Unit 1: Automobile Wiring Systems & Cables

1. Explain the parts of vehicle electric system

Ans- The main parts, systems and circuits of the vehicle electrical systems are as follows:

Battery- This unit supplies the electrical energy for vehicle electrical systems, during non-operation of the engine. Also it provides energy for cranking the engine during starting. The battery acts as a storage unit for the electrical energy (Fig. a).

Charging System- After the battery has discharged some of its energy, electrical energy must be supplied to restore its fully charged state. The charging system offers this service and also, provides energy to the complete electrical system at all times during operation of the engine.

Starting System- Instead of the manual cranking of the engine with a starting handle, the electrical starting system makes the engine to start at the touch of a switch.

Ignition System- For operation of the engine each cylinder needs a spark at the appropriate time. To produce a spark a voltage much higher than that given by the battery is necessary. The ignition system transforms the battery voltage to a value often in excess of 20 kV to produce the spark.

Lighting System- For security purposes the vehicle must have different lights to show its presence and also to help the driver to visualize the movement of the vehicle. Bright driving lights must not dazzle the drivers of oncoming vehicles and hence some arrangement is incorporated to dip the main beam.

Auxiliary Equipment- In addition to the main systems, many other auxiliary items is installed in vehicle. These components have been increased over recent years and will continue to expand to improve vehicle operation, driver control and comfort of passengers. The equipment include windscreen wipers and washers, horns, direction indicators and hazard warning systems, heating and ventilation systems, door-locking actuators, electrically-operated windows, electrical seat adjustment, electrical mirrors, electric sun roof operation, electric dipped rear view mirror, rain sensor, air-bag, type pressure warning, cruise control systems, adaptive noise control, vehicle security systems and other instruments.

2. What are connectors?

Ans- Bullet connectors of the soldered and crimped forms are still used to join two or more cables. But more efficient types of connectors are used for greater security and improved protection against the ingress of salt and moisture, specifically when the connector has to handle low currents. Some E-type connectors, illustrated in Fig. e, are environmentally protected types available in 3, 5, 7 and 9 way forms.

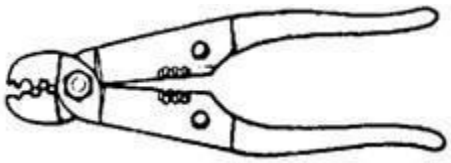


Fig. e. Crimping tool for fitting terminals

The sealing features of these connectors reduce the risk of electrical breakdown even when they are exposed to outside environment.

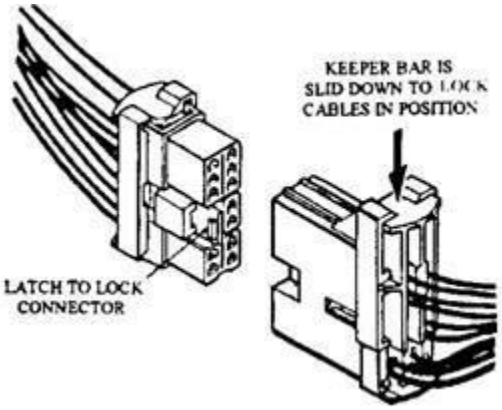


Fig. e. Cable connector.

3. Explain Fuses with its types?

Ans- Fuses are available in different forms as shown in Fig. h. The glass cartridge type is the oldest, which uses a sort length of tinned wire joined at each end to a metal cap and enclosed in a glass cylinder. A strip of paper, colour coded and marked with fuse rating, is placed close to the wire. Different ratings are manufactured to suit the various circuits. If the current exceeds the rating, the fuse 'blows', that is the wire melts, and the circuit is broken. Same fuses, e.g. ceramic type, are rated according to the continuous current that can be carried by the fuse. This current is normally half the current required to melt the fuse. Fuses are either mounted centrally on a fuse board or placed in a separate fuse holder 'in-lined' to protect an auxiliary. Some vehicles install a fusible link in the main output lead from the battery. This heavy duty fuse melts if an accident causes the main cable short to earth.

