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Powertrain and Mechatronic Systems in Electric Vehicles

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**Partnership for Promotion and Popularization of Electrical Mobility through
Transformation and Modernization of WB HEIs Study Programs/PELMOB**

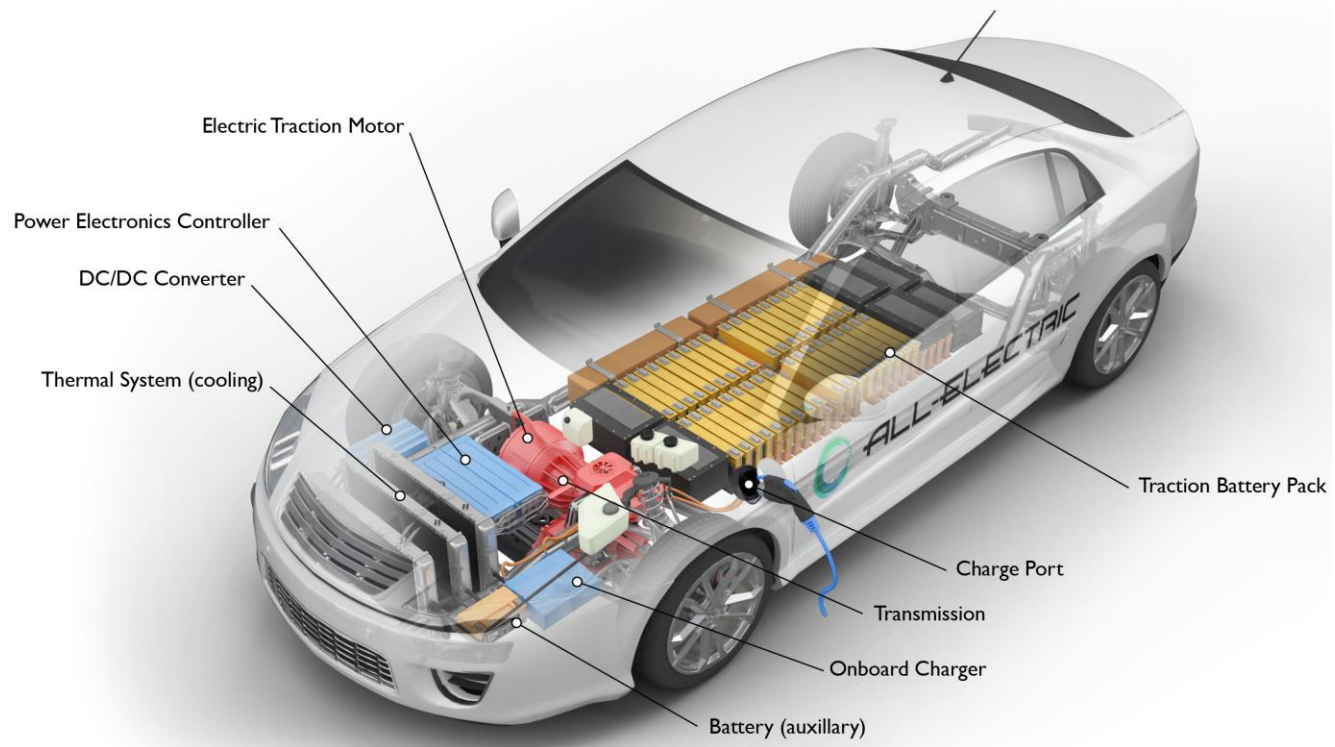
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Pogonski sistemi

- The powertrain of an electric vehicle includes all the components involved in converting power into motion.
- The main components of the powertrain include:
 - Battery Pack
 - DC-AC inverter
 - Electric motor
 - On-board charger
- In addition to these basic components, there are other hardware and software parts in the powertrain, such as:
 - *Battery management system*
 - *DC-AC converter*
 - *Thermal management*
 - *Body Control Module(BCM)*

Powertrain systems



Powertrain assembly components

Battery Pack

- An electric battery is a device that stores chemical energy that is converted into electrical energy
- Electric car batteries are slowly starting to lose the amount of energy they can store over time.
- Environmental factors, such as constant exposure to extreme temperatures, will affect the performance of the battery and may lead to degradation.
- Batteries don't work well when it's very cold and when the energy from the batteries is used to heat the car.

