Product Knowledge Document

ELECTRIC VEHICLE TECHNOLOGY

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INTRODUCTION

- An electric car is a Plug -in electric automobile that is propelled by one or more electric motors , using energy typically stored in rechargeable batteries.
- Since 2008, a renaissance in electric vehicle manufacturing occurred due to advances in batteries, concerns about increasing oil prices, and the desire to reduce greenhouse gas emission
- Several national and local governments have established tax credits, subsides, and other incentives to promote the introduction and adoption in the mass market of new electric vehicles, often depending on battery size, their electric range and purchase price.

TYPES OF ELECTRIC VEHICLE

There are 3 types of electric vehicle

1. Battery Electric Vehicle (BEV)

A battery electric vehicle (BEV) runs entirely using an electric motor and battery, without the support of a traditional internal combustion engine, and must be plugged into an external source of electricity to recharge its battery. Like all electric vehicles, BEVs can also recharge their batteries through a process known as regenerative braking, which uses the vehicle's electric motor to assist in slowing the vehicle, and to recover some of the energy normally converted to heat by the brakes.

2. Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in hybrids (PHEVs) use an electric motor and battery that can be plugged into the power grid to charge the battery, but also has the support of an internal combustion engine that may be used to recharge the vehicle's battery and/or to replace the electric motor when the battery is low. Because Plug-in Hybrids use electricity from the power grid, they often realize more savings in fuel costs than tradition hybrids electric vehicles (HEV).

TYPES OF ELECTRIC VEHICLE

3. Hybrid Electric Vehicle (HEV)

Hybrid Electric Vehicles (HEVs) have two complementary drive systems: a gasoline engine with a fuel tank; and an electric motor with a battery. Both the engine and the electric motor can turn the transmission at the same time, and the transmission then turns the wheels. HEVs cannot be recharged from the electricity grid – all their energy comes from gasoline and from regenerative braking.

HISTORY

- Electric cars were among the preferred methods for automobile propulsion in the late 19th century and early 20th century, providing a level of comfort and ease of operation that could not be achieved by the gasoline cars of the time.[The electric vehicle stock peaked at approximately 30,000 vehicles at the turn of the 20th century.
- n 1897, electric cars found their first commercial use in the US. Based on the design of the Electrobat II ,a fleet of twelve hansom cabs and one brougham were used in New York City as part of a project funded in part by the Electric Storage Battery Company of Philadelphia. During the 20th century, the main manufacturers of electric vehicles in the US were Anthony Electric, Baker, Columbia, Anderson, Edison, Riker, Milburn, Bailey Electric and others. Unlike gasoline-powered vehicles, the electric ones were less noisy, and did not require gear changes.
- Advances in internal combustion engine (ICE) in the first decade of the 20th century lessened the relative advantages of the electric car. Their much quicker refuelling times, and cheaper production costs, made them more popular. However, a decisive moment was the introduction in 1912 of the electric starter motor which replaced other, often laborious, methods of starting the ICE, such as hand-cranking.
- Six electric cars held the land speed record. The last of them was the rocket-shaped La Jamais contente, driven by Camille Jenatzy, which broke the 100 km/h (62 mph) speed barrier by reaching a top speed of 105.88 km/h (65.79 mph) on 29 April 1899.

HISTORY

- In the early 1990s, the California Air Resources Board (CARB) began a push for more fuel-efficient, lower-emissions vehicles, with the ultimate goal being a move to zero-emissions vehicles such as electric vehicles. In response, automakers developed electric models, including the Chrysler TEVan, Ford Ranger EV pickup truck, GM EV1, and S10 EV pickup, Honda EV Plus hatchback, Nissan Altra EV miniwagon, and Toyota RAV4 EV. Both US Electricar and Solectria produced 3-phase AC Geo-bodied electric cars with the support of GM, Hughes, and Delco.
- California electric automaker Tesla Motors began development in 2004 on what would become the Tesla Roadster (2008), which was first delivered to customers in 2008. The Roadster was the first highway legal serial production all-electric car to use lithium -ion battery cells, and the first production all-electric car to travel more than 320 km (200 miles) per charge.
- Tesla global sales passed 250,000 units in September 2017.The Renault -Nissan-Mitsubishi Alliance achieved the milestone of 500,000 units electric vehicles sold in October 2017.Tesla sold its 200,000 Models in the fourth quarter of 2017.Global Leaf sales passed 300,000 units in January 2018, keeping its record as the world's top selling plug-in electric car ever. Tesla delivered its 100,000 Models in October 2018.
- Many countries have set goals to ban the sales of gasoline and diesel powered vehicles in the future, notably; Norway by 2025, China by 2030, India by 2030, Germany by 2030, France by 2040, and Britain by 2040 or 2050. Similarly, more cities around the world have begun transitioning public transportation towards electric vehicles, than previously was the case.

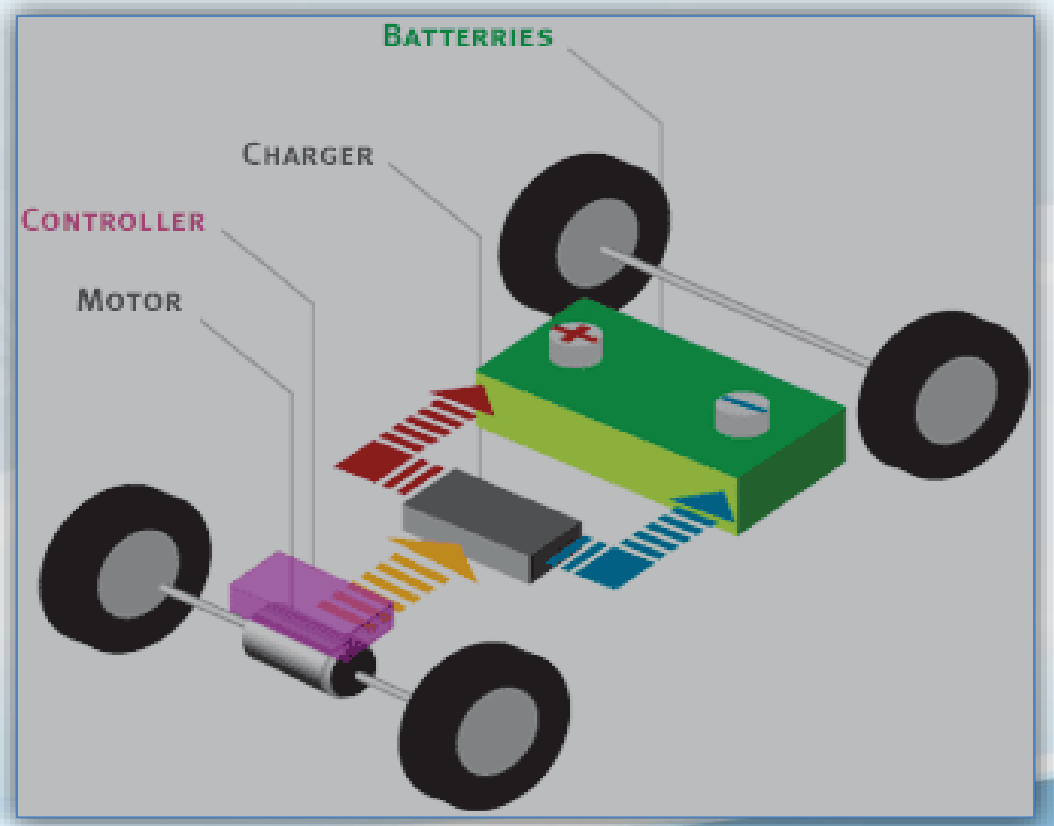
ELECTRIC VEHICLE ADVANTAGES

- No vibration
- No Oil Change
- Minimal Maintenance
- No Smell
- No Noise
- No gears to change(Transaxle free)
- No handcrank
- Quick start
- No backfiring
- Fast and smooth acceleration
- Efficiency More than 90% (While Internal Combustion Engine 30%)

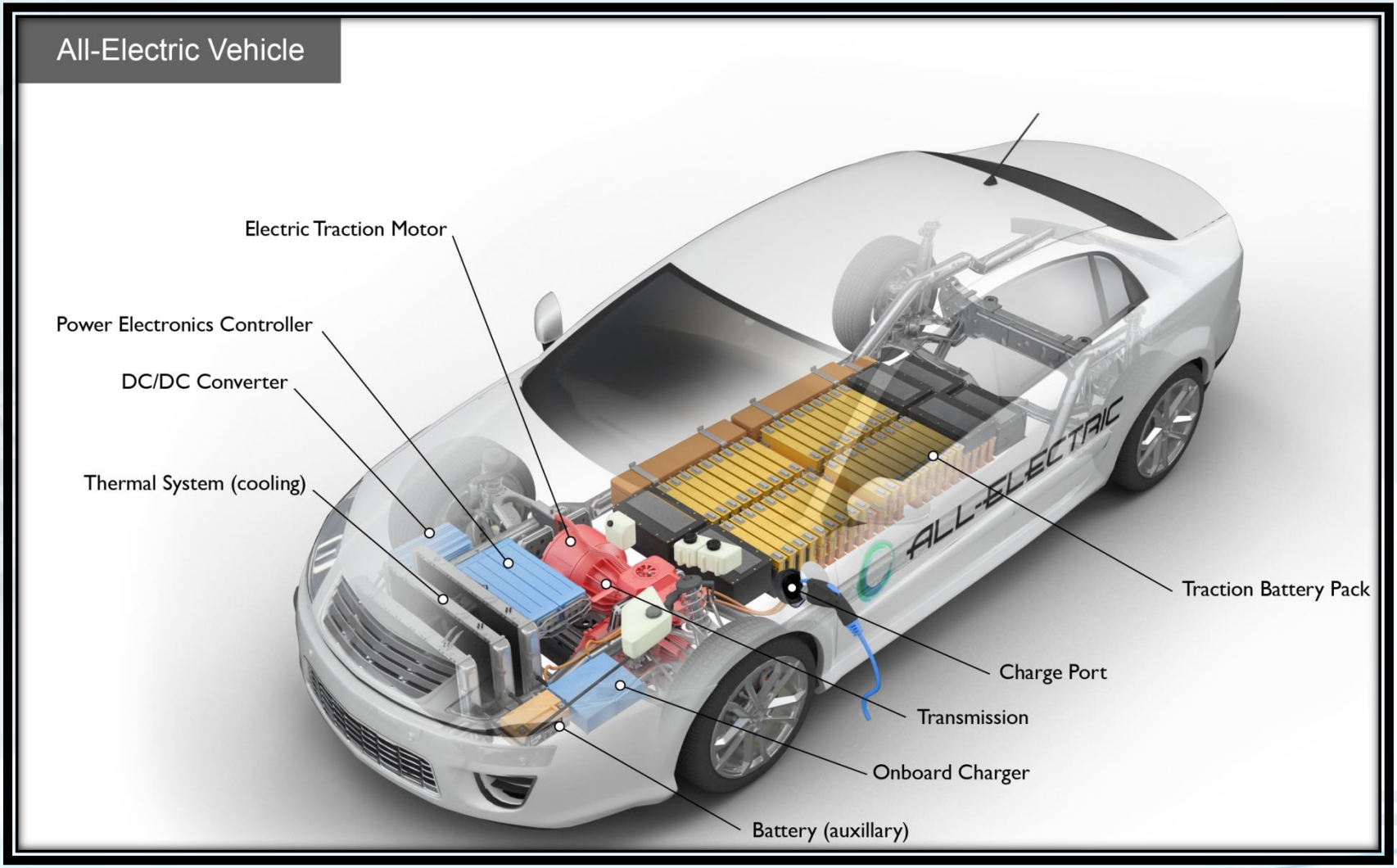
ELECTRIC CAR CONSTRUCTION

Electric car are consist of

- **Motors**
- **Controllers**
- **Batteries and Chargers**
- **Braking**
- **Auxiliary Batteries and DC-DC converters.**



