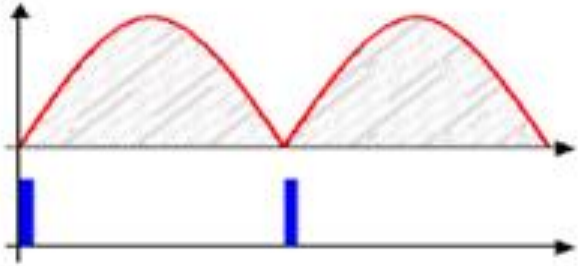
POWER ELECTRONICS

R

L

C



- PASSIVE ELEMENT (R L C)
- Switch (MOSFET,IGBT,BJT,GTO)

"Combination of passive element and switches & diodes make power electronic circuits to produce required output in expected form"

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Dual BLDC Based Formula Racing Vehicle

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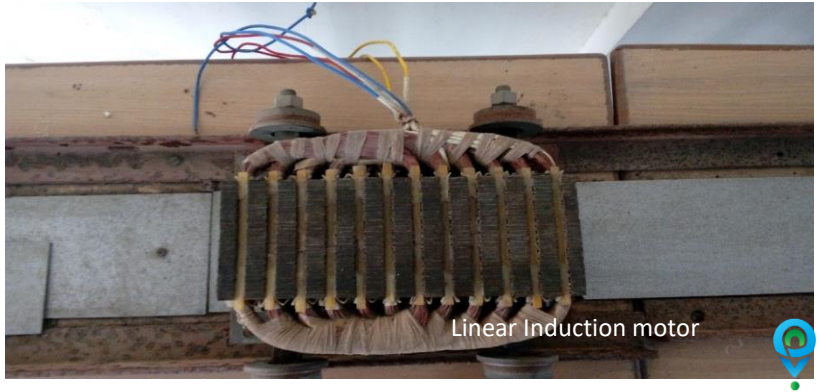
Sample Projects


Hybrid Vehicle
Active Engine & BLDC


PMDC based E-Bike

Electric Vehicle using SR Motor


Linear Induction motor

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Technological Innovations

- **Autonomous Vehicles**: Self-driving cars, particularly when electric or hybrid, could revolutionize transportation efficiency and safety.
- **Advanced Battery Technologies**: Developments in battery life and charging speeds will make electric vehicles and other battery-operated sustainable transport more viable.
- **IoT and Smart Infrastructure**: Internet of Things (IoT) technology will continue to integrate with transport infrastructure, offering real-time monitoring and more efficient utilization of resources.

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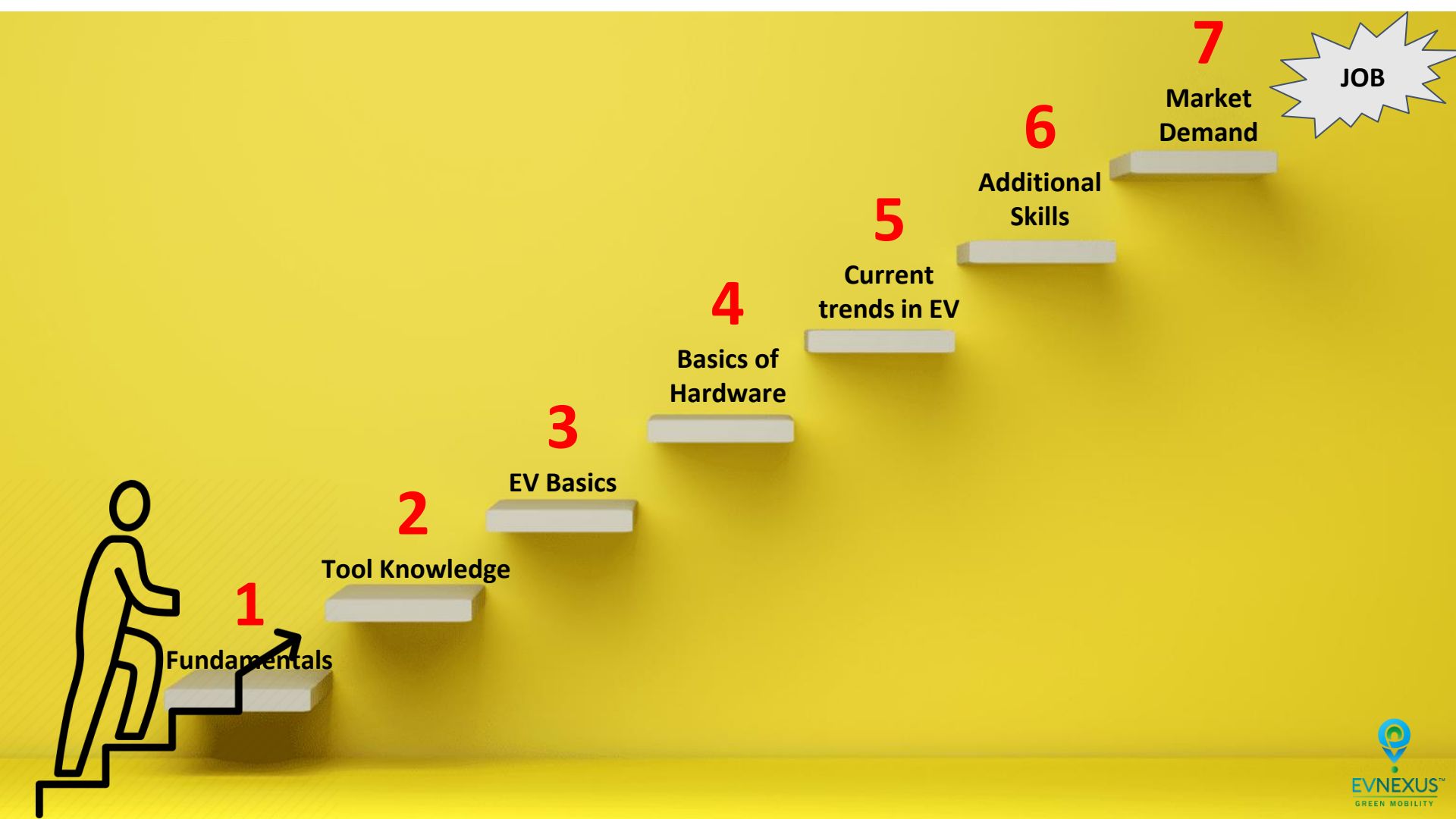
1
Fundamentals
2
Tool Knowledge
3
EV Basics
4
Basics of Hardware
5
Current trends in EV
6
Additional Skills
7
Market Demand
JOB

Additional Skills

1.Vehicle diagnostic software

2.Battery Management System (BMS) software

3.Electric vehicle simulation tools

4.Firmware and software update tools

5.Telematics platforms

6.Data analytics and big data tools

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