Characteristics of batteries used in EVs

Battery type	Energy density (Wh/kg)	Power density (W/kg)	Cycle lifetime (Charging/discharging)
Olovna kiselina	30 – 40	120 - 200	200 - 300
Nickel-Metal Hydride	50 – 80	250 – 1000	300 – 500
lithium-ion	100-150	1000 – 1500	500 - 1000

DC-AC inverter

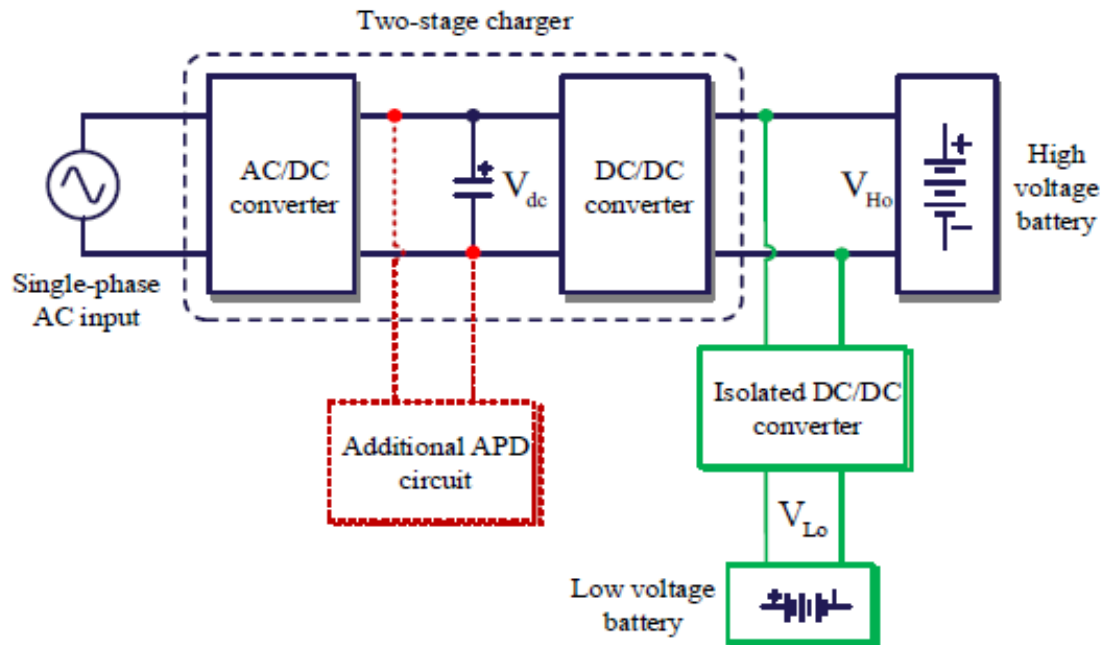
- The battery is converted to alternating current (AC) and then supplied to the electric motor.
- A sophisticated engine management system (also known as the Powertrain Electronic Control Unit) manages this power transmission.
- An AC-DC inverter is installed in the car, converts alternating current into direct current, and then powers the car's battery.

Electric motor

- An electric motor converts electrical energy into mechanical energy.
- This mechanical energy is then transferred to the wheels via a one-way transmission.
- Electric vehicles use different types of electric motors:
 - DC Series Motor
 - Brushless DC Motor
 - Permanent Magnet Synchronous Motor (PMSM)
 - Three Phase AC Induction Motors (IM)
 - Reluctance Motors (SRM)

On-board charger

- The built-in charger converts alternating current (AC) from the charging source into direct current (DC).
- There are two types of battery use in EVs:
 1. High Voltage (HV) Battery for Traction Motor Drives,
 2. Low Voltage (LV) Battery for Backup Power Supplies