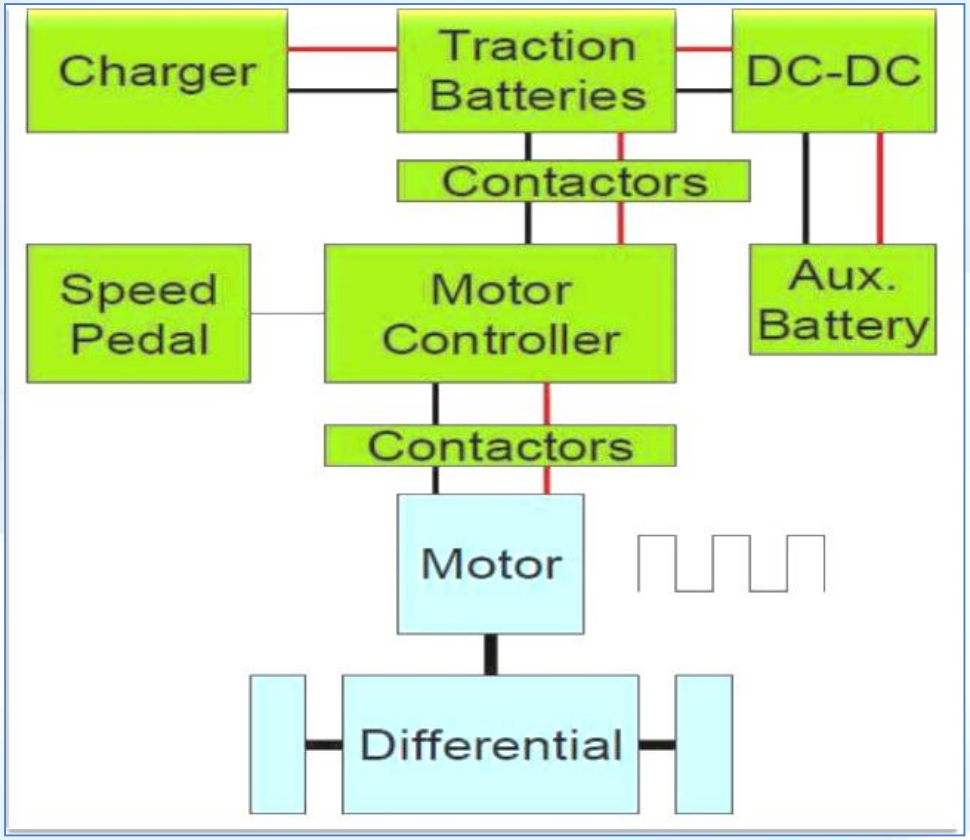
ELECTRIC CAR CONSTRUCTION



ELECTRIC CARS : HOW THEY WORK?

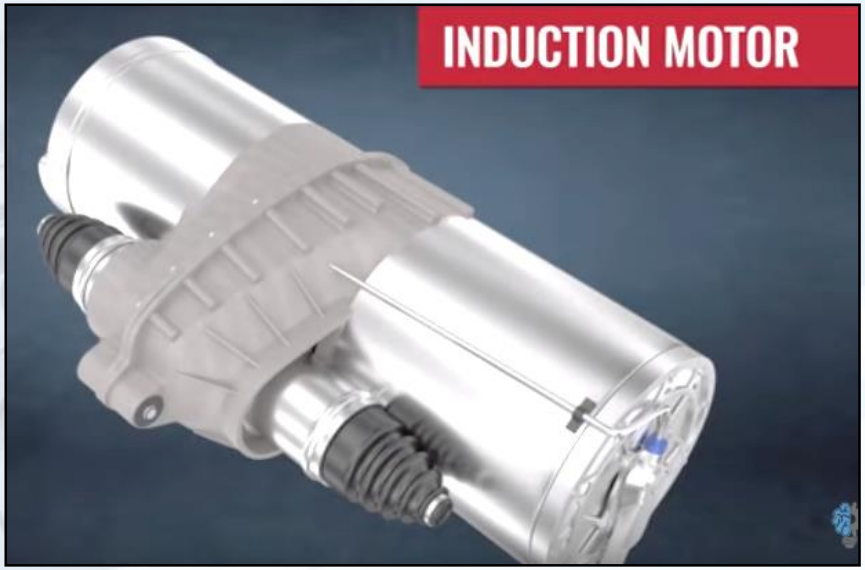
Basic Principle

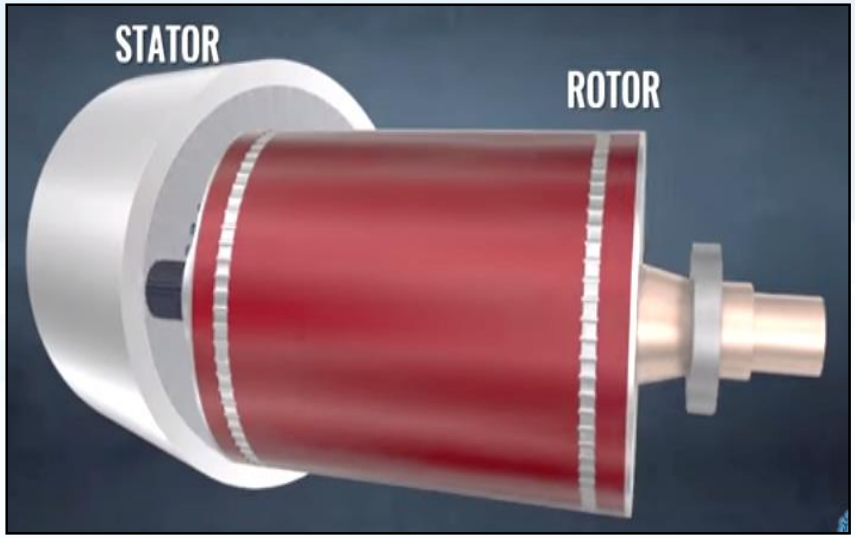
- An Electric car is powered by an Electric Motor rather than a Gasoline Engine.
- The Electric Motor gets its power from a controller.
- The Controller is powered from an array of rechargeable batteries.



ELECTRIC CARS : HOW THEY WORK?

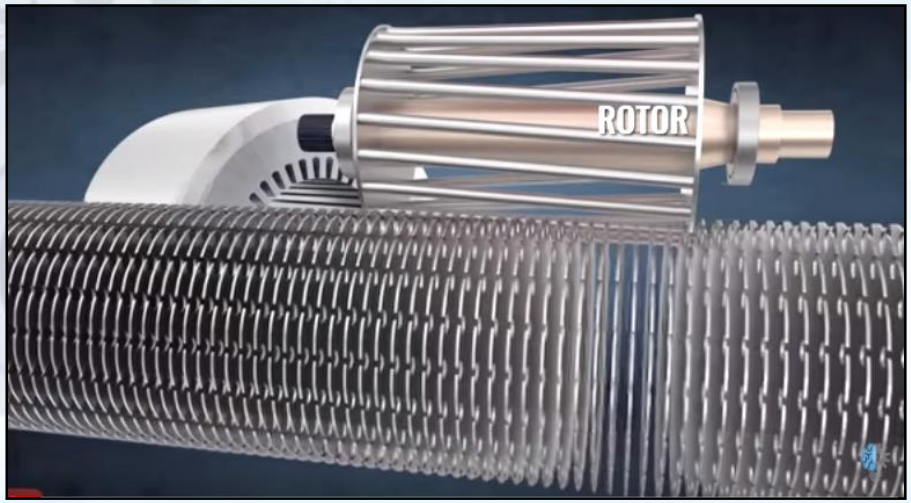
- **The Induction motor has two main parts the stator and rotor**

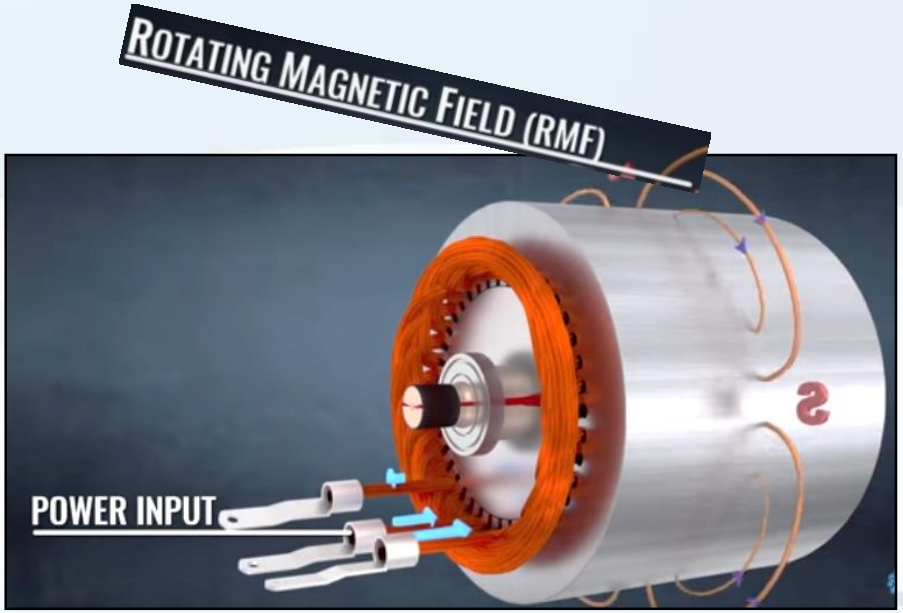




ELECTRIC CARS : HOW THEY WORK?

