

# EVs Are Made Of This

8 crucial parts that make up an electric vehicle

<https://www.designnews.com/content/evs-are-made-redux>

## Introduction

Last year *Design News* published this description of the parts that make up an electric vehicle (EV). As EVs are finally reaching the mainstream, the information here is more important than ever. Just a couple years ago, most EVs, aside from those produced by EV pioneer Tesla, were small commuter cars whose range was limited to less than 100 miles. But now, a whole group of new medium-sized EVs are joining Tesla with sedans and crossover sport-utility vehicles that can go more than 250 miles on a single charge.



Even if you know how a gasoline engine works, EVs bring a whole new set of components, and a different language to describe them. If you are shopping for an EV, or might be in the near future, it could be helpful to know what the different pieces and systems do in a modern electric vehicle.

Here are eight of the major parts that make up an EV. Reading about them won't provide you with a degree in electrical engineering, but it might help you understand how this exciting new technology works.

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(Image source: Tesla)

## Traction Battery

Lithium ion batteries power electric vehicles. There are several different configurations (small cylindrical cells, pouch cells, prismatic cells). There are also several different chemistries (particularly for the cathode materials). Individual cells are combined together to create battery modules and groups of modules are combined to produce a battery pack. All together there could be several thousand individual battery cells in an EV's pack. The voltage of a typical pack is in the 300-400 volt range. Lithium ion batteries require careful monitoring of the temperature and voltage of each cell and must be continuously balanced to avoid degraded performance and short pack life. The size of a pack is given by the number of kilowatt-hours (kWh) of energy that it can hold. A typical EV pack might hold 60-150 kWh. Some packs are air-cooled while others are liquid-cooled. Battery packs are extremely heavy (well over 1,000 pounds) and are often placed low, under the vehicle floor, to produce a low center of gravity to enhance handling performance. The bigger the pack, the further you can go.

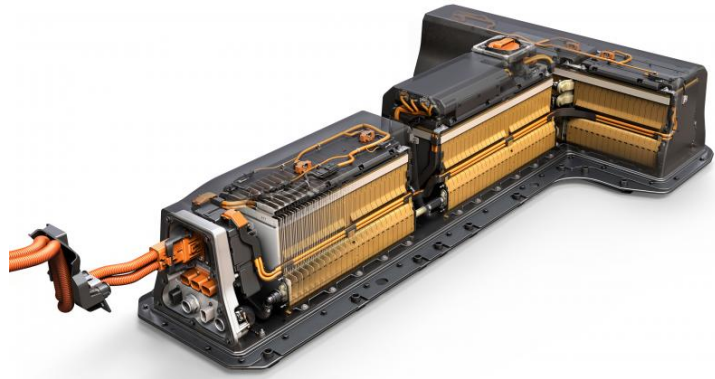


(Image source: Jaguar)

## Battery Management System (BMS)

A lithium ion pack requires the individual cell temperatures and voltages to be monitored. This is accomplished through the Battery Management System (BMS). During charging the BMS ensures that the cells have the same voltage level (usually within 0.01 volts). Without a BMS, it might be possible for one cell to dramatically overcharge, potentially causing a danger from fire or explosion. During discharge, without a BMS, it might be possible for one cell to underperform, requiring the others in a module to be drained too quickly, or at too high a rate. When you consider that a BMS has to keep track of hundreds or even thousands of battery cells and modules, the technology seems impressive. The BMS keeps your EV safe.

*(Image source: Chevrolet)*



## DC to DC Converter

The high-voltage traction battery does the heavy lifting of propelling the vehicle. But the majority of an EV's electrical system is actually powered by a 12-volt lead-acid battery, similar to the starting battery in a gasoline-powered vehicle. The 12-volt system operates the lights, horn, blower motors, and most of the computer systems that control the electric drive. A DC to DC Converter takes some of the energy from the 300-volt traction battery and converts it to 12-volts to run all the systems and keep the on-board 12-volt battery fully charged. On some EVs the traction battery also powers the heating and cooling system. It takes advantage of the power available to quickly make the cabin more comfortable.

*(Image source: Exide)*



## Controller

The EV controller is an electronic microprocessor that takes driver's inputs such as accelerator or brake pedal application and turns them into signals that transmit (usually along a CAN/BUS communications line) to the power electronics in the inverter that provide power to the motor. In many ways, the controller acts as an electronic brain, accepting inputs from the vehicle and requests from the driver and determining how to best instruct the motor to respond. The way in which the controller is programmed makes your EV drive the way it does.