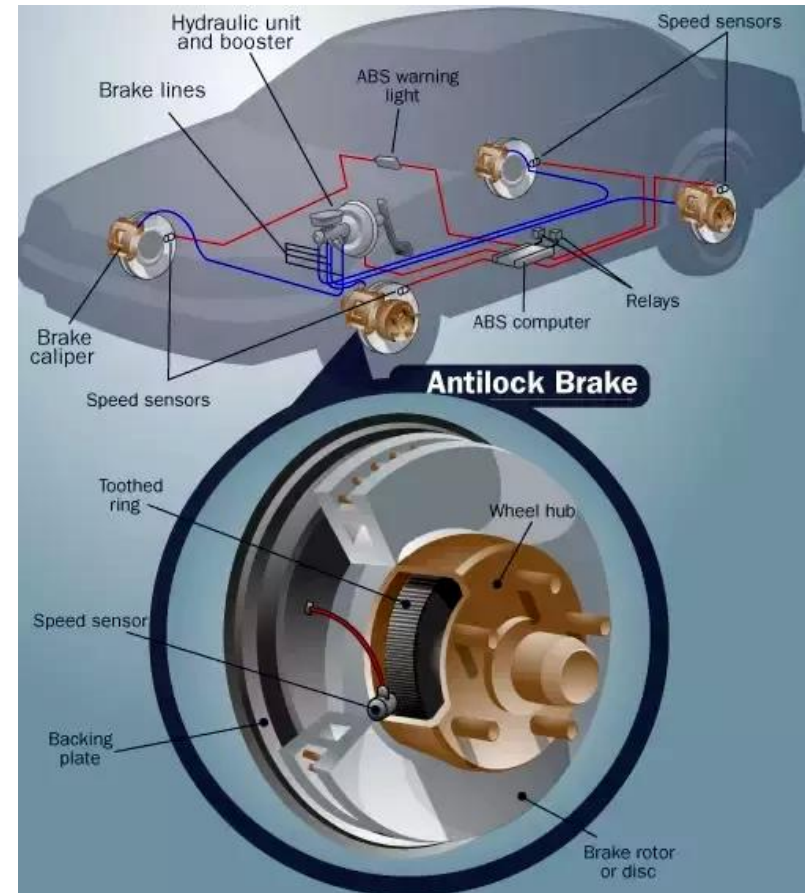
Two-stage charger with additional active power separation circuit

Mechatronics systems

- Mechatronic systems in electric vehicles are a combination of mechanical components, electronic components, and an information processing unit.
- Some of the key areas in which mechatronics is applied in electric vehicles:
- Vehicle Safety Systems
 - Anti-lock brakes (ABS)
 - Electronic Stability Programs (ESP)
 - Traction Control System (TCS)
 - Collision Avoidance (CA)
 - Lane-Keeping Assistant
- Suspension
- Control Systems
- Battery Management Systems

