UNIT-I Automobile electrical and electronics

Electrical components in automobile

Automobile electrical system has gradually evolved over the years and today it assimilates automatic computer control of the automotive mechanics. In the early days, automobiles electrical system comprised of only basic wiring technologies that were used for distributing power to other parts of a vehicle. It had only switches, wires, relays and controlled motors as its key components but today's electrical system includes sensors, actuators, alternators, battery, oxygen sensors, generator, starter solenoid, starter drive, high power electrical system and other devices.

Components of automobile electrical system

1. armature
2. automobile battery
3. automobile ignition system
4. automobile starting system:
5. automotive computer chips
6. automotive electrical wiring:
7. charging system
8. spark plugs

Armature: Armatures are the moving parts of an electric machine generally alternators, generator or motors of a vehicle, which vibrates when electromotive force is produced. The armature used in automobile comprises of a series of coils and groups of insulated conductors circumscribed around a core of iron. Also known as the rotating part of a dynamo, armatures are generally fixed on ball bearings and are mostly made of copper wire coiled around an iron core.

The major functions of armature are:

1. produce an electromotive force.
2. to transmit current in a rotating machines and force in a linear Machine.

Automobile battery:

Automobile battery refers to an electrochemical device comprising of primary and secondary cells that are used for transforming chemical energy into mechanical energy.

Most of the vehicles today uses 'lead acid' batteries. Batteries are mostly of two types i.e. Non-rechargeable and rechargeable. Often called as disposable batteries, non-rechargeable batteries are used once and then dumped. While rechargeable batteries are those devices that can be easily recharged by applying electrical current that turns or reverses a chemical reaction. A normal battery has an initial voltage of about 1.6 volts and produces between 500-1000 amps. The market size of automobile battery industry is worth us $ 48 billion a year. China, hong kong, united states, india and taiwan are the major battery manufacturing countries on the global platform.

Automobile ignition system:

Automobile ignition system constitute of various devices, tools and components that are used for igniting the fuel in an internal combustion engine of a vehicle. In this system, electric current is used for burning the mixture of air and fuel with the help of coil, battery, and spark plug. Ignition system is assembled in only those automobile engines, which operates with the help of petrol or gasoline. The two main functions of automobile ignition system are to produce enough voltage so that it can easily create a spark for burning air/fuel mixture and secondly it exercises control over the timing of spark and transmit it to the apt cylinder. A typical automobile ignition system produces voltage somewhere between 20000 volts and 50000 volts from a 12-volt source. Automobile ignition system can be further classified into three main heads such as mechanical

Major components used in automobile ignition systems are

: coil wires

ignition distributor

magneto ignition

coil parts electronic timing controllers ignition box ignition

switch ignition

coils ignition controller magneto.

Automobile starting system:

Automobile starting system is considered to be the heart of automobile electrical system. The starting system of an automobile includes those devices, which are used for initiating an engine of a vehicle. Once the key is put into the ignition switch then the current pass through battery cables to starter motor. After this, starter motor turn the engine and the downward moving piston create suction where air and fuel mixture is burned and then the engine starts.

Charging system:

The charging system of an automobile has three basic components such as alternator, regulator, and the interconnecting wiring. The main function of automobile charging system is to control and regulate the charge in the battery of a vehicle. Automobile charging system generally generates a voltage between 13.5 and 14.4 volts when the engine is working. It produces electrical current for operating automobile lights, music systems, heater, engine electrical system and other electrical components.

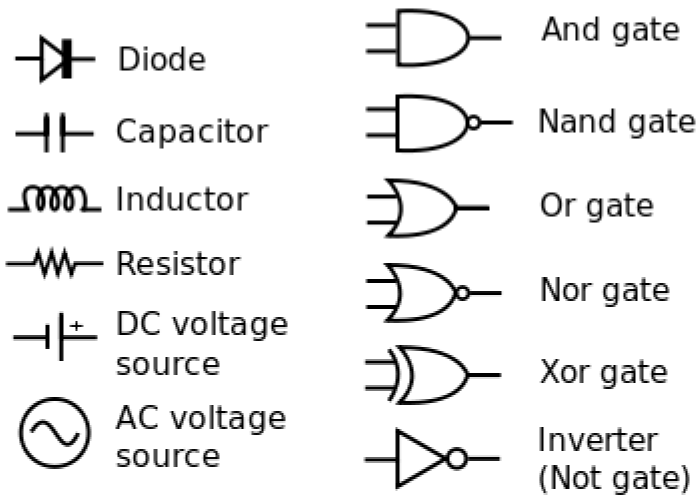
Automotive electrical wiring:

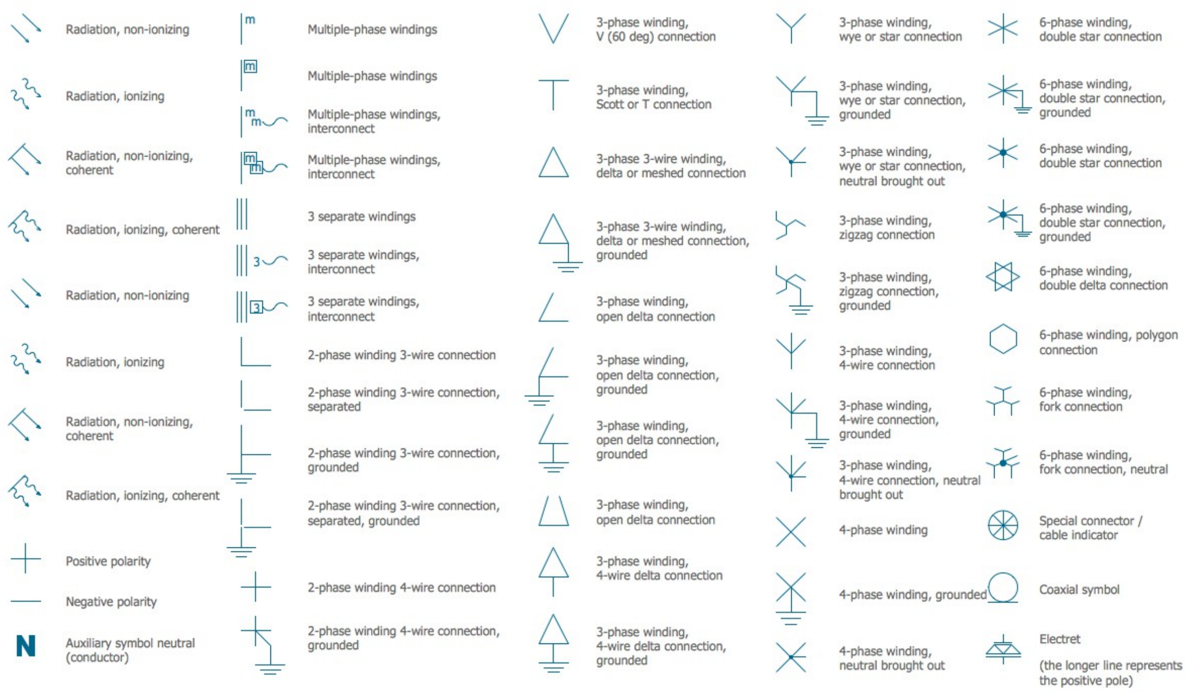
The electrical wiring system of an automobile incorporate different types of devices, flexible electrical wires, electrical fuses, connectors, fuse blocks used for fastening one end of an automobile component to the power source device. These electrical wiring components are used for bearing mechanical loads and transmitting communication signals or electrical energy.

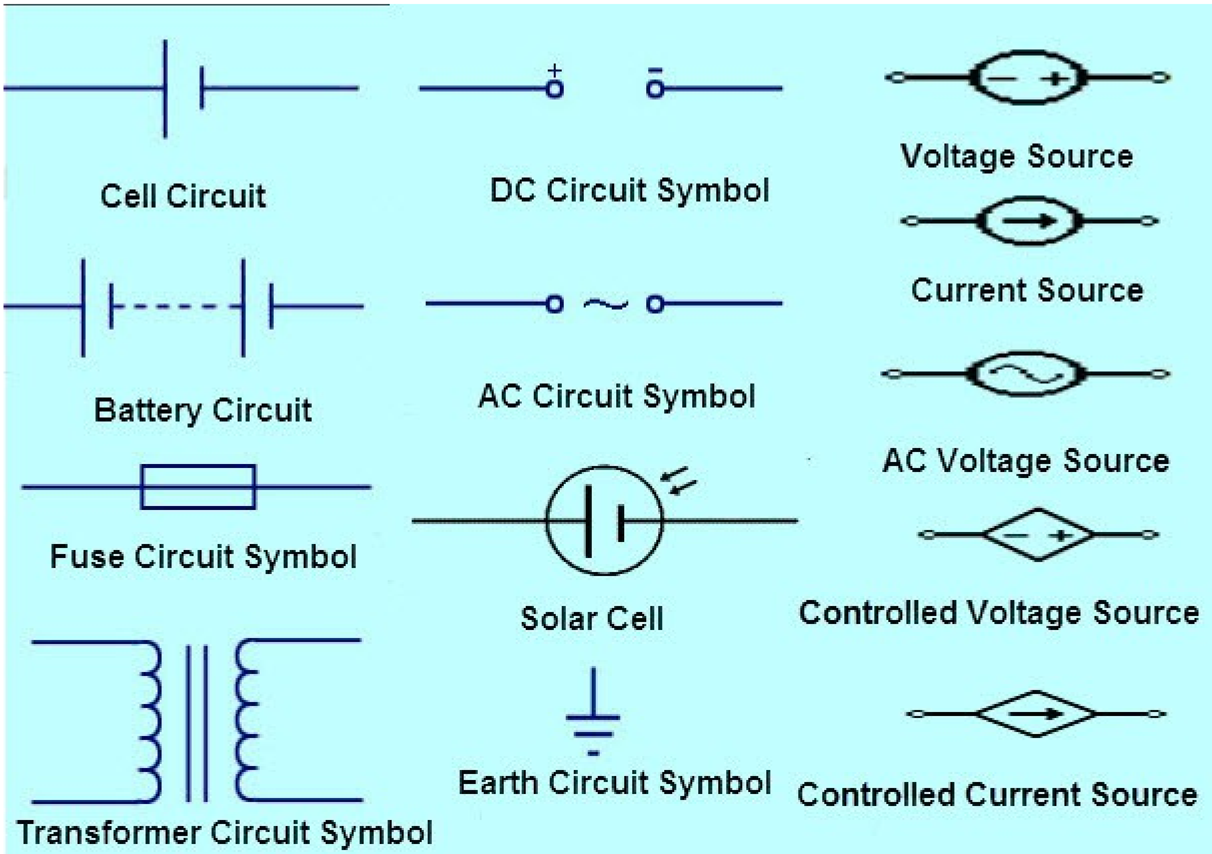
ELECTRICAL AND ELECTRONICS COMPONENTS:

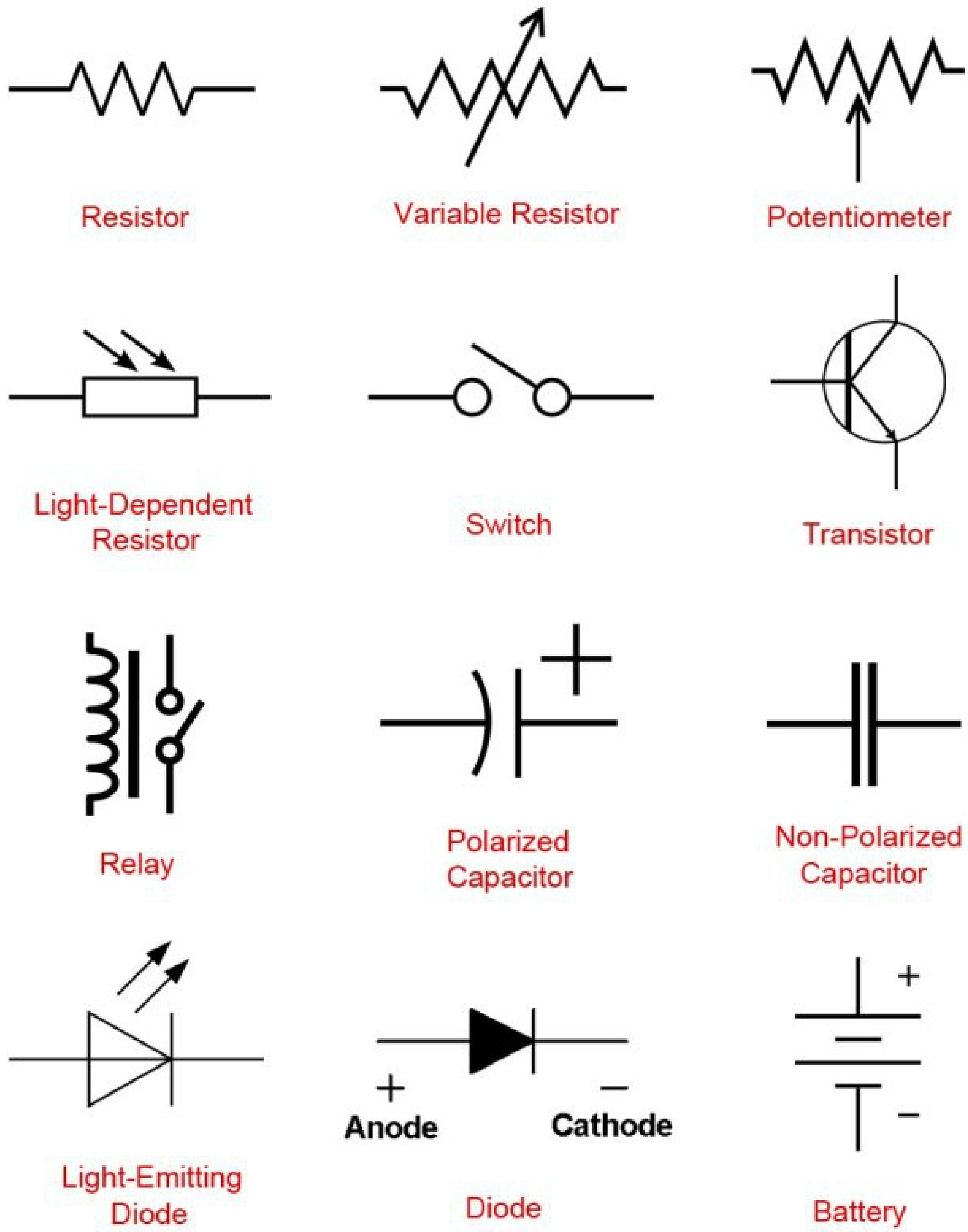
An electronic component is any basic discrete device or physical entity in an electronic systemused to affect electrons or their associated fields. Electronic components are mostly industrial products, available in a singular form and are not to be confused with electrical elements, which are conceptual abstractions representing idealized electronic components.