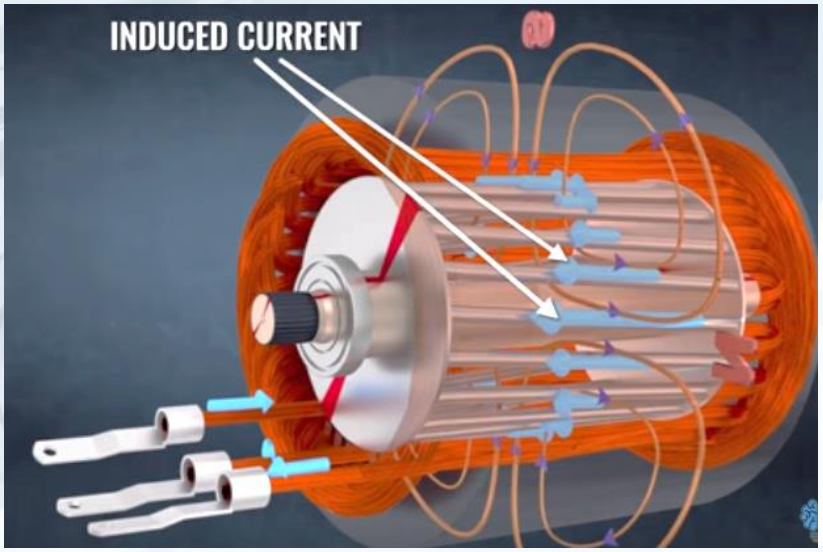
- The rotor is simply collection of conducting bar short circuited by end rings
- A 3phase AC power input is given to the stator, the 3 phase alternating current in the coil produces a rotating magnetic field, then motor produces a four pole magnetic field , then this rotating magnetic field induces current on rotor bar to turn, in induction motor rotor always behind the RMF
- An induction motor has neither brushes nor a permanent magnet at the same time it is robust and powerful.

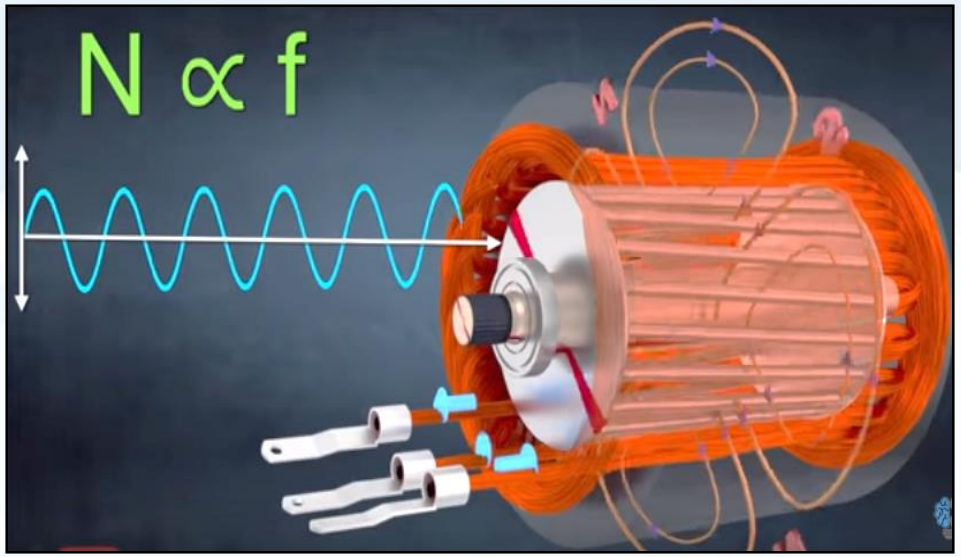




ELECTRIC CARS : HOW THEY WORK?

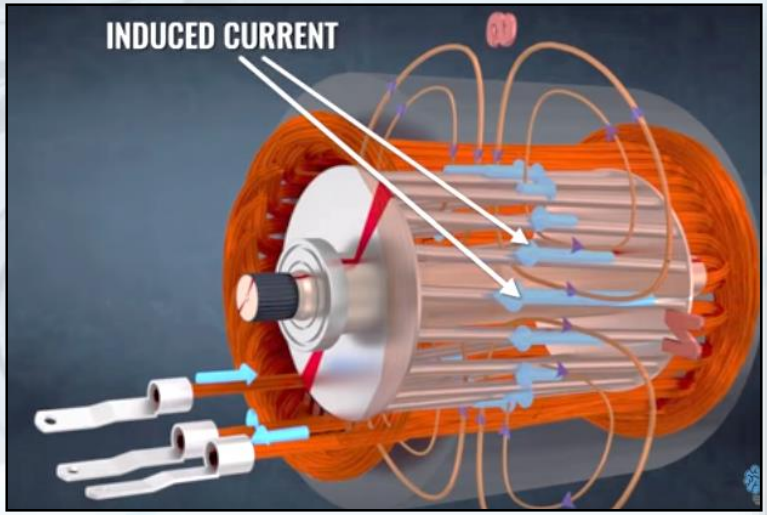
- **Induction motor speed depend upon frequency of AC power supply so, just by varying the frequency of the power supply we will be able to alter the speed of drive wheels, this simple facts makes electric car be controlled easy and reliable**
- **Motor supply from variable frequency drive which interns control motor speed, the motor speed can range from 0-18000 RPM this the most sizable advantage of electric car over IC Engine**

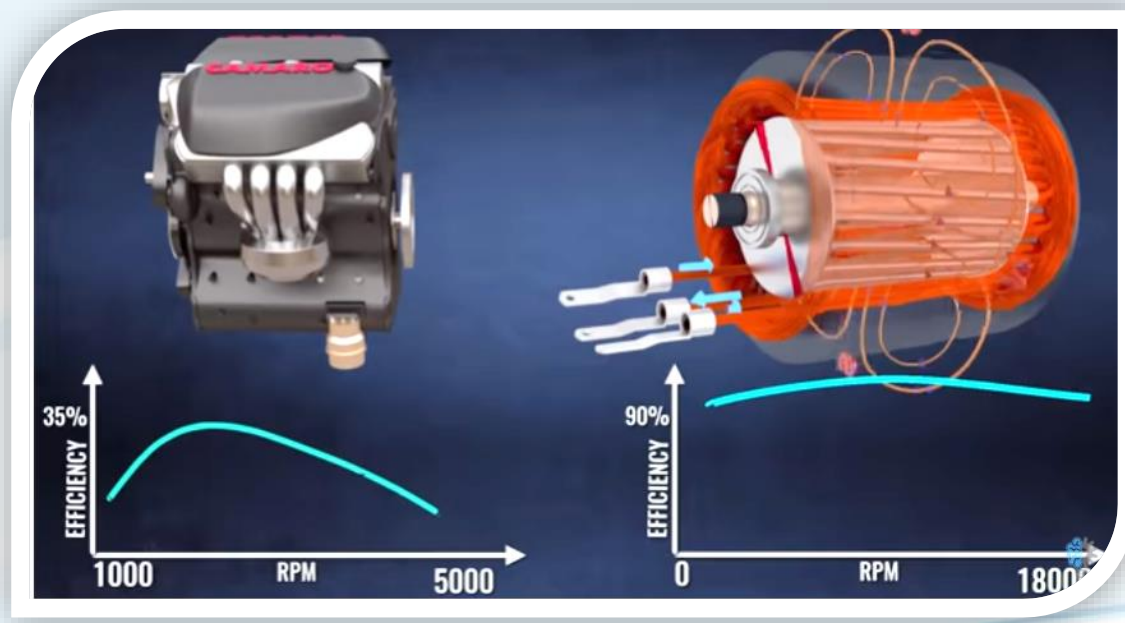




ELECTRIC CARS : HOW THEY WORK?

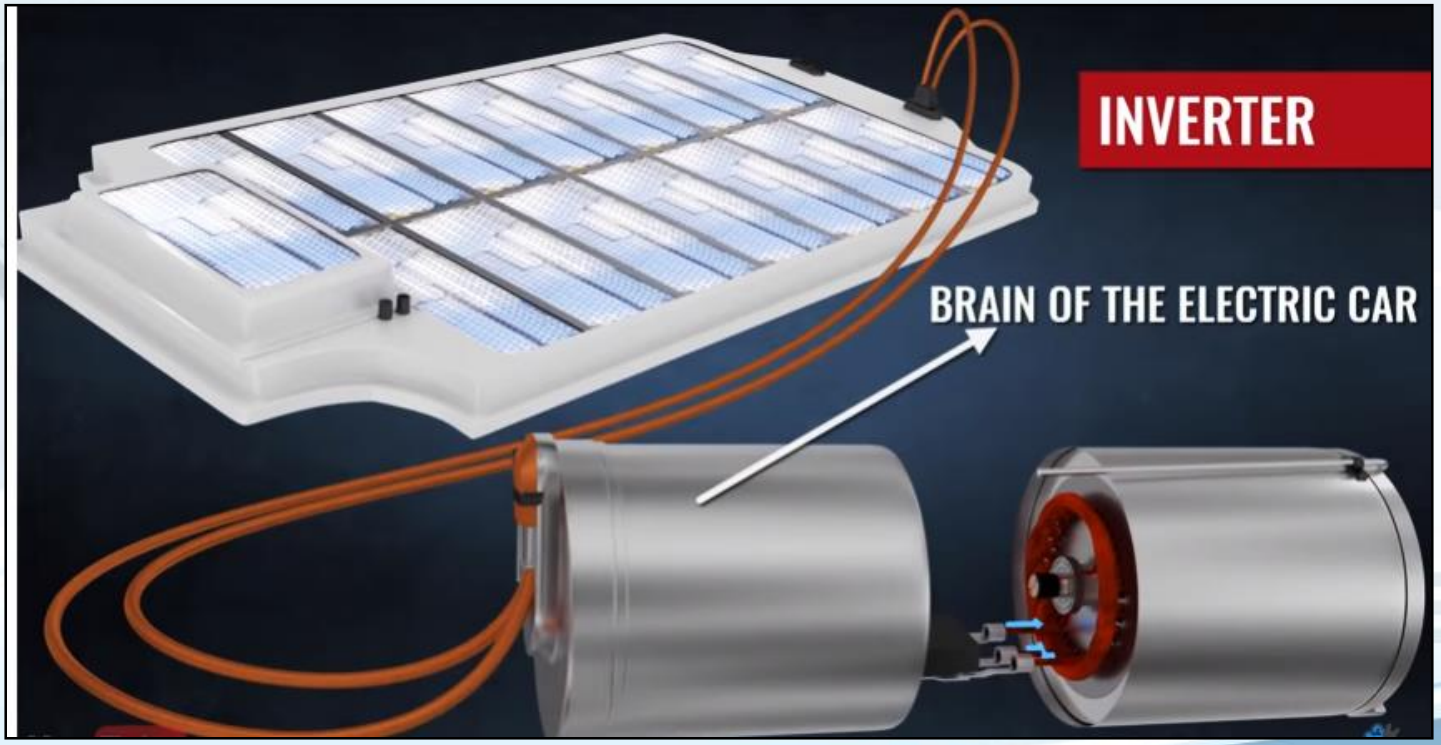
- **An IC Engine produces usable torque and power output only within limited speed range, therefore directly connecting the engine rotation to the drive wheel is not possible, so transmission must be used to vary the drive wheel speed to obtain different speed ratio. On the other hand an induction motor will work efficiently in any speed range(different speed range can be achieved) thus no transmission is required for electric cars.**