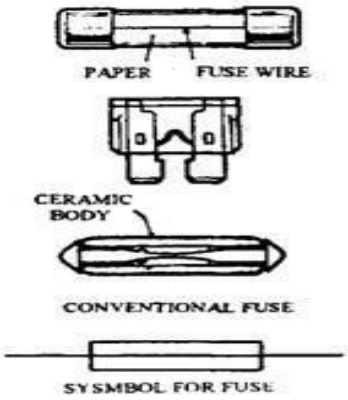


Fig. h. Types of fuses

4. What are vehicle circuits?

Ans- A vehicle's wiring system can be subdivided into a number of simple circuits which are connected in series. Each of these circuits consists of the battery, the electrical components, and its switch including the following three wires or cables.

i. The feed wire which connects one of the battery terminals posts of the switch
ii. The switch wire which connects the switch to the component;
iii. The return wire which connects the component to the second battery terminal post, either directly or indirectly through the frame of the vehicle.

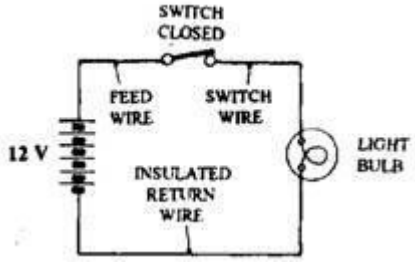


Fig. 1. Insulated-return circuit

In a more elaborate wiring circuit, one switch controls several sub-circuits having two or more components jointed together in series or parallel (Fig. m). In addition, it may have overload fuses. Also one switch may have two 'on' positions, to switch circuits whenever necessary.

5. Draw Diagram of a typical wiring system

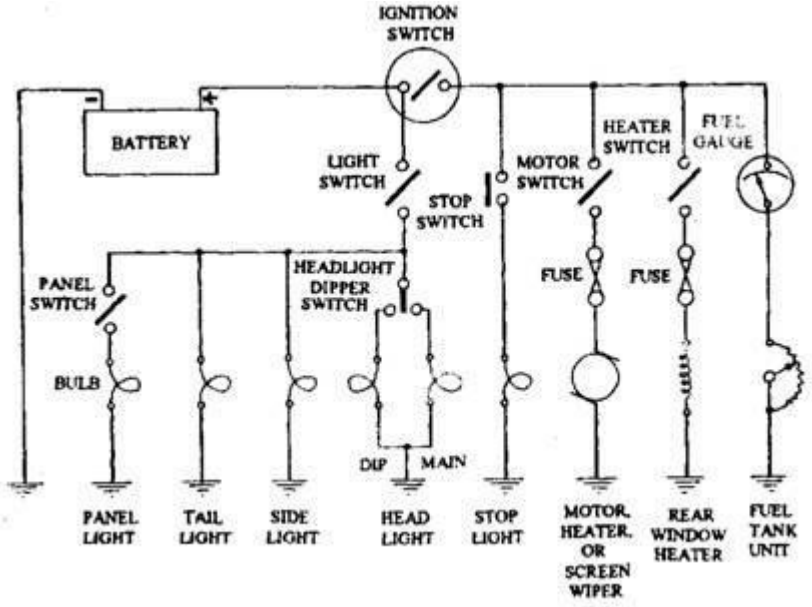


Fig. 1. Basic wiring circuit of vehicle.

6. Explain Multiplex wiring system?

Ans- As the vehicle has incorporated more and more electrical system, the wiring harness servicing the electrical equipment has also increased, both in size and complexity. Since the early 1980s automotive engineers are trying for other methods to switch power to the various circuits around the vehicle, and multiplexing is one such technique.

Repeated use of a wire is the main feature of a multiplex wiring system. Each piece of information (from switches, sensors and ECUs) is converted into a digital (ON-OFF) signal and transmitted serially throughout the system. The techniques is illustrated using a simple example in Fig. i.

The four motors A, B, C and D are operated from four switches. Information on the status of each switch is passed by the sending unit, in a predetermined sequence, along just one transmission line called a data line. The receiving unit decodes the digital data and operates relays or transistor switches, and provides current to the appropriate motor. Since each data is sent many times in every second, the response of the system appears almost instantaneous so far as the driver is concerned, giving a feeling as if the switches were wired directly to the motors. A multiplex system in practice incorporates many sending and receiving units, placed at strategic locations around the vehicle and all connected to the same data bus.