Electronic components have a number of electrical terminals or leads. These leads connect to create an electronic circuit with a particular function (for example an amplifier, radio receiver, or oscillator). Basic electronic components may be packaged discretely, as arrays or networks of like components, or integrated inside of packages such as semiconductor integrated circuits, hybrid integrated circuits, or thick film devices. The following list of electronic components focuses on the discrete version of these components, treating such packages as components in their owner right.


Diode
Capacitor
Inductor
Resistor
DC voltage source
AC voltage source
And gate
Nand gate
Or gate
Nor gate
Xor gate
Inverter (Not gate)


Radiation, non-ionizing
Radiation, ionizing
Radiation, non-ionizing, coherent
Radiation, ionizing, coherent
Radiation, non-ionizing
Radiation, ionizing
Radiation, non-ionizing, coherent
Radiation, ionizing, coherent
Positive polarity
Negative polarity
N
Auxiliary symbol neutral (conductor)
Multiple-phase windings
Multiple-phase windings
Multiple-phase windings, interconnect
Multiple-phase windings, interconnect
3 separate windings
3 separate windings, interconnect
3 separate windings, interconnect
2-phase winding 3-wire connection
2-phase winding 3-wire connection, separated
2-phase winding 3-wire connection, grounded
2-phase winding 3-wire connection, separated, grounded
2-phase winding 4-wire connection
2-phase winding 4-wire connection, grounded
3-phase winding, V (60 deg) connection
3-phase winding, Scott or T connection
3-phase 3-wire winding, delta or meshed connection
3-phase 3-wire winding, delta or meshed connection, grounded
3-phase winding, open delta connection
3-phase winding, open delta connection, grounded
3-phase winding, open delta connection, grounded
3-phase winding, open delta connection
3-phase winding, 4-wire delta connection
3-phase winding, 4-wire delta connection, grounded
3-phase winding, wye or star connection
3-phase winding, wye or star connection, grounded
3-phase winding, wye or star connection, neutral brought out
3-phase winding, zigzag connection
3-phase winding, zigzag connection, grounded
3-phase winding, 4-wire connection
3-phase winding, 4-wire connection, grounded
3-phase winding, 4-wire connection, neutral brought out
4-phase winding
4-phase winding, grounded
4-phase winding, neutral brought out
6-phase winding, double star connection
6-phase winding, double star connection, grounded
6-phase winding, double star connection
6-phase winding, double star connection, grounded
6-phase winding, double delta connection
6-phase winding, polygon connection
6-phase winding, fork connection
6-phase winding, fork connection, neutral
Special connector / cable indicator
Coaxial symbol
Electret
(the longer line represents the positive pole)


Cell Circuit
DC Circuit Symbol
Voltage Source
Current Source
Battery Circuit
AC Circuit Symbol
AC Voltage Source
Fuse Circuit Symbol
Solar Cell
Controlled Voltage Source
Transformer Circuit Symbol
Earth Circuit Symbol
Controlled Current Source



WIRING HARNESS:

What Is A Wiring Harness?

The wiring harness has been our core business since 1987. Sumitomo Electric Wiring Systems designs and manufactures the highest quality and most reliable wiring harness products for the automotive industry.

A wiring harness is an organized set of wires, terminals and connectors that run throughout the entire vehicle and relay information and electric power, thereby playing a critical role in "connecting" a variety of components. Power and information travel through this network much like the circulatory and central nervous systems of the human body.

As cars continue to provide advanced functions, their component parts increasingly require electronics to save space and meet other requirements. Experts at efficient design and configuring complex circuits, SEWS creates wiring harnesses that contribute tremendously to the development and advancement of car manufacturers around the world.

Wiring Harness Components

A close look at a typical wiring harness will reveal a network of electric wires, connectors, terminals, clamps, tape, convoluted tubes, and sheaths.


Electric Wire for Automobiles

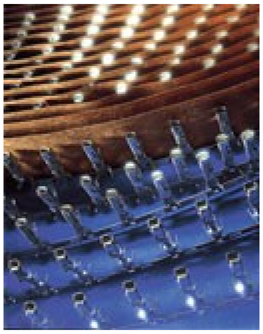
Wiring harnesses consist of various wires bundled together, with each individual wire responsible for carrying the electric signals and energy used in starting the engine, lights, meters, navigation systems, power windows and doors, and other devices in the vehicle.