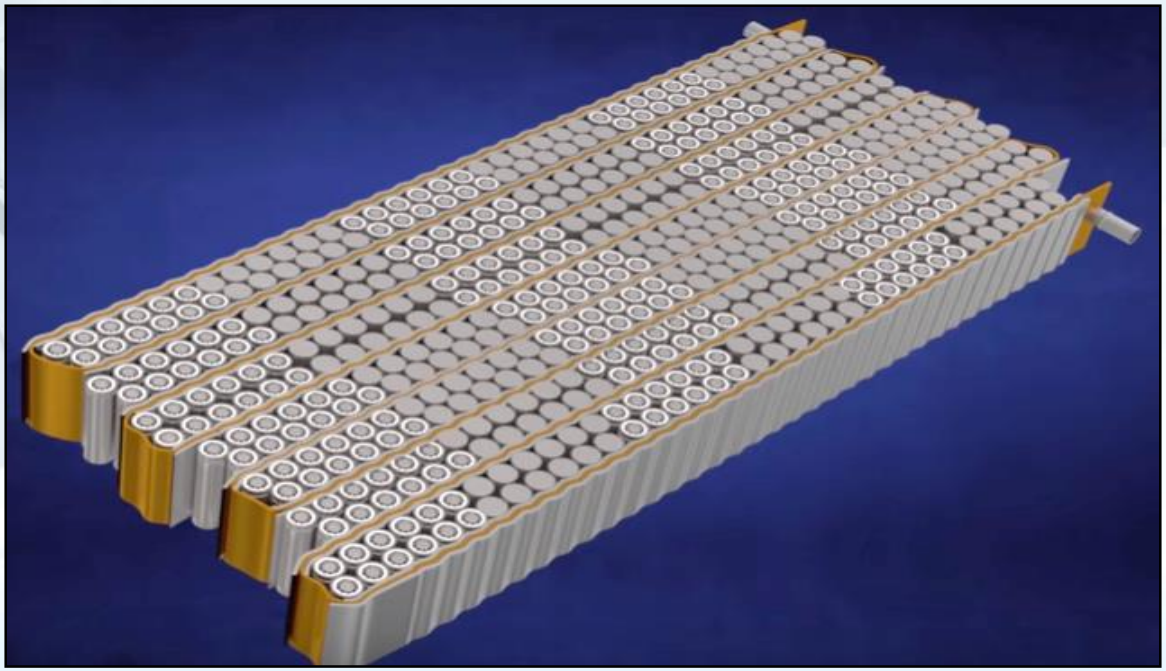
ELECTRIC CARS : HOW THEY WORK?

- A motor receive power from battery pack, battery produces DC power so before supplying to motor it has to be converted to AC , an inverter is used for this purpose. This power electronic devices also control the Ac power frequencies thus controlling the motor speed
- Moreover the inverter can even very the amplitude of AC power which in terns control the motor power output, thus inverter act as the brain of the electric car.



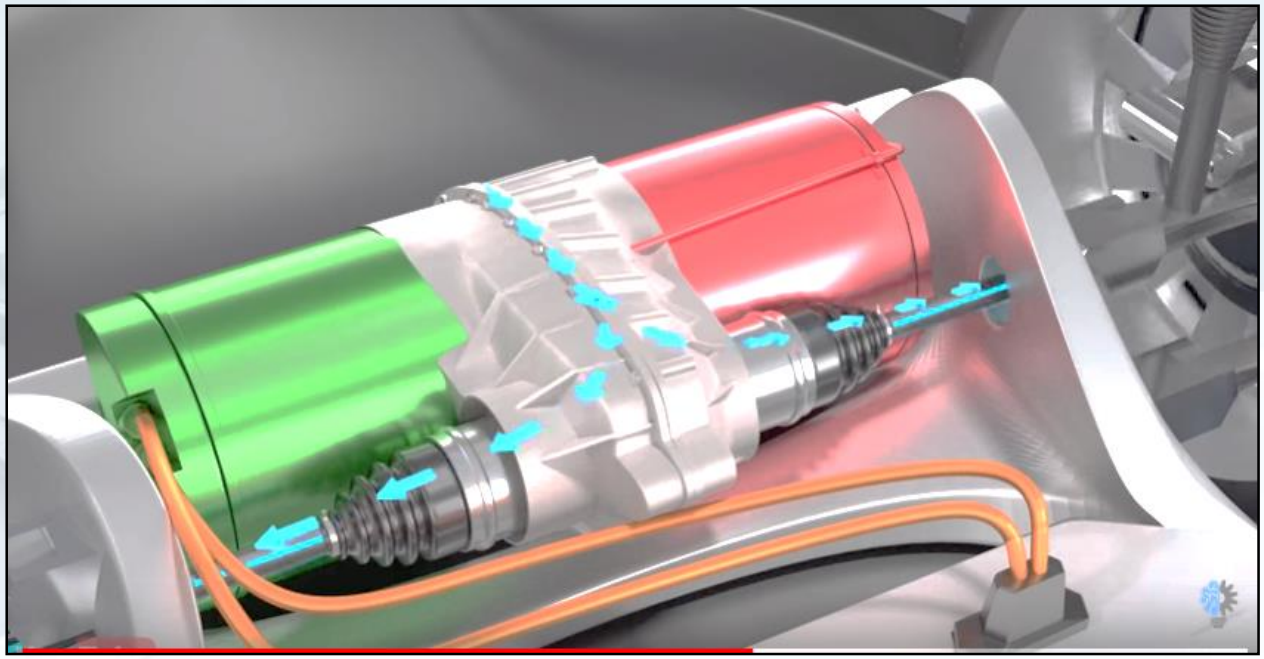
ELECTRIC CARS : HOW THEY WORK?

- **Battery pack is a collection of carbon-Lithium ion cells, this cells are connected in combination of series and parallel to produce power required to run a electric car , Glycol coolant is passed through metallic inner tubes through the gaps between the cells, this minimizes thermal hotspots and even temperature distribution is achieved to leading higher battery pack life**
- **The cells are arranged in detachable marginal. The heated glycol is cooled by passing through radiator**



ELECTRIC CARS : HOW THEY WORK?

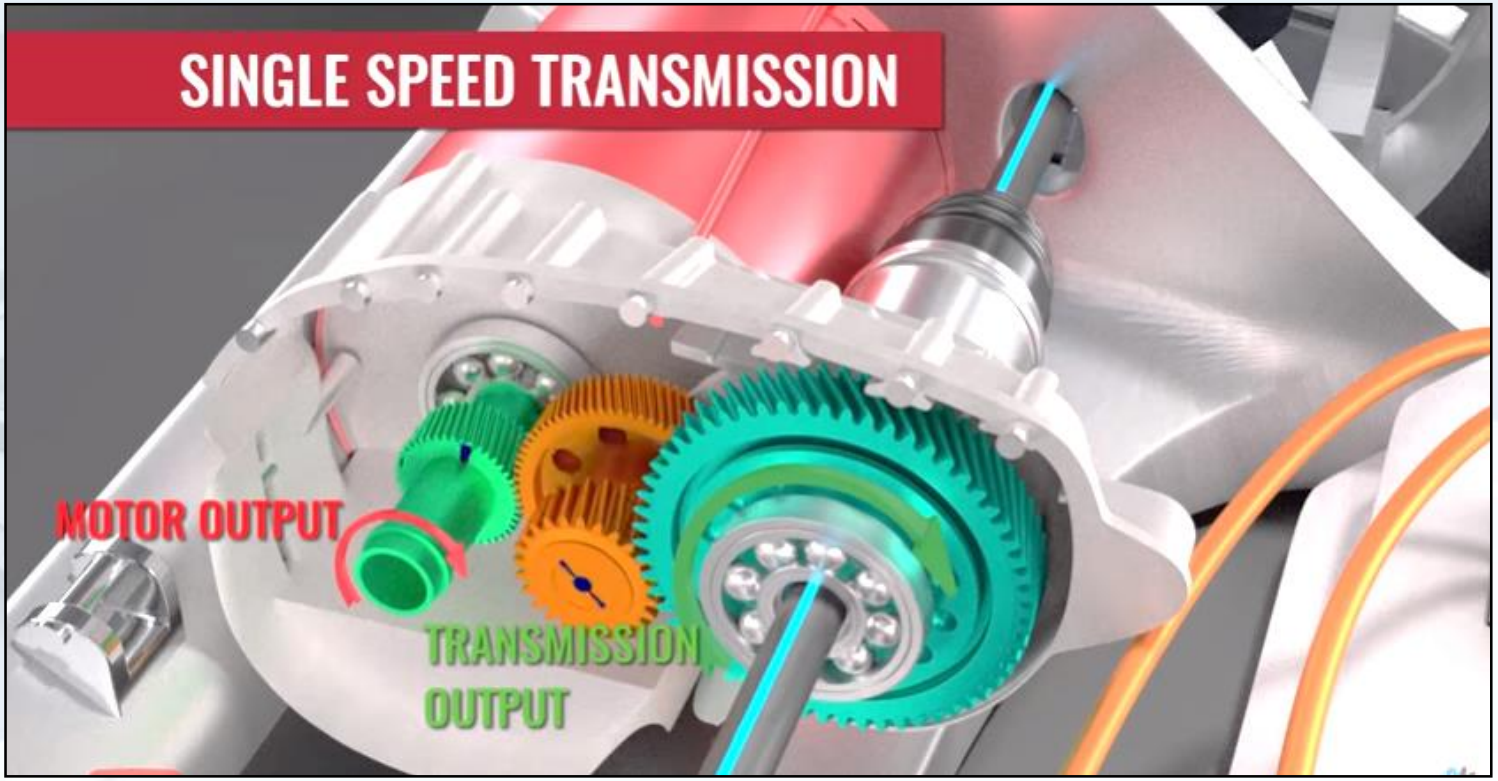
- **The power produced by the motor is transferred to drive wheel by a gear box**



ELECTRIC CARS : HOW THEY WORK?