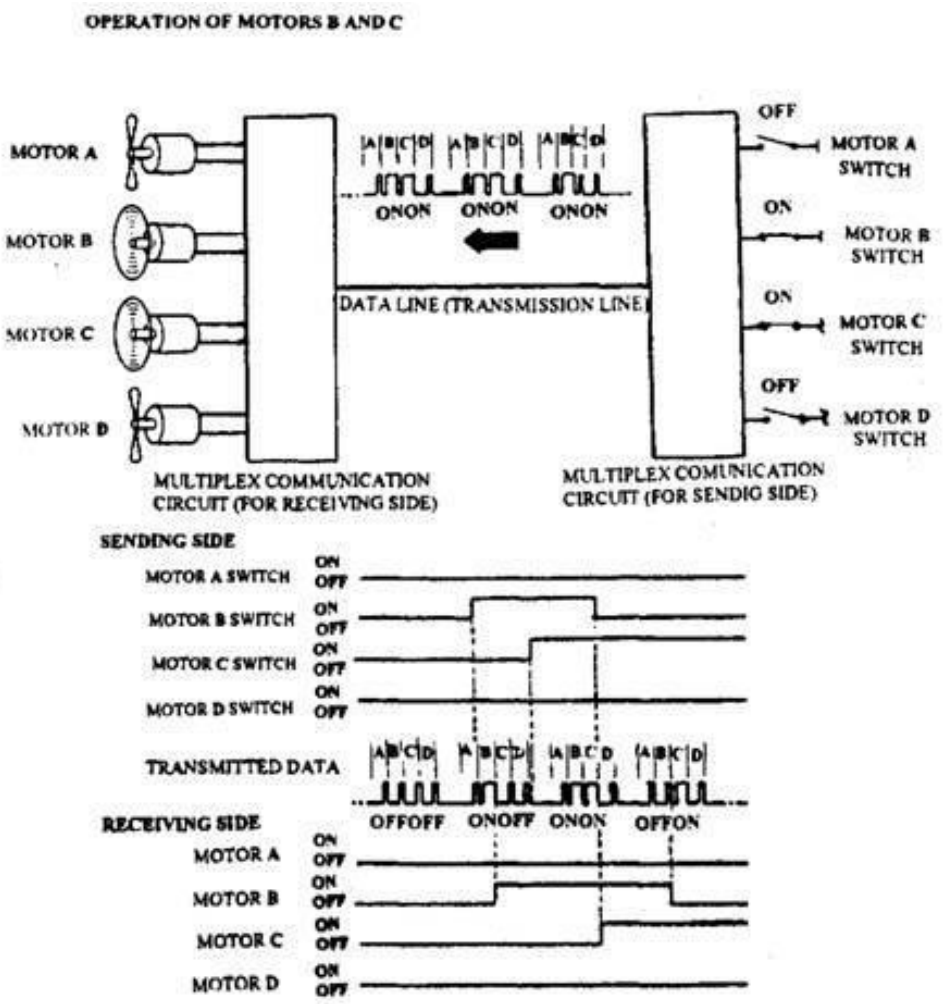


Fig. i. Use of multiplexing to transmit signal information along a single wire

7. State advantages of Multiplex Wiring System

Ans- Multiplex wiring systems have the following advantages over a conventional 'peint'to point' wiring system.

- Multiplex wiring harnesses are smaller and simpler, so that there is a saving on easy and weight.
- It is easy to have automated manufacture of the harness. (Hi) Harness installation on the vehicle assembly track can be much faster.
- A reduction in the number of wires and connectors improves reliability.
- Self-diagnosis features can be incorporated into the AJB electronics, which helps the technician to trace faults.

8. What is CAN (Controller Area Network) and explain its properties?

Ans- CAN is a high speed serial data bus capable of transferring up to 1 million bits of data per second. The engine and chassis control ECUs can be connected to the common CAN bus. The direct mode of

communication between the components makes it possible to reduce the number of sensors and actuators by 'sharing" their information between the various ECUs. It permits to design vehicle electronic systems using ECUs from different suppliers with a minimum of interconnecting wiring. The CAN requires only one sensor for each measurement variable to supply all systems with this signal. However from safety and reliability considerations, two sensors can be incorporated with CAN for double checking of the same measured parameter. CAN provide the following basic properties

- It is a multi-master system, i.e. each ECU can temporarily control the action of all the other ECUs.
- When the bus is not transferring data, any ECU can start to transmit. If two or more ECUs start to transmit at the same time, the ECU having the most important data gains bus access.
- An ECU can direct any other ECU to send data.
- The system is capable of detecting and signaling data transmission errors already occurred. If data is destroyed by errors during transmission, then it is automatically retransmitted.
- The system can distinguish between temporary errors and permanent failures of ECUs. Defective ECUs are automatically switched off.