*(Image source: Volkswagen)*





## Inverter

Early electric vehicles often used brushed-DC motors that would operate on the direct current produced by the batteries and moderated by the controller. More recently, brushless DC (BLDC) motors, also known as synchronous DC, or even AC motors have arrived. Instead of direct current, they operate on alternating current. This alternating current is produced by the inverter, which takes direct current from the battery and changes it into alternating current that is used to power the BLDC motor. The frequency of the AC current determines the speed at which the motor spins. The inverter has a position sensor on the motor that allows it to time its current impulses to the motor to keep the motor spinning and producing the torque necessary to move the vehicle. The inverter takes its commands from the controller and converts them into signals for the motor. The inverter contains high-level power electronics, capable of providing several hundred volts and several hundred amps to the motor. The more robust the inverter, the more efficient and reliable your EV.

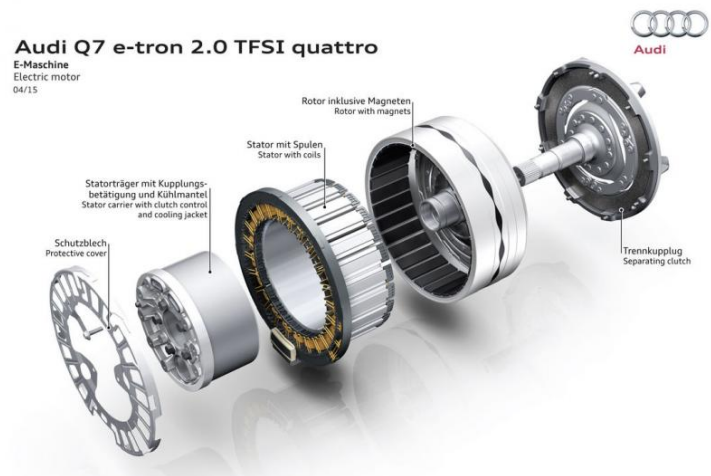
(Image source: Audi A.G.)



## Traction Motor

The brushless DC (BLDC) motor is used in almost all modern EVs. It is more efficient and operates at a higher speed than the traditional brushed DC motor that the original EVs used. A typical BLDC motor has a stator, or rotor, that contains four to eight permanent magnets and that spins in the center section of the motor. The stator is surrounded by a series of electric coils that make up the commutator. The inverter provides energy to the coils in such a way that they become electromagnets that oppose the magnetism in the permanent magnets, producing motion. By timing the motion properly, the motor spins. The permanent magnets are often made with so-called rare-earth elements such as niobium or neodymium. Because electric motors produce their maximum torque at zero rpm, the motor often does not require a transmission, but can be used with direct drive, or through a gear reduction system. Some EVs use a single motor, powering the front or rear wheels. Others use a pair of motors, one at the front and one at the rear to create all-wheel drive. Occasionally, three motors are employed, two powering the rear wheels and one powering both the front wheels. It is also possible to build motors into the wheels, providing four motors, one for each wheel position. Motor cooling can be accomplished either by air-cooling or liquid cooling. The more power (in kilowatts, or kW) your EV produces, the more performance it will provide you, provided the cooling system is capable of keeping the motor temperature in check.

(Image source: Audi A.G.)



## Regenerative Braking

One way EVs produce high levels of efficiency is by capturing energy normally lost to heat during braking. When a vehicle slows down, the motor can operate as a generator, producing electricity at the same time it slows the vehicle. The

electrical energy produced by the regenerative braking can be applied to the battery, helping to recharge it slightly. The amount of regenerative braking can be adjusted (using the controller) to provide a significant reduction in speed without using the vehicle's normal hydraulic brakes. Regenerative braking can add more than 20% to the vehicle range during stop and go driving in the city. Some EVs have aggressive regenerative braking, allowing nearly one-pedal driving where you almost never need to touch the brake pedal.

*(Image source: Jaguar)*

## **Chargers and Charging**

Most EVs have an on-board charger that is capable of plugging into normal 120-volt household current (Level 1 charging) or into a special 220-volt line (Level 2 charging) that is wired into the home garage circuit. Onboard chargers are limited by the amount of current that the home circuits can provide. Typical level 1 charging can produce 1.9 kilowatts (kW) of power and provides about 4 miles of range for every hour of charging. Level 2 charging is generally limited to 3.3 kW to 6.6 kW and can provide up to 20 miles of range for every hour of charging. Fast DC charging, also called Level 3 charging, is also possible for some EVs. In this case a special plug sends direct current directly into the battery at power levels of 150 kW or greater. A Level 3 charger can add 50-150 miles of range in a half an hour of charging. At the very least you need Level 2 charging at home to ensure your EV has a “full tank” every morning. If you want to make any long trips in your EV, Level 3 charging capability is a must.

*(Image source: Siemens)*