- **A single speed transmission is used because a motor is efficient to produce a wider range of speed. Motor speed is reduced in two step by using two gears, even a reverse gear can be achieved by changing the order of power phase for it,**

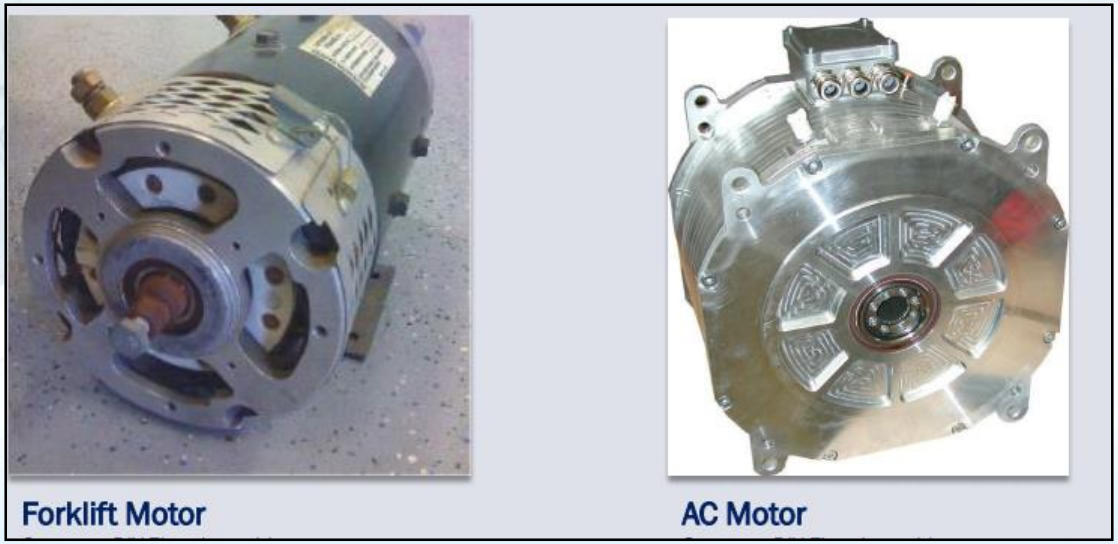
ELECTRIC CARS : HOW THEY WORK?



ELECTRIC CARS : HOW THEY WORK?

MOTORS

- The motor is the main component of an EV. It is very important to select proper type of motor with suitable rating. For example, it is not accurate to simply refer to a 10 hp motor or a 15 hp motor, because horsepower varies with volts and amps, and peak horsepower is much higher than the continuous rating. It is also confusing to compare electric motors to gas engines, since electric motors are given a continuous rating under load, and gas engines are rated at their peak horsepower under unloaded condition. For accurate identification, a motor should be identified by name or model number. Following are the commonly used motors in EVs:
- Electric cars can use AC as well as DC motor



MOTORS

- **DC Motors**

Run on a voltage ranging roughly between 96 to 192 volts. Most of them come from Forklift Industry. DC installations are simpler ,Another feature of DC motors is that they can be overdriven for short periods of time (up to a factor of 10), which is good for short bursts of acceleration.

- **Series wound brushed DC motors**

Series wound brushed DC motors (the field winding and armature are connected in series) are the best for the road-going EVs today, as they have a high torque, are cheap compared to other types, have wide availability, and require simple controllers as compared to other types.

- **AC Motors**

AC motors operate at high rpm that have to be stepped down, are expensive, and require a complex speed control mechanism.

- ***Brushless DC Motors***

Brushless DC motors require expensive controllers, but need very little maintenance.

MOTORS

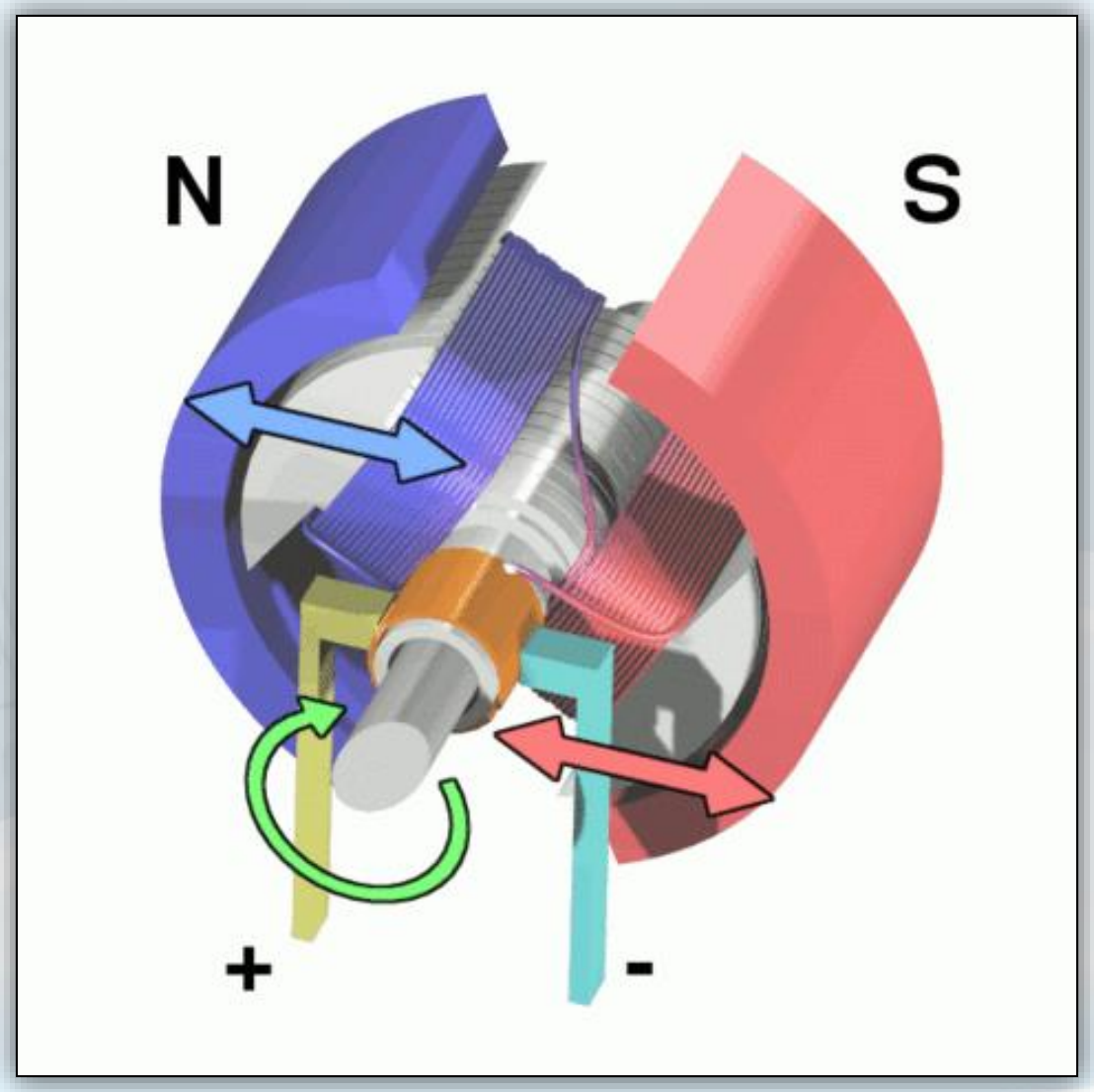
- **Permanent Magnet Motors**

Permanent magnet motors are very efficient, but only in a very narrow rpm band, and quickly lose their efficiency in the varying speeds of normal driving.

- **Shunt Wound DC Motors**

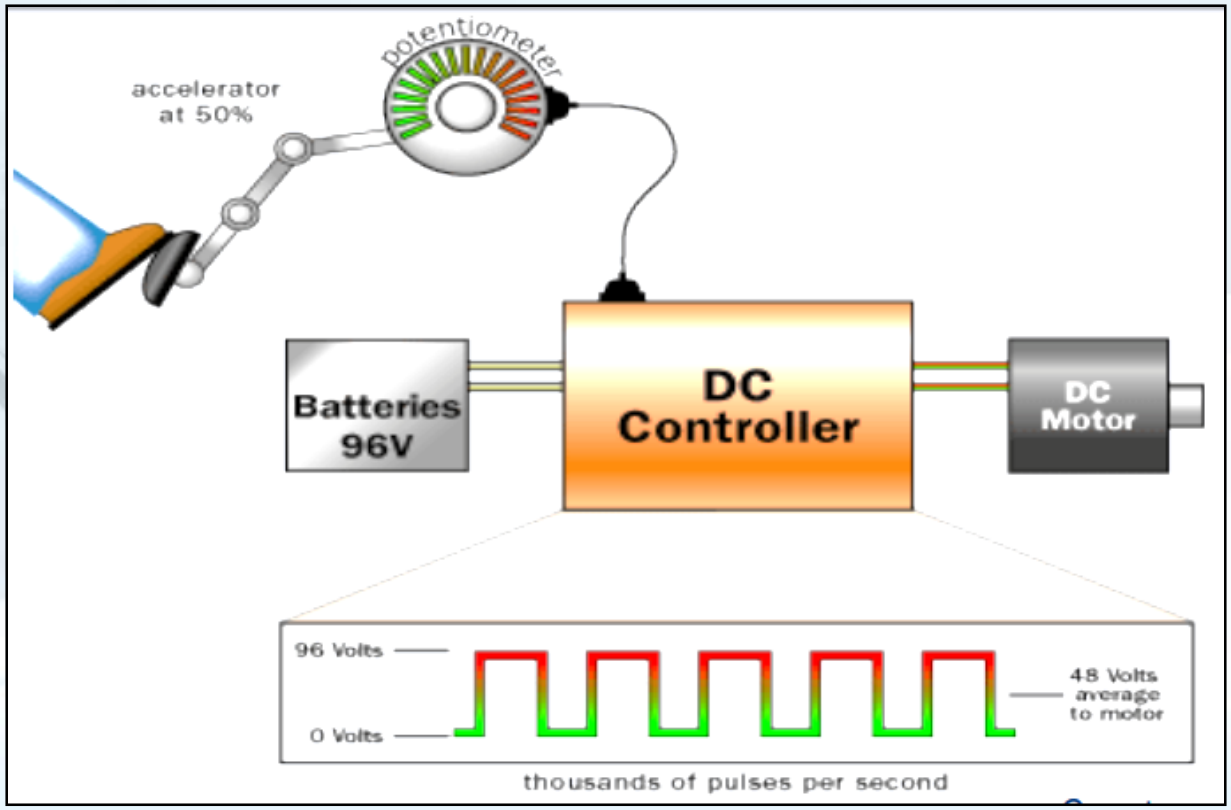
Shunt and compound motors are more expensive to build and have poorer acceleration than series motors.