9. What is insulated return circuit and earth return circuit?

Ans- **Insulated return circuit** -Some vehicle application requires a separate insulated-cable system for both the feed and the return conductors. It is also safer because with separate feed and return cables, it is practically impossible for the cable conductors to short even if chafed and touching any of the metal bodywork, as the body is not live since it is not a part of the electrical circuits. From the safety reasons, an insulated return (Fig. k) is essential for vehicles transporting highly flammable liquids and gases, where a spark could very easily set off an explosion or a fire. The vehicles, such as coaches and double- decker buses use large quantity of plastic paneling. For these vehicles an insulated return is more reliable and safer. The insulated return off course uses extra cable that makes the overall wiring harness heavier, less flexible, and bulky, consequently increases the cost to some extent.

Earth-return circuit- All electrical circuits incorporate both a feed and a return conductor between the battery and the component requiring supply of electrical energy. The vehicle with a metal structure can be used as one of the two conducting paths. This is called as the earth return (Fig. l). A live feed wire cable forms the other conductor. To complete the earth-return path, one end of a short thick cable is bolted to the chassis structure while the other end is attached to one of the battery terminal posts.

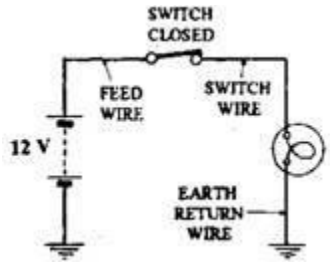


Fig. l. Earth-return circuit

The electrical component is also required to be earthed in a similar way. Only one battery-to-c hassis conductor is necessary for a complete vehicle's wiring system and similarly any number of separate earth-return circuits can be wired. An earth-return system, therefore, reduces and simplifies the amount of wiring so that it is easy to trace electrical faults

10. What is Short circuit and Open circuit?

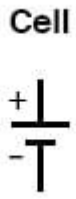
Ans- Open Circuit- When a wiring circuit is not continuous so that no current flows, then the system are called open- circuit. This situation may be normal such as when a switch breaks the circuit or it may be unintentional, due to poor connections, partially broken or connected terminals, or fractured or burnt-out wire. It is usually difficult to find out intermittent unwanted open circuits, which can cause damage to other electrical components. Permanent open circuits are normally easier to find.

Short Circuit- Short circuit occurs in a wiring system when the insulation of a live cable is chafed so that the bare portion of wire either touches some part of the metal earth return, such as the chassis, or is crossed with another exposed piece of wire resulting in a closed circuit with the battery in series. This may cause sparking as the vehicle's body vibrates. Also overheating at the short may take place, which can melt the insulation and expose more bare wire or other electrical connections. The battery also discharges rapidly due to continuous current flow. Eventually the wires may melt together and overload the shorted wiring so that it again overheats and burns through the wire, thereby becoming a potential source of fire hazard. Therefore the wiring circuits on the vehicle are safeguarded by fuses, which blow and prevent further current flow in the event of a short circuit

UNIT II: STORAGE BATTERY

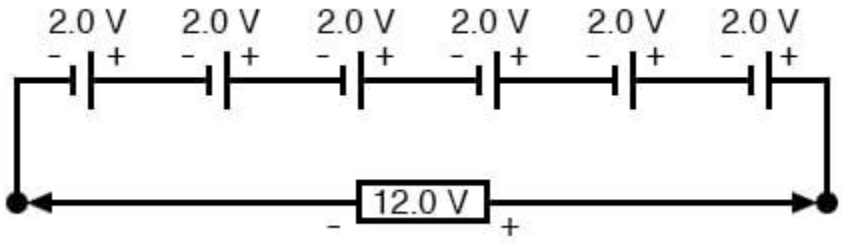
1. Write a short note on the Battery Construction

The symbol for a cell is very simple, consisting of one long line and one short line, parallel to each other, with connecting wires:



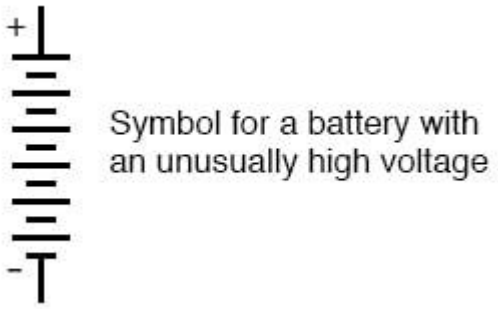
The symbol for a battery is nothing more than a couple of cell symbols stacked in series:

As was stated before, the voltage produced by any particular kind of cell is determined strictly by the chemistry of that cell type. The size of the cell is irrelevant to its voltage. To obtain greater voltage than the output of a single cell, multiple cells must be connected in series. The total voltage of a battery is the sum of all cell voltages. A typical automotive lead-acid battery has six cells, for a nominal voltage output of 6 x 2.0 or 12.0 volts:



The cells in an automotive battery are contained within the same hard rubber housing, connected together with thick, lead bars instead of wires. The electrodes and electrolyte solutions for each cell are contained in separate, partitioned sections of the battery case. In large batteries, the electrodes commonly take the shape of thin metal grids or plates and are often referred to as *plates* instead of electrodes.

For the sake of convenience, battery symbols are usually limited to four lines, alternating long/short, although the real battery it represents may have many more cells than that. On occasion, however, you might come across a symbol for a battery with unusually high voltage, intentionally drawn with extra lines. The lines, of course, are representative of the individual cell plates:



2. Explain Different types of Batteries

Classification/ Type of batteries given below :

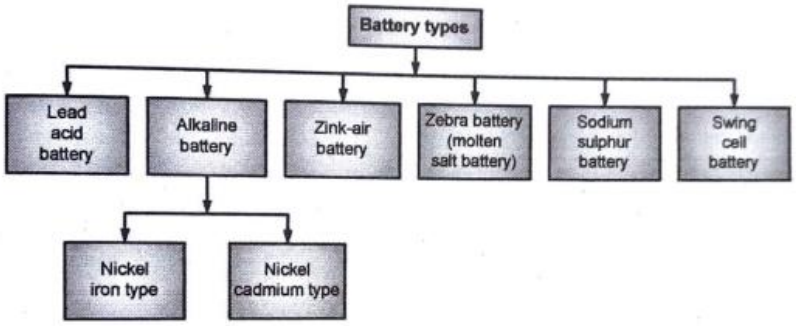


Fig. 7.3.1 : Battery Types

1) Lead Acid Battery
2) Alkaline Battery
   (i) Nickel iron type
   (ii) Nickel cadmium type
3) Zinc-Air Battery
4) ZEBRA Battery (Molten salt Battery)
5) Sodium Sulphur Battery
6) Swing Cell Battery

3. What is a Lead Acid Battery?

It is the first type of rechargeable battery ever created. Compared to modern rechargeable batteries, lead–acid batteries have relatively low energy density. Despite this, their ability to supply high surge currents. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by starter motors. Lead-acid batteries suffer from relatively short cycle lifespan (usually less than 500 deep cycles) and overall lifespan, as well as slow or long charging time

Discharge

A lead-acid cell with two lead sulfate plates.

Fully discharged: two identical lead sulfate plates and diluted sulfuric acid solution

In the discharged state both the positive and negative plates become lead(II) sulfate ($PbSO_4$), and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water.

Negative plate reaction

$Pb(s) + HSO{-}4(aq) \rightarrow PbSO4(s) + H+(aq) + 2e-$

In the fully charged state, the negative plate consists of lead, and the positive plate is lead dioxide. The electrolyte solution has a higher concentration of aqueous sulfuric acid, which stores most of the chemical energy. Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which bubbles out and is lost. The design of some types of lead–acid batteries allows the electrolyte level to be inspected and topped up with pure water to replace any that has been lost this way.

4. What are the batteries' maintenance and care?

1. Keep the battery top clean. Use a stiff bristle brush, being careful not to scatter the corrosive particles with the bristles.

2. You can wipe off battery tops with a cloth moistened with water and ammonia or baking soda solution.

3. Do not clean with solvents.

4. Replace cables with broken or corroded strands. It takes a complete cable to transfer full voltage.

5. Clean both the terminals and battery cable ends with a wire brush, whenever they are disconnected, to remove any corrosion. Coat surfaces with mineral grease or vaseline after clamp terminals are tightened.

6. Keep battery cradles operable and hold-downs tight.

7. Make periodic hydrometer tests. A failing battery can be detected before the situation becomes critical.

8. Keep the water level up, but, avoid overfilling. The excess may be forced out later along with acid and do serious damage to adjacent components.

