🔋 1. What is BMS?

BMS (Battery Management System) is an electronic system that manages a rechargeable battery by:

- Monitoring its state (SoC, SoH)
- Protecting the battery from operating outside its safe limits
- Controlling the charging and discharging process
- Balancing the cells
- Communicating data to other systems

🎯 2. What is a Resolver?

A **resolver** is an analog rotary position sensor that converts the mechanical angle of a rotating object into an electrical signal. It's commonly used in electric motors to:

- Measure rotor position
- Provide speed feedback
- Ensure accurate motor control

A. Series Hybrid

- **Working:** Engine → Generator → Electric Motor → Wheels
- **Advantages:**
  - Simple mechanical layout
  - Good at low-speed, stop-and-go traffic
- **Disadvantages:**
  - Inefficient at high speed
  - Requires large motor and battery
- **Applications:** Chevrolet Volt (mode), some buses

B. Parallel Hybrid

- **Working**: Engine and Motor both connected to drivetrain
- **Advantages**:
  - Better efficiency at highway speeds
  - Smaller motor and battery needed
- **Disadvantages**:
  - Complex transmission
  - Less regenerative braking efficiency
- **Applications**: Honda Civic Hybrid, Hyundai Ioniq

C. Series-Parallel Hybrid

- **Working:** Combines both series and parallel operation
- **Advantages:**
  - Flexible and efficient across speed ranges
  - Optimized fuel economy
- **Disadvantages:**
  - Complex powertrain and control
- **Applications:** Toyota Prius, Ford Fusion Hybrid

4. Types of Batteries & Their Cell Voltages

Battery Type	Nominal Cell Voltage
Lead Acid	2.0 V
Nickel-Cadmium (NiCd)	1.2 V
Nickel-Metal Hydride (NiMH)	1.2 V
Lithium-ion (Li-ion)	3.6 – 3.7 V
Lithium-Polymer (Li-Po)	3.7 V
Solid-State Battery	~3.7 V
Sodium-ion (emerging)	~2.3 – 3.0 V

5. List of Motors with Working Principle & Specs

Motor Type	Working Principle	Specs (Typical)
BLDC (Brushless DC)	Electronic commutation via inverter	High efficiency, 2kW–100kW, 90–95% efficient
PMSM (Permanent Magnet Synchronous Motor)	Uses rotor with permanent magnets & sinusoidal back EMF	High torque density, used in EVs
Induction Motor (AC)	Induced current in rotor due to stator's magnetic field	Rugged, less costly, 50kW–150kW
SRM (Switched Reluctance Motor)	Reluctance torque generation via switched stator	Simple & robust, noisy, under development
DC Motor (Brushed)	Commutator & brushes supply current to armature	Simple control, low cost, lower efficiency

6. Full Forms

- **DoD**: Depth of Discharge
- **SoC**: State of Charge
- **SoH**: State of Health
- **RUL**: Remaining Useful Life
- **ERG**: Exhaust Gas Recirculation (usually EGR, check spelling)
- **CRDi**: Common Rail Direct Injection
- **LVDT**: Linear Variable Differential Transformer

7. Sensors and Actuators Used in HEVs

Sensors:

- Current Sensor (Hall-effect)
- Voltage Sensor
- Temperature Sensor
- Speed Sensor
- Position Sensor (Encoder, Resolver)
- Accelerometer
- Gyroscope
- Fuel Level Sensor
- O2 Sensor (Lambda Sensor)
- Battery SoC/SoH Sensor
- Brake Pedal Position Sensor
- Throttle Position Sensor

Actuators:

- Electric Motor
- Fuel Injector
- Throttle Actuator
- Relay / Contactor
- Cooling Fan
- Electric Brake Actuator
- Transmission Solenoid