Electric Motor

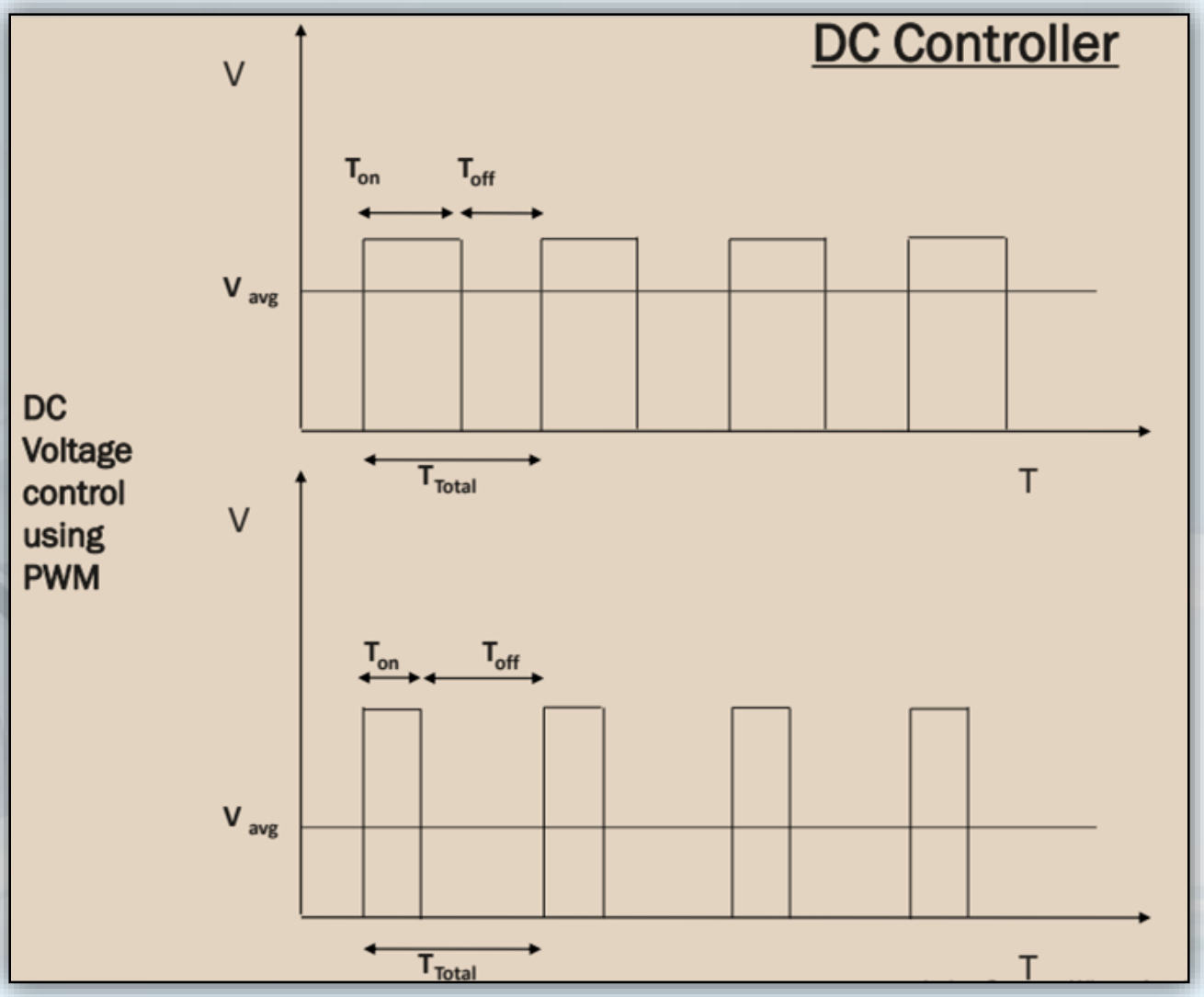


DC CONTROLLERS

- **The controller delivers a controlled voltage to the motor, depending upon potentiometer output.**
- **PWM controls the speed.**

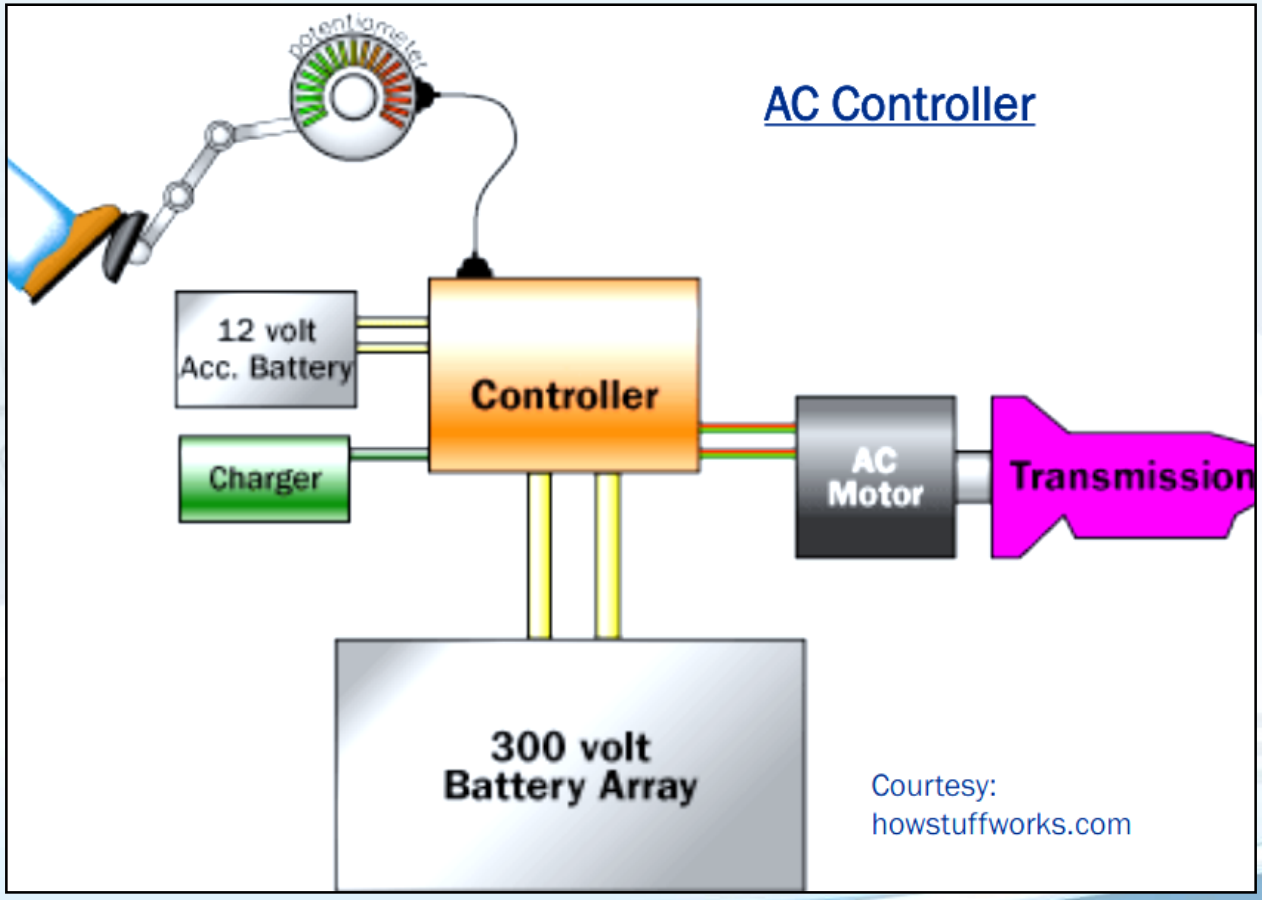


DC CONTROLLERS

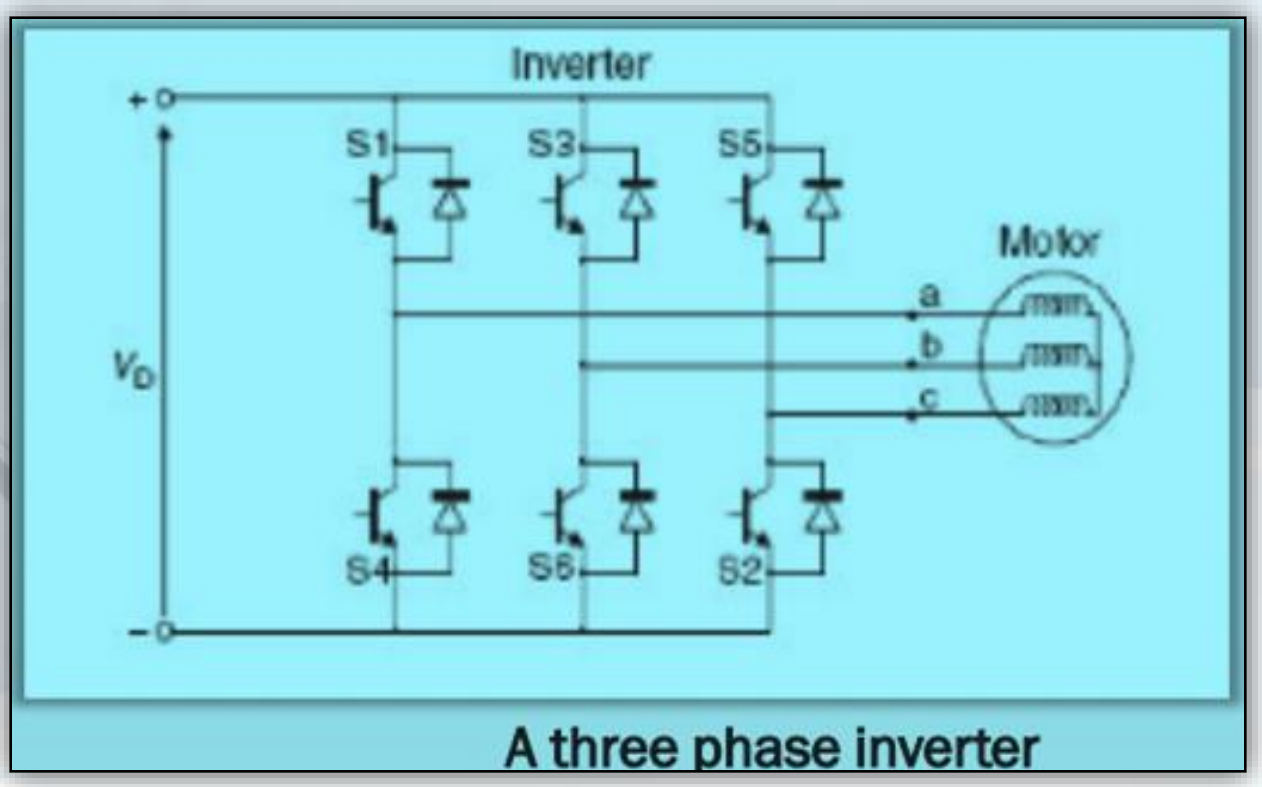


AC CONTROLLERS

- An AC controller creates 3 pseudo sine waves which are 120 degree apart (3-phase AC).
- Using six sets of power transistors, the controller takes in 300 volts DC and produces 240 volts AC, 3-phase.