9. Normally battery water is distilled water, but it may be drinking water that is free of minerals. Even slightly impure water is better than no water.

10. Adding water to a cell will lower the specific gravity of the electrolyte, but, this does not mean that the cell has lost any of its charge. Make your hydrometer test later.

11. Watch for batteries that require excessive water. That need may be an indication of a charging system out of adjustment and you may be subjecting your battery to the damaging effect of overcharging.

5. Explain High Rate Discharge Test Machine

High Rate Discharge test is a vital quality test to ensure the reliability of batteries. An electrical load test after formation charging is essential to assure performance and quality by discharging the battery at a high current for a short time period. The machine is equipped with a reject station as standard.

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- For automotive batteries from 36Ah to 240Ah
- Automatic high-rate discharge test for automotive batteries
- Easy battery centering and positioning system with pre-adjusted fixtures
- Reject station for failed batteries
- Water Cooling system for testing cables
- Protection against over current, overheat
- Enclosure IP 20

6. Explain Battery Discharging Battery Charging

Discharging or charging is always occurring inside a battery at any given time. The electrolyte solution contains charged ions, made up of sulfate and hydrogen. The sulfate ions are negatively charged, while the hydrogen ions have a positive charge. When an electrical load is placed across a battery's terminals (starter motor, headlight, etc.) the sulphuric acid breaks down, the resulting sulphate ions travel to the negative plates and react with the plate's active material giving up their negative charge through ionization. This causes the battery to discharge or produce electrical energy. This excess electron flow out of the negative side of the battery, through the electrical device, and back to the positive side of the battery is what creates DC current. Once the electrons arrive back at the positive battery terminal, they travel back into the cells and re-attach themselves to the positive plates. The discharge process continues until the battery is discharged and there is no more chemical energy left.

Battery Charging Chemistry

Charging a battery reverses the chemical process that occurs during discharge. The sulfate and hydrogen ions basically switch places. The electrical energy used to charge a battery is converted back to chemical energy and stored inside the battery. Battery chargers, including alternators and generators, produce a higher voltage than the battery's open circuit voltage.

When charging amperage exceeds the level of the natural absorption rate, the battery may overheat, causing the electrolyte solution to bubble creating flammable hydrogen gas. Hydrogen gas, when combined with oxygen from the air, is highly explosive and can easily be ignited by a spark.

7. What is the charging system of a vehicle?

The charging system keeps a charge in your battery and provides electrical energy for the radio, lights, and other features while the car is running. The modern charging system consists of the alternator, battery, wiring, and electronic control unit (ECU) its main parts are the battery, alternator, and voltage regulator. If any parts of the charging system are worn, a vehicle will be hard to start or may not start at all. The battery stores the power that initially starts the engine, and the alternator generates the electricity that's stored in the battery.

A battery charger consists of a rectifier circuit, power circuit, ripple monitoring, control circuit, regulator circuit, and fault detection circuit. This charger can also be used as a DC source for a control and protection circuit of a substation during normal operation, or to charge the battery in floating mode. When discussing car battery voltage, we're generally talking about a 12-volt battery. When we take a closer look, we see car battery voltage can range anywhere from 12.6 to 14.4. With the engine off, the fully charged car battery voltage will measure 12.6 volts.

The 3 functions of the charging system: - it supplies all the vehicles 12-volt electricity when the engine is running. - It provides a 13-15v output, which is slightly higher than a fully charged battery @12.6v. - It changes current and volume output to meet different electrical loads.

8. What are the battery-selection criteria for low-power design?

A battery is an electrochemical device that can store energy in the form of chemical energy. It translates to electric energy when the battery is connected in a circuit due to the flow of electrons because of the specific placement of chemicals.

1. Nominal Voltage: Voltage of a fully charged cell across the positive and negative terminals of the battery.
2. Energy/Battery Capacity: The energy stored in a battery is called the battery capacity.

3. Energy Density: The energy density is the measure of how much energy a battery contains in proportion to its weight. Higher the energy density of the battery, the more costly the battery technology is.
4. Self-Discharge Rate: Batteries do not last forever. Even if they remain unused, electrochemical reactions are still taking place, slowly draining the battery naturally. This process is called the self-discharge rate.
5. Shelf Life: Battery shelf life is the length of time a battery can remain in storage without losing its capacity.
6. Battery Life: It is the run time on a full charge battery in mAh.