Vehicle Safety Systems

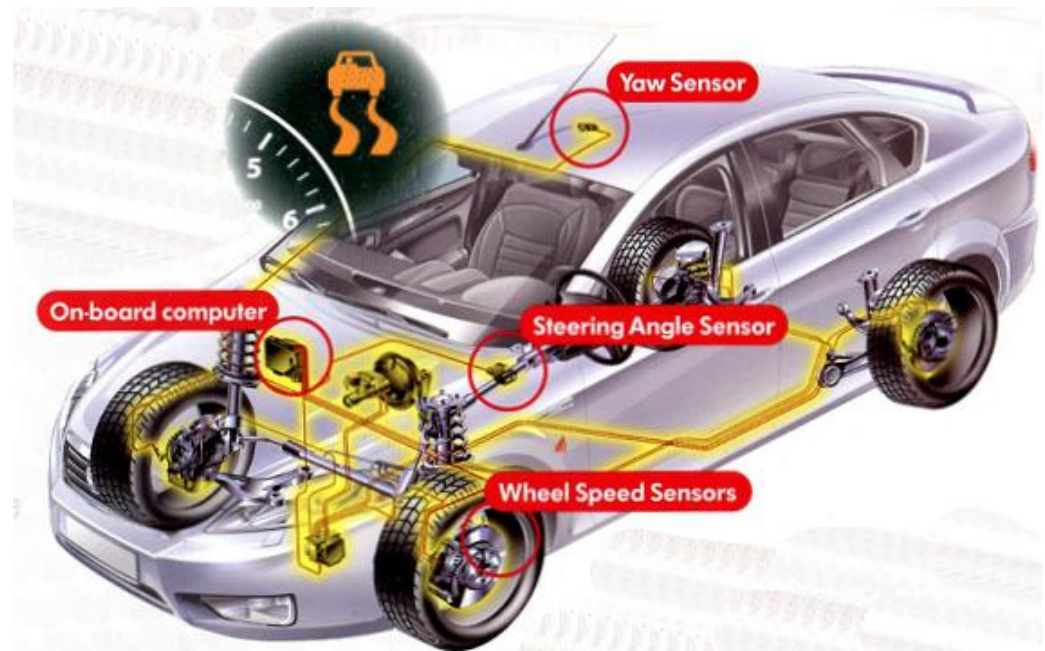
- Mechatronic systems in electric vehicles are a combination of mechanical components, electronic components, and an information processing unit.
- *Passive safety systems include seat belts, airbags, and additional structural members.*
- *Active safety systems work before an accident and are designed to prevent an accident from happening in the first place.*
- *The Antilock Braking System (ABS) is a system that automatically controls the braking force of the brake when the car brakes*
- Intelligent Braking Systems (IBS) have been introduced to optimize performance.



Antilock kočioni sistem (ABS)

Vehicle Safety Systems

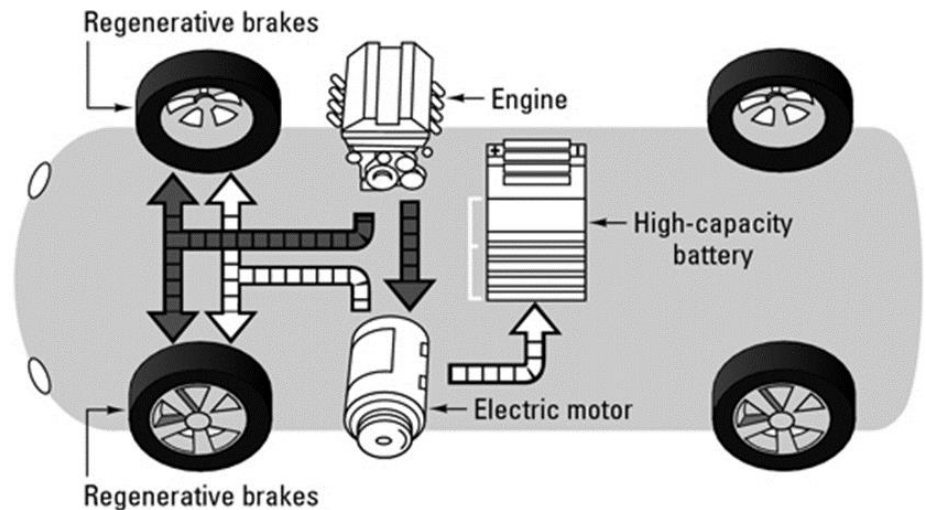
- Electronic Stability Program (ESP) improves vehicle stability by detecting and reducing traction loss
 - ESP compares the expected direction of the driver in steering and braking inputs with the vehicle's response to lateral acceleration, rotation (yawing) and individual wheel speeds.
 - There are two main ways to activate the ESP system.
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- There are two main ways to activate the ESP system:
 - that generate a corrective steering torque are compensated by the control commands
 - the use of individual wheel braking, as this is easier to achieve with the existing ABS hardware.