AC CONTROLLERS



A three phase inverter

BATTERIES AND CHARGERS

- Lead acid batteries used, until recently.
- A weak link in the electric cars.
- Heavy, Bulky, limited capacity (12 – 15 kilowatt hours), slow charging rate, short life and expensive.
- NiMH batteries give double the range and last 10 years, but expensive.
- Lithium ion and NiMH batteries likely to be used if their prices can be made competitive with lead acid batteries.
- Charging done from power grid (household/ charging station).
- A good charger monitors battery voltage, current flow and battery temperature to minimize charging time.
- 120/240 Volts.
- Part of the controller/separate box.
- Magna – charge inductive charging system.

BATTERIES AND CHARGERS

- Batteries typically account for one third or more of vehicle weight and one fourth or more of the life-cycle cost of an electric vehicle. Major improvements in batteries are expected because, until recently, little effort has been put into designing and building batteries of the size needed for vehicles
- The list of electric vehicle battery includes batteries with solid, liquid, and gaseous electrolytes; high and ambient temperatures; replaceable metals; and replaceable liquids. At least 20 distinct battery types have been suggested.
- The battery used should have higher voltage, the better the acceleration, and a higher top speed can be achieved, it also depends on the type of motor and the controller used
- 6 V batteries are used because their specific energy is higher. For performance,12 V batteries are used. 12 V batteries are very popular with the newer components being used in cars with 144 V systems. The 8 V battery packs offer a good balance between the range of the 6 V and the acceleration capabilities of the 12 V.

BATTERIES AND CHARGERS

- **Temperature has a direct effect on the performance of a lead-acid battery. The concentration of sulfuric acid inside the battery increases and decreases with temperature. A battery being used in 32°F weather will only operate at 70% of its capacity. Likewise, a battery being used in 110°F weather will operate at 110% of its capacity. The most efficient temperature that battery manufacturers recommend is 78°F. Because the temperature factor is important in colder climates, insulated battery boxes or thermal management systems are used.**

TYPES OF BATTERIES AVAILABLE TODAY

- **Deep-Cycle Lead-Acid**

Most EVs today are fitted with deep-cycle lead-acid batteries The most common makes are Trojan, U.S. Battery, Alco, Deka, Exide, and GNB. Deep-cycle batteries have tall lead plates and are designed for deep discharge cycles. They have a life span of 400 to 800 cycles. Normal batteries, like those used in ICE vehicles, are not suitable for EV use and they will quickly wear out after 30 cycles.

- **Horizon Lead-Acid**

To develop this battery, Electrosource invented a patented process to extrude lead onto fiber-glass filaments that are woven into grids in the battery's electrode plates. The results are greater power capacity, longer life cycle, deep discharge without degeneration, rapid recharge, and high specific energy. These batteries are sealed and maintenance free.

BATTERIES AND CHARGERS

- **Nickel Cadmium/Nickel Iron**

They are more expensive than lead-acid batteries because nickel is costly. Ni-Cd advantages are higher energy density and a cycle life of 1000 charges. Although they can be recharged very quickly, they have a tendency to overheat. Cadmium is highly toxic, so recycling efforts have to be managed very carefully. Ni-Fe batteries have high energy density and are capable of over 1000 deep-discharge cycles before recharging. They need to be 11% overcharged to be charged. The result of the overcharging is water loss and a build-up of hydrogen, which is a safety concern.

- **Nickel-Metal Hydride**

A nickel-metal hydride battery is composed of nontoxic recyclable materials and is environmentally friendly. The NiMH has twice the range and cycle life of today's lead-acid batteries. It is composed of nickel hydroxide and a multicomponent, engineered alloy consisting of vanadium, titanium, nickel, and other metals. It is sealed, is maintenance free, and can be charged as quickly as 15 minutes. It can withstand overcharging and over discharge abuse.

BATTERIES AND CHARGERS

- **Sodium Sulfur**

Sodium sulfur (NaS) batteries are still under development by Ford Motor Company. Ford Ecostars are fitted with these batteries and have a range up to 150 miles per charge. The NaS battery uses a ceramic beta-alumina electrolyte tube with sodium negative electrodes and molten sulfur positive electrodes within a sealed insulated container. Presently, the battery costs 7 times more than lead-acid batteries, The main disadvantage of the NaS battery is the high temperature, which has raised safety hazards. Also, the battery must be charged every 24 hours to keep the sodium and sulfur from solidifying.

- **Sodium Nickel Chloride**

Sodium nickel chloride ($NaNiCl_2$) batteries are under development by AEG Anglo Batteries GmbH (Ulm, Germany). The battery operates at a temperature of 300°C and is claimed by its manufacturer to be safe in accidents and will operate even if one of its cells fails. The battery can be cooled down and reheated without damage; however, no current can be drawn from the battery if the temperature is below 270°C. Costs to produce the battery are very high. BMW and Mercedes Benz are testing EVs with $NaNiCl_2$ batteries.

- **Lithium-Iron**

The lithium-ion battery was predicted to be a long-term battery. The battery is being developed for Nissan by Sony Corporation. The promising aspects of the battery are its low memory effect, high specific energy of 100 Wh/kg, high specific power of 300 W/kg, and a battery life of 1000 cycles. The battery is 28.8 V and consists of eight metal cylindrical cells encased in a resin module.

BATTERIES AND CHARGERS

- **Lithium-Iron**

Each battery has a built-in cell controller to ensure that each cell is operating within a specified voltage range of 2.5 to 4.2 V during charging and discharging. The cell controller communicates with the vehicle's battery controller to optimize power and energy usage. The disadvantages of the lithium-ion battery are its very high cost and the ventilation system required to keep the batteries cool.

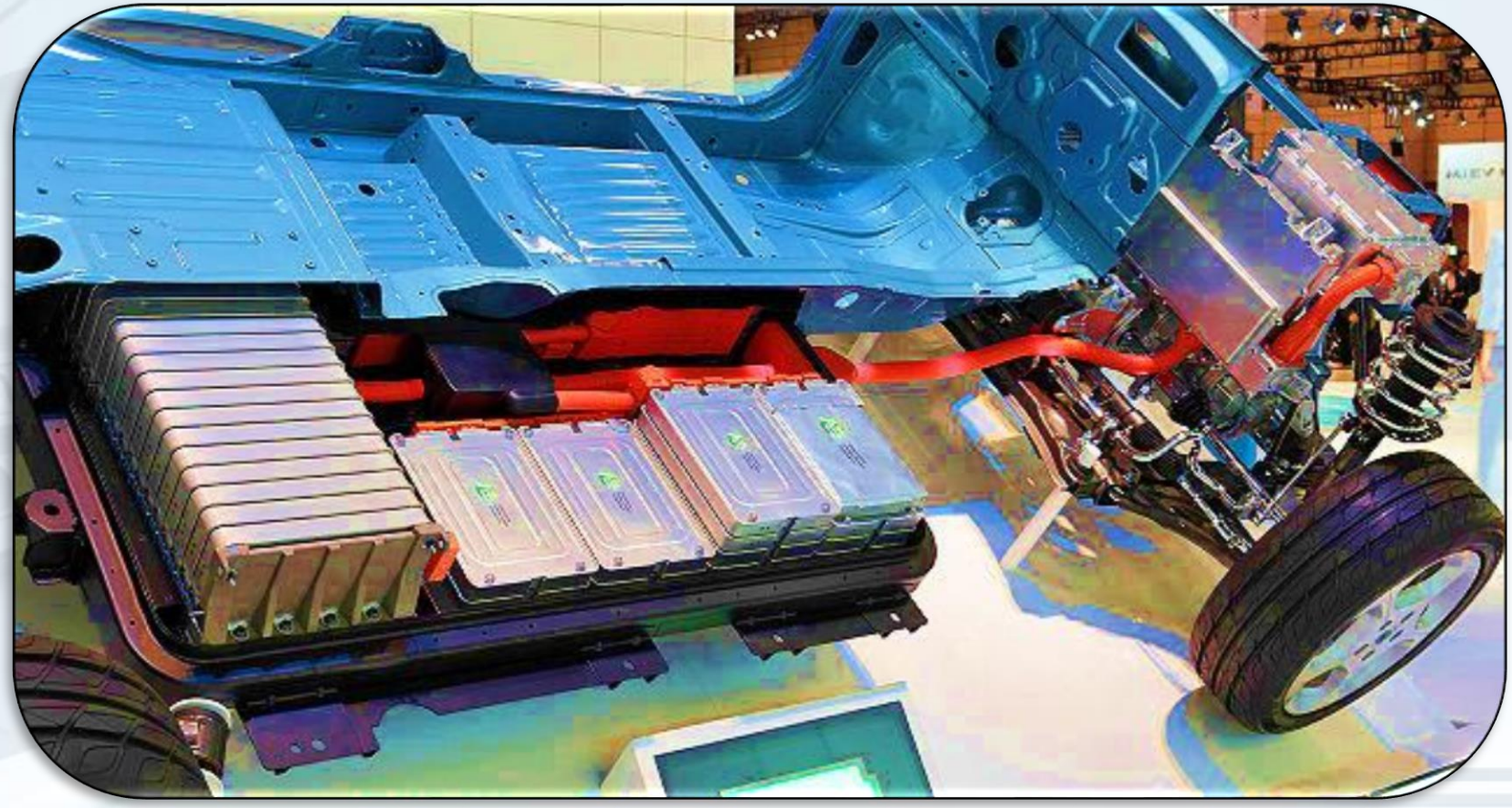
- **Lithium Metal Sulfide**

The lithium metal sulfide battery is an elevated-temperature battery based on a lithium alloy/molten salt/metal-sulfide electrochemical system. This system provides high specific power for better acceleration. Other advantages include its small size, low weight, and low cost per kilowatt hour. The battery is composed of iron disulfide and a lithium- aluminum alloy that is completely recyclable. SAFT America, Cockeysville is currently researching this type of battery.

- **Lithium-Polymer**

The lithium-polymer battery is based on thin film technology. The battery is expected to cost 20% more than lead-acid but deliver twice the energy, with a life span of 50,000 miles. It has an operating temperature between 65 and 120°C. It can be fast charged in less than 90 minutes but can be damaged by overcharging. The major challenge confronting this technology is scaling up its size to properly power an EV.