There are many different types of wire used in a wiring harness. Some varieties are more flexible, more heat resistant or more cold resistant, and others can be smaller for easier routing or larger for products requiring more current.

Not only does SEWS use these various wires in the construction of wiring harnesses, but we also manufacture the wire we use. This is another important factor in helping us ensure the very best quality in all of our wiring harness products.


Connectors

In their role of connecting wires and cables within an automobile, connectors must function in environments with extreme temperature variations, vibrations, water, electromagnetic interference, and other conditions. With the increased use of information technology, we have developed a variety of connectors and other components that connect wires to GPS, TV, and other wave receiving devices in today's automobiles.


Terminals

Terminals are the current-carrying connection points between the wires and the features in the automobile. Made of a variety of metals, these parts can be coated differently to meet a number of conditions.

Low Voltage / Tension (LT) Cables are normally1KV Tested Cables for400/600 Volt Operation.

Medium Voltage / Tension (MV) Cables are normally for50KV Tested Cables for Operation from3.3KV to33KV

All above50KV range Cables are HT & EHT Cables.

The lead–acid battery was invented in 1859 by French physicist Gaston Planté and is the oldest type of rechargeable battery. Despite having a very low energy-to-weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make them attractive for use in motor vehicles to provide the high current required by automobile starter motors.

As they are inexpensive compared to newer technologies, lead–acid batteries are widely used even when surge current is not important and other designs could provide higher energy densities. Large-format lead–acid designs are widely used for storage in backup power supplies in cell phone towers, high-availability settings like hospitals, and stand-alone power systems. For these roles, modified versions of the standard cell may be used to improve storage times and reduce maintenance requirements. Gel-cells and absorbed glass-mat batteries are common in these roles, collectively known as VRLA (valve-regulated lead–acid) batteries.

In 1999 lead–acid battery sales accounted for 40–45% of the value from batteries sold worldwide excluding China and Russia, and a manufacturing market value of about $15 billion.

UNIT-2

Discharge

Fully discharged: two identical lead sulfate plates

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. The discharge process is driven by the conduction of electrons from the negative plate back into the cell at the positive plate in the external circuit.

Negative plate reaction

$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + H^+(aq) + 2e^-$ Release of two conducting electrons gives lead electrode a net negative charge

As electrons accumulate they create an electric field which attracts hydrogen ions and repels sulfate ions, leading to a double-layer near the surface. The hydrogen ions screen the charged electrode from the solution which limits further reactions unless charge is allowed to flow out of electrode.

Positive plate reaction

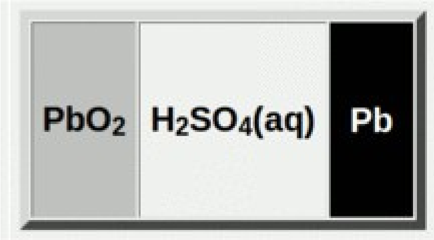
$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$

The total reaction can be written as

$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

The sum of the molecular masses of the reactants is 642.6 g/mol, so theoretically a cell can produce two faradays of charge (192,971 coulombs) from 642.6 g of reactants, or 83.4 ampere-hours per kilogram (or 13.9 ampere-hours per kilogram for a 12-volt battery). For a 2 volts cell, this comes to 167 watt-hours per kilogram of reactants, but a lead–acid cell in practice gives only 30–40 watt-hours per kilogram of battery, due to the mass of the water and other constituent parts.

Charging



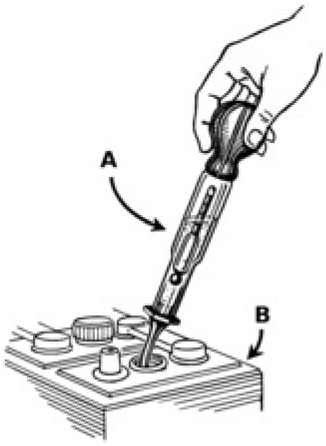
Fully recharged: Lead negative plate, Lead dioxide positive plate and sulfuric acid electrolyte

In the fully charged state, the negative plate consists of lead, and the positive plate lead dioxide, with the electrolyte of concentrated sulfuric acid.

Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which is lost to the cell. The design of some types of lead-acid battery allow the electrolyte level to be inspected and topped up with any water that has been lost.

Due to the freezing-point depression of the electrolyte, as the battery discharges and the concentration of sulfuric acid decreases, the electrolyte is more likely to freeze during winter weather when discharged.

Measuring the charge level[edit]



A hydrometer can be used to test the specific gravity of each cell as a measure of its state of charge.