Elektronski program stabilnosti(ESP)

Vehicle Safety Systems

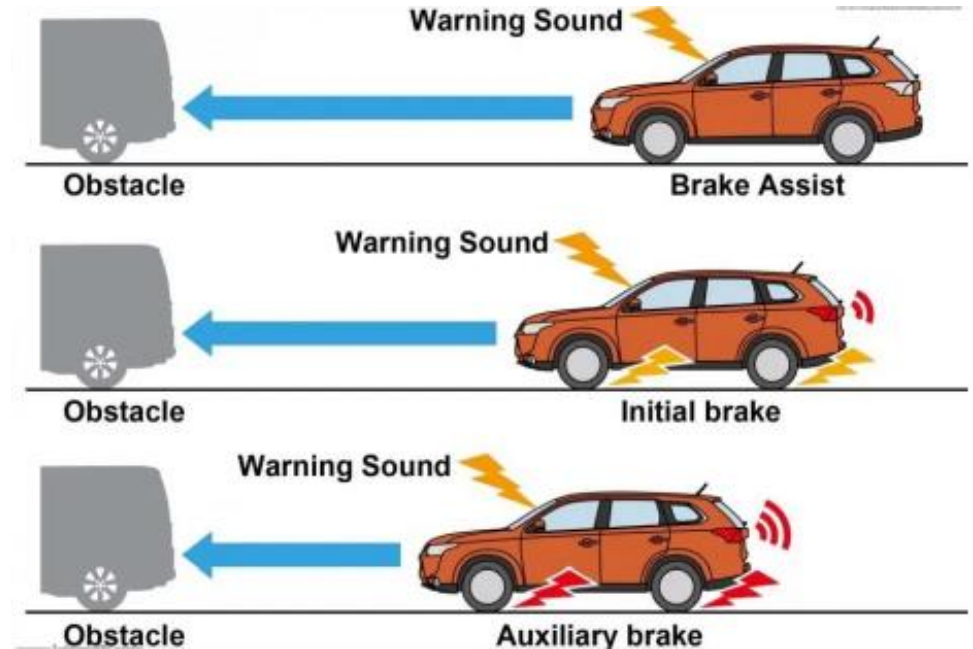
- *Traction Control System (TCS) is a longitudinal traction controller like ABS, but they work after encountering large amounts of longitudinal slip that occur when the wheels spin without traction on the road surface*
- In such cases, the TCS intervenes by applying a brake to the spinning wheel until traction is achieved.
- The result is close to optimal traction on all four wheels.



Electronic Stability Program (ESP)

Vehicle Safety Systems

- *Collision Avoidance (CA)*. Autonomous driving requires the ability to identify and avoid obstacles in the vehicle's path.
- Collision avoidance can be divided into two categories.
- The first is to determine a collision-free path between obstacles whose locations have been determined.
- The second case is the sudden and unexpected detection of an obstacle with an inevitable collision.



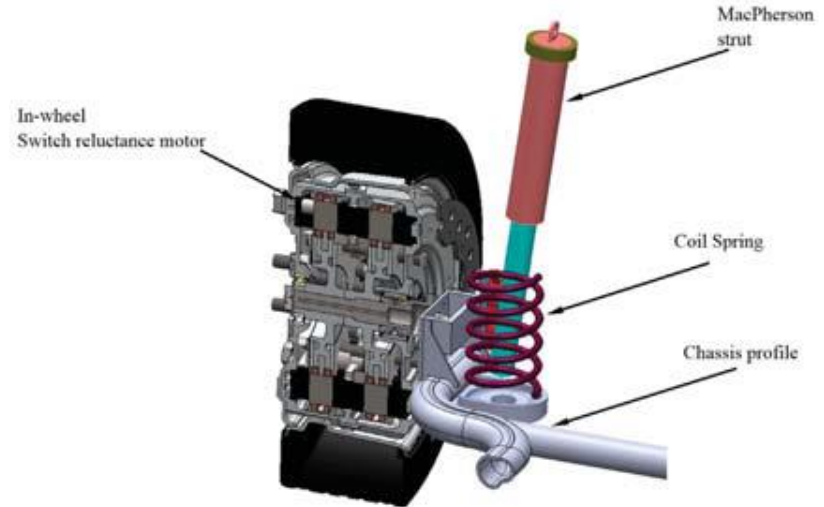
Collision Avoidance in EV

- *Lane Assist (LA) monitors the markers in the lane you are driving, as well as the surrounding area due to the presence of vehicles or other objects.*



Lane Assist in EV.