RECHARGEABLE BATTERIES

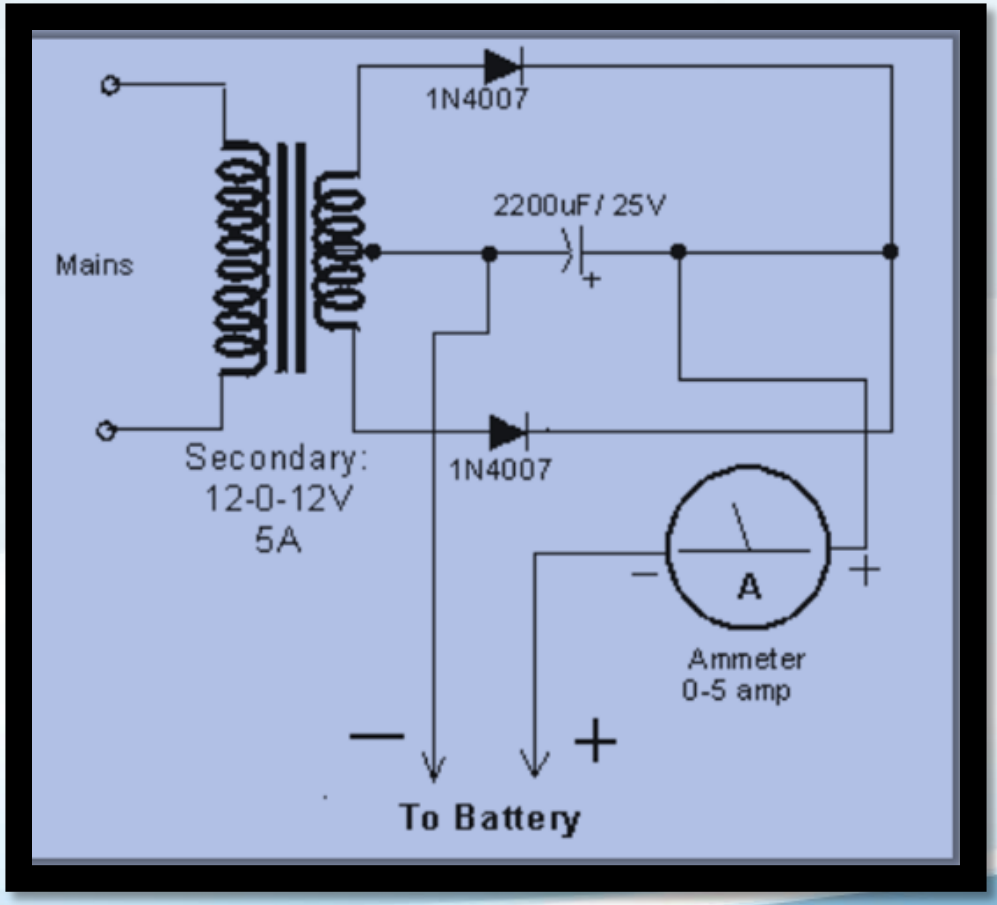


BATTERIES AND CHARGERS

Battery type	Energy/weight Watthours/Kg	Energy/Volume Watt-hours/L	Power/weight Watt/kg	Energy/US$ Watt-hr/$
Lead- acid	30-40	60-75	180	4-10
Nickel – Zinc	60-70	170	900	2-3
Lithium-Ion	160	270	1800	3-5
Lithium-Polymer	130-200	300	2800	3-5

CHARGER WORKING

- Voltage Outlet: 240/120 V AC.
- Battery Requirement: DC Voltage.
- AC to be converted to DC.
- Rectification needed.



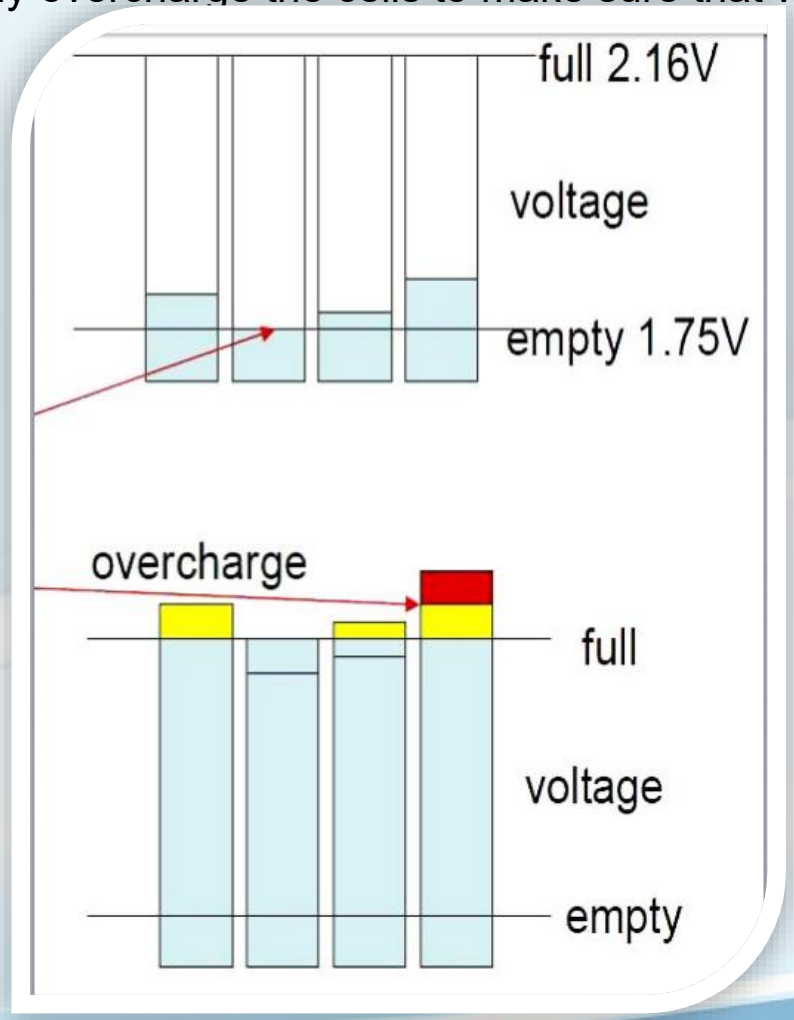
CHARGER WORKING

- A good charger is crucial to EV performance. Early crude chargers simply slugged voltage into the batteries until the charger was turned off. This caused the batteries to gas heavily toward the end of the charge, and it shortened battery life. Later chargers used timers to taper the charge down and shut off. These are better, but still did not fully synchronize with the needs of the batteries. Modern chargers can sense the level of charge in the battery pack, and taper the charging current accordingly. The final, low-current part of the charge cycle serves to equalize the charge in all the batteries.

- There are differences between 220 V and 110 V input chargers. A 220 V will charge the pack faster, but it is bulkier and heavier, not really suitable for on-board mounting. A 110 V charger will charge more slowly, but it is small and light enough to be mounted on-board so the driver can take advantage of opportunity charging anywhere there is 110 V power.

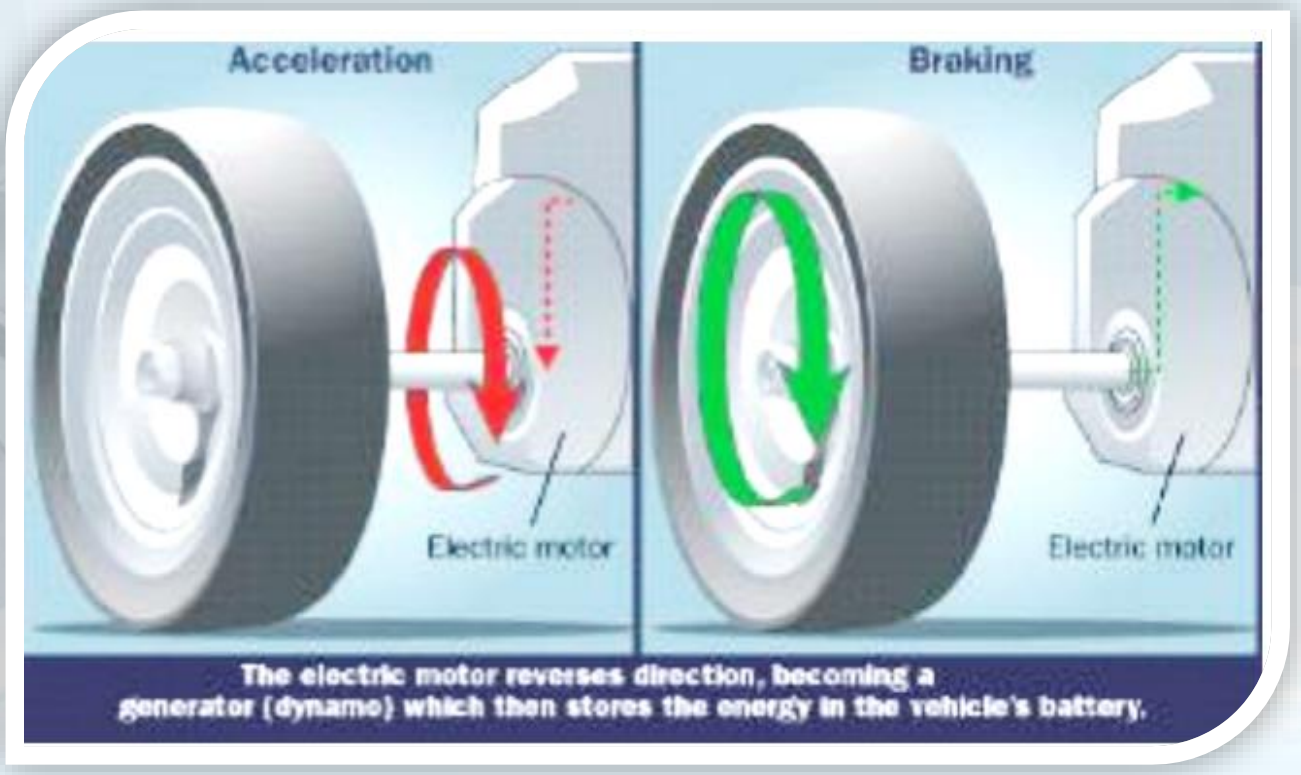
EQUALIZING

- An electric vehicle has a string of batteries, Closely matched but not identical. Weaker batteries need more recharge and Weak battery gets weaker. Solution is “Equalizing”. Gently overcharge the cells to make sure that weakest cells are fully charged.



BRAKING

- Regenerative braking along with conventional friction braking.
- Motor as a generator.
- Recaptures car's kinetic energy and converts it to electricity to recharge the batteries.



CHALLENGES AND FUTURE

- Battery Problems

  Long recharging time - refuelling required only minutes. Battery weight – 100 pound Lead acid batteries = 1 pound of gasoline, Battery costs.
- Range concerns
- Price
- Consumer acceptance
- Market.

THANK YOU

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Are there any Questions?