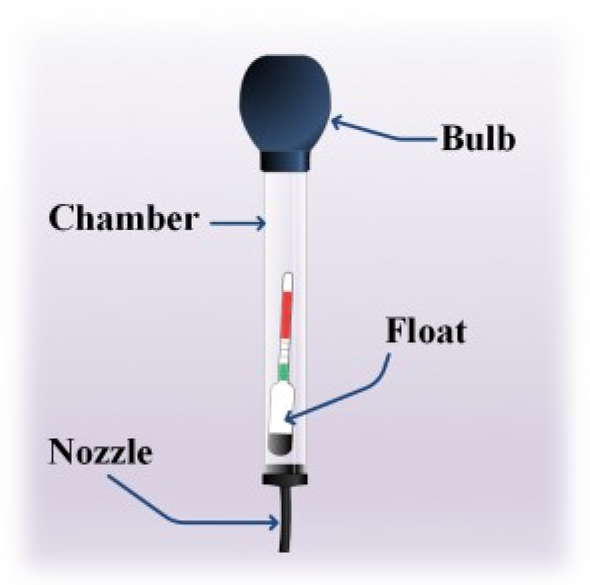
Because the electrolyte takes part in the charge-discharge reaction, this battery has one major advantage over other chemistries. It is relatively simple to determine the state of charge by merely measuring the specific gravity of the electrolyte; the specific gravity falls as the battery discharges. Some battery designs include a simple hydrometer using colored floating balls of differing density. When used in diesel-electric submarines, the specific gravity was regularly measured and written on a blackboard in the control room to indicate how much longer the boat could remain submerged.

The battery's open-circuit voltage can also be used to gauge the state of charge. If the connections to the individual cells are accessible, then the state of charge of each cell can be determined which can provide a guide as to the state of health of the battery as a whole, otherwise the overall battery voltage may be assessed.

Note that neither technique gives any indication of charge capacity, only charge level. Charge capacity of any rechargeable battery will decline with age and usage, meaning that it may no longer be fit for the intended purpose even when nominally fully charged. Other tests, usually involving current drain, are used to determine the residual charge capacity of a battery.

HOW TO CHECK A BATTERY WITH A HYDROMETER

Step by Step Hydrometer Procedure



If you’ve ever used an eyedropper, you are capable of using a hydrometer to test your battery state of charge.

The picture to your right shows the basic parts to a hydrometer. You will want to familiarize yourself with these parts so that you understand this procedure.

Types of Tests

There are basically two types of tests. Choose the type you're going to run.

The first type is one where you charge the battery to see if all cells accept a full charge.

The second is where you allow the battery to become discharged and make your measurement at that point. This allows you to see if one or two cells are discharging faster than the others. This is a fairly good test to see if a cell has lost capacity.

Preliminary Steps

You're about to determine whether an expensive item is good or bad. Make a mistake, and you will be forking out money for something you didn't need. You're also about to do something that can be risky to your health. Do pay attention to step one. If you're going to be a cowboy, at least do so with your eyes wide open.

Charge or discharge your battery

Disconnect your battery to ensure that it is not under load (being drained by a device connected to it). Disconnecting the negative lead is often the smartest and best way of doing this.

Allow your battery sufficient time to settle while disconnected. Twenty four hours is generally the most conservative and best approach. Otherwise, an overnight rest will usually do.

Make your measurements between temperatures between 60 and 80 degrees F. Temperature affects the specific gravity of the measurement. Getting much beyond this range could give you some pretty crazy results.

Do you test in an area that has good ventilation and running water. The battery fumes are dangerous. The running water will be used if you accidentally get the acid onto skin or into your eyes. If you do so, flush with the water generously

Materials Required

Step 1 – Put on Goggles and Gloves… Have Some Baking Soda Around

Acid burns. Acid blinds. Asking you to be safe is not about making your life difficult, but about making sure you can continue to live a healthy life.

Use the baking soda to neutralize any spills immediately.

Note – Safety glasses and face shields are not goggles. Acid splashes and neither safety glasses or face shields provide adequate protection. That said using a face shield and goggles do increase your protection.

Step 2 – Open Battery Cell Caps

A 12 volt battery has six cells. A six volt battery has three cells.

Sometimes the cells each have their own cap and sometimes they share a large rectangular cap with other cells.

Sometimes the caps twist off, and sometimes they need to be gently pried of. Take your time. Don’t force anything.

Step 3 – Position Hydrometer Over Cell and Squeeze Bulb

There should be no liquid in your hydrometer after performing this step.

Step 4 – Insert Hydrometer Nozzle into the Cell to Be Tested

You will want to get the nozzle well into the liquid. This liquid is known as electrolyte. You’re measuring the specific gravity of this electrolyte.