- *Suspension system*
- Electric vehicles have suspensions as well as internal combustion engines.
- Typical variants of suspension are:
 - fixed
 - independent suspension



*Electric Vehicle (EV) Suspension Design with SRM
Wheel Motor*

Vehicle Safety Systems

- **Control systems.** Electric cars are designed to have electric power steering.



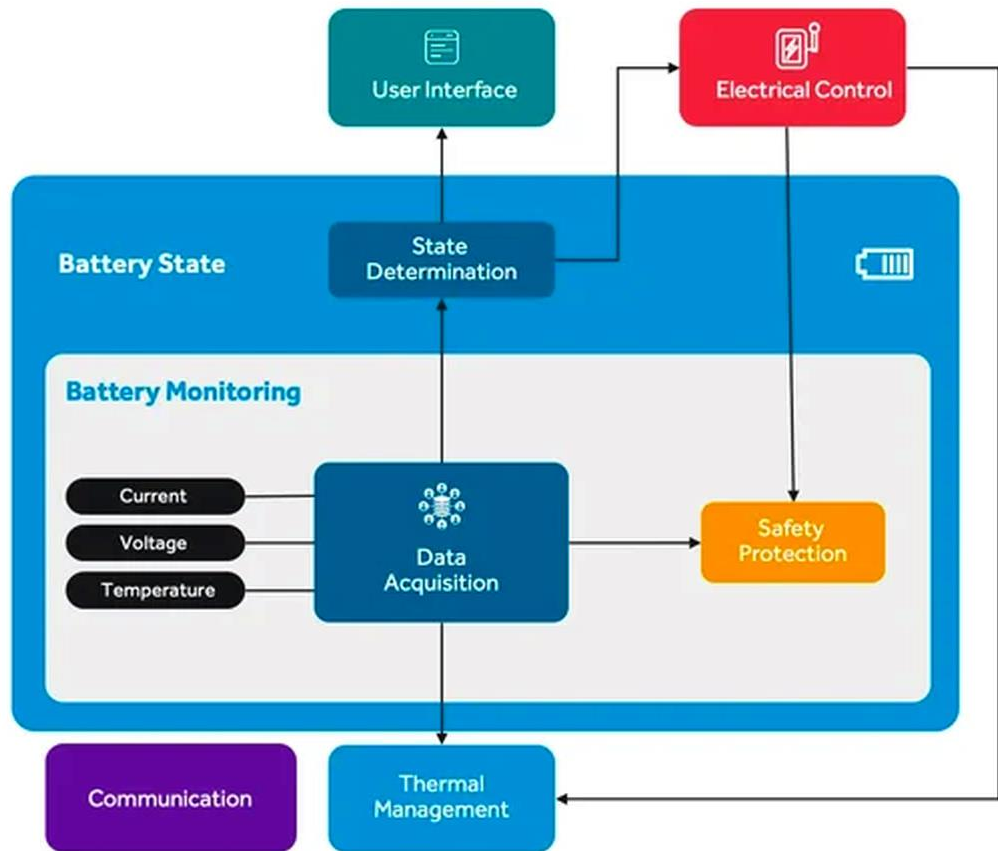
Four-wheel steering systems

a) Driving in the opposite direction, at low speeds.

b) Driving in the same direction at medium and high speeds

Vehicle Safety Systems

- A **battery management system** (BMS) manages the battery's electronics and becomes a key factor in ensuring the safety of electric vehicles.
- The BMS monitors the health status (SoH) of the battery, collects data, controls the environmental factors that affect the cell, and balances them to ensure the same voltage in the cells.



Tipičan sistem za upravljanje baterijama



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