9. Give different current Batteries in India

1. Amara Raja Batteries

Amara Raja Batteries is India's second-largest automotive battery manufacturer. The company has recently set up India's maiden technology hub to develop lithium-ion cells, at its Tirupati facility in Andhra Pradesh. Amara Raja has invested Rs 200 m into the hub.

2. Exide Industries

Exide Industries is primarily engaged in the manufacturing of storage batteries and allied products in India. The company is the leading storage battery manufacturer in India with a leader in almost all categories such as automotive, industrial, and submarine. The company has recently invested Rs 331.7 m (US$ 4.5 m) in its subsidiary Exide Leclanche Energy and increased its stake from 77.9% to 80.2%.

3. Tata Group - Tata Power/Tata Chemicals

Tata Power is an Indian electric utility company and is part of the Tata Group. The core business of the company is to generate, transmit, and distribute electricity. The company is building an ecosystem for EVs with the support of group companies - Tata Chemicals and Tata Motors. Tata Power will bring in the know-how while Tata Chemicals will provide battery technology.

4. Hero MotoCorp

Hero MotoCorp, formerly Hero Honda, is the largest two-wheeler manufacturer in India and the world. The company has a toe-hold in the domestic electric vehicle (EV) segment with a roughly 34.6% stake in EV start-up Ather Energy.

5. Maruti Suzuki

Maruti Suzuki is a subsidiary of the Japanese automotive manufacturer Suzuki. The company sells hatchbacks, sedans, motor utility vehicles (MUVs), and sport utility vehicles (SUVs) in India. The company plans to procure lithium-ion battery packs from a newly formed joint venture (JV) with Toshiba and Denso as it looks to build a portfolio of hybrid cars.

10. Explain Lithium Batteries

A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible reduction of lithium ions to store energy. The negative electrode of a conventional lithium-ion cell is typically graphite, a form of carbon. This negative electrode is sometimes called the anode as it acts as an anode during discharge. The positive electrode is typically a metal oxide and is sometimes called the cathode as it acts as a cathode during discharge. Positive and negative electrodes remain positive and negative in normal use whether charging or discharging and therefore are clearer terms than anode and cathode, which are reversed during charging**.** Li-ion is the predominant battery type used in portable consumer electronics and electric vehicles. It also sees significant use for grid-scale energy storage and military and aerospace applications. Compared to other rechargeable battery technologies, Li-ion batteries have high energy density, low self-discharge, and no memory effect (although a small memory effect reported in lithium iron phosphate batteries has been traced to poorly made cells). Lithium-ion batteries can be a safety hazard if not properly engineered and manufactured, because cells have flammable electrolytes and if damaged or incorrectly charged, can lead to explosions and fires. Much progress has been made in the development and manufacturing of safe lithium-ion batteries.

11. State advantages and disadvantages of Lithium-ion battery

There are many advantages to using a li-ion cell of battery. As a result the technology is being used increasingly for a huge number of widely varying applications. Everything from small electronic devices, through smartphones and laptops to vehicles and many other applications.

- High energy density: The high energy density is one of the chief advantages of lithium ion battery technology. With electronic equipment such as mobile phones needing to operate longer between charges while still consuming more power, there is always a need to batteries with a much higher energy density.
- Self-discharge: One issue with many rechargeable batteries is the self discharge rate. Lithium ion cells is that their rate of self-discharge is much lower than that of other rechargeable cells such as Ni-Cad and NiMH forms. It is typically around 5% in the first 4 hours after being charged but then falls to a figure of around 1 or 2% per month.
- Low maintenance

Disadvantages:

- Protection/battery management system required: Lithium-ion cells and batteries are not as robust as some other rechargeable technologies. They require protection from being overcharged and discharged too far. In addition to this, they need to have the current maintained within safe limits.
- Ageing: One of the major lithium ion battery disadvantages for consumer electronics is that lithium ion batteries suffer from ageing. Not only is this time or calendar dependent, but it is also dependent upon the number of charge discharge cycles that the battery has undergone.
- Transportation: This li-ion battery disadvantage has come to the fore in recent years. Many airlines limit the number of lithium ion batteries they take, and this means their transportation is limited to ships.
- Cost: A major lithium ion battery disadvantage is their cost. Typically they are around 40% more costly to manufacture than Nickel cadmium cells. This is a major factor when considering their use in mass produced consumer items where any additional costs are a major issue