Step 5 – Release Bulb to Suck Electrolyte into the Chamber

You will want enough electrolyte in the chamber to cause the float to be freely suspended in the liquid

Step 6 – Allow Liquid and Float to Settle – Take A Reading

You’ve been moving stuff around. The float and electrolyte are likely bouncing. Give it a little time to settle. Take your reading. If you have a common automotive hydrometer, the float will be marked with green, red and white zones. These are generally good reliable indicators of the current specific gravity of a cell.

Step 7 – Insert Nozzle into Cell and Squeeze Bulb

You’re replacing the electrolyte you took out of the cell. This is a pretty important step.

Step 8 – Repeat for Remaining Cells.

You will be repeating steps 2 through 7. You should probably make a note of the results of each cell.

Step 9 – Think About and Interpret Your Results.

The biggest mistake with this measurement is a misinterpretation that causes a good cell to be declared bad. Was your battery really charged before the test? Did you allow it time to settle in an open circuit condition after charging?

Now, the one thing you can be sure of is that you have bad a cell if there is a dramatic deviation between your readings.

Step 10 – Clean Up

You may have little drops of acid in or nearby your work area. This is a good time to clean it up. You really don't want loved ones to accidentally put their hands in it.

Battery Characteristics & Fault Diagnosis

Yuasa lead-acid batteries are built to the highest standards. They are manufactured, in most cases to correspond with or exceed the vehicle manufacturer's requirements and specifications.

Nevertheless, it should be clearly understood that wet (filled) lead acid battery is "a live" product. Whether it is in storage or in service, it has a finite life. All batteries once filled will slowly self discharge. The higher the storage temperature and humidity of the storage area, the greater the rate of self discharge.

To ensure the batteries are not allowed to discharge to the point where they are damaged (sulphated) or so incapable of giving designed service life, regular checks of the recharge date label on the back of the battery, and voltage checks of batteries with less than 4 month remaining should be made. It is important to ensure good turn around of stock, first in, first out, especially with slow running stock of low volume lines. Batteries with a voltage of 12.35V or below should be recharged immediately. Recharging must not be effected by means of a rapid charger due to the inefficiencies when attempting to recharge a partially sulphated battery which leads to excessive gassing and damage to the active material grid bonds within the battery, which are critical to ensure battery life.

Ideally use a recharge rate as stated in "recommended recharge rate and period" according to battery type and catalogue instructions. At the end of discharge, all cells should be gassing freely. It is clearly recommended that batteries are left to stand for a minimum of 3 hours after charging to ensure any gases trapped in the upper battery casings are allowed to diffuse into the atmosphere. If a battery has been recharged, the recharge date on the back label should be updated by 6 months after second recharge date by physically notching the label. (Note a maximum of two recharges are allowed prior to sale, and product should not be sold a maximum of 9months after the expiry of first recommended recharge date).

Battery Problems

Non Manufacturing Defects

Physical Damage
If the battery is stored, handled or fitted incorrectly, if the connectors leads are hammered onto terminals, leads are not correctly fastened, the battery will have damage to casing and/or terminals. This is not a manufacturing fault.
* Note all batteries picked and dispatched from Yuasa’s UK warehouse are photographed prior to dispatch to ensure our shipping quality targets are met.

Sulphation
If a battery is allowed to stand in a discharged state either on or off a vehicle for a period of time, a chemical reaction takes place which will permanently impair the performance and life of the battery, this process is called “sulphation”.

Sulphation can be seen as a fine white/grey coating on the positive plate and a non metallic luster on the negative plate. In most cases this signifies the battery as not serviceable. Attempts to recharge batteries left in a discharged state, even at very low charge rates will lead to damage to the grid and active material interfaces and also sulphate deposits can be formed within the separators which produce dendritic shorts.

The damage can occur in storage or if the battery is installed on the vehicle (or equipment) that is not used for a period of time, for example tractor, motorcycle, boat, airport vehicle even a car or truck that is stored with the battery connected can still damage the battery. This is because there is a permanent drain on the battery from items such as the alarm, clock, lights, etc left on which drag the battery down to its lowest possible state of charge. The longer the period left, the greater the sulphation builds up on the plates.

The sulphation hinders the efficiency of the electrochemical reactions within the battery between the active material of the plates and the acid. This is not a manufacturing fault.

Wear and Tear
As the battery is cycled, i.e. charged and discharged, the active materials within the battery plates are in motion in order to release the electricity stored by the battery. Every time the battery is charged and discharged a small amount of active material is permanently lost from the plates.

As the ultimate battery life is determined by many factors, such as temperature, battery operating state of charge, duty cycle, etc it is impossible to stipulate a minimum/maximum life expectancy in the field. This process of normal ageing will eventually cause the battery to lose capacity and it will come to the point where the battery can no longer start the vehicle or equipment. Modern fuel injected cars start much more quickly, typically using a surface discharge off the battery plates, hence the unexpected failure of the battery is more often than not seen when the battery is first put under stress, for example on a cold morning, or after a weekend stand. This is not a manufacturing fault.

It is always best to take the opportunity of free battery checks prior to the onset of cold weather or long airport parking periods.

Deep Cycling
As above, every time a battery is charge and discharge cycled a small amount of material is lost. If a battery is subjected to deep discharging (greater than 35%) and rapid charging the process is accelerated. Additionally if the recharge does not recover the discharge cycle in full, the battery will exhibit loss of performance and concentration of the acid can occur between plates which can lead to corrosion and loss of performance.

Even after recharging, the voltage will be low (under 12.4V) but if the cells acid gravities are checked they will generally be even across the battery. This is not a manufacturing fault.

Overcharging
If the alternator regulator is not set properly, or alternator voltage control circuit fails, then the battery can be subjected to an excessive charge.

If left unchecked the battery will overheat and will start to evaporate the electrolyte. The overcharging will accelerate the break up of the active material and grids and the battery will lose performance. Examination of the battery will typically show low acid level and usually a black coating on filler plugs and a strong smell. It is recommended that the alternator charging voltage is checked by a mechanic. This is not a manufacturing fault.

False Claim
In order to minimise fraudulent battery claims each Yuasa battery has its own individual unique number found on the back label of the battery. It is recommended that this number is recorded on the proof or purchase at point of sale, to enable a double cross check to be made during the claim procedure. The label has been made tamperproof.

Incorrect Application
The batteries recommended within this Yuasa application list are equal to or above the original equipment specification. Fitting a smaller or less powerful battery will result in a shorter service life and earlier failure. The failure will normally be seen as deep cycling/premature wear and tear.

It should be noted that a vehicle fitted originally by manufacturer with an AGM battery should be replaced only with an AGM battery. Likewise, a vehicle originally fitted with an EFB battery should only be replaced by and EFB or AGM battery.
This is not a manufacturing fault.

Undercharging
Undercharging occurs if the battery is not receiving enough charge to return it to a full state of charge, this will slowly cause sulphation. This fault can occur if the car is being used only occasionally for short journeys, or for Start-Stop urban motoring. Undercharging will occur if alternator voltage is low (13.6-13.8volts), the alternator belt is loose or battery cables are worn and causing high resistance – If in doubt seek advice from an auto electrician.

Battery Problems

Manufacturing Faults

Due to the high demands of the OEM market and the technical and manufacturing standards of Yuasa batteries, the rate of genuine manufacturing faults is negligible.

Short Circuit/dead cell
Typically seen in a battery within 12 months service life. One cell will show a dramatically lower acid specific gravity reading than the others. The problem cell will usually boil visibly under a high discharge, all other remaining cells will show a good specific gravity reading of 1.26 or above. Short Circuit/dead cells seen in later life are usually associated with the recovery of a sulphated/overdischarged battery. It is possible to see variable acid specific gravities between cells if sulphation is the route cause.

Internal Break
The battery will have good specific gravity but no voltage reading. Check for any physical damage which may have caused an internal break

Alkaline batteries

(IEC code: L) are a type of primary battery dependent upon the reaction between zinc metal and manganese dioxide.

Another type of alkaline batteries are secondary rechargeable alkaline battery, which allows reuse of specially designed cells.

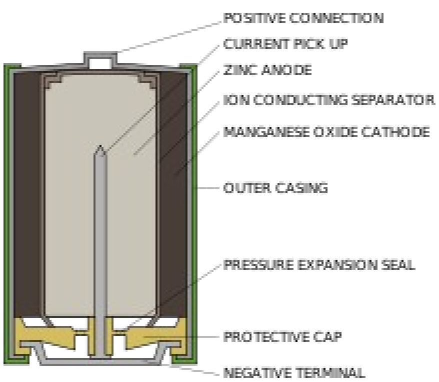
Compared with zinc-carbon batteries of the Leclanché cell or zinc chloride types, alkaline batteries have a higher energy density and longer shelf-life, with the same voltage.

The alkaline battery gets its name because it has an alkaline electrolyte of potassium hydroxide, instead of the acidic ammonium chloride or zinc chloride electrolyte of the zinc-carbon batteries. Other battery systems also use alkaline electrolytes, but they use different active materials for the electrodes.

Alkaline batteries account for 80% of manufactured batteries in the US and over 10 billion individual units produced worldwide. In Japan alkaline batteries account for 46% of all primary battery sales. In Switzerland alkaline batteries account for 68%, in the UK 60% and in the EU 47% of all battery sales including secondary types.

Alkaline batteries are used in many household items such as MP3 players, CD players, digital cameras, pagers, toys, lights, and radios.

In an alkaline battery, the negative electrode is zinc and the positive electrode is manganese dioxide (MnO_2). The alkaline electrolyte of potassium hydroxide is not part of the reaction, only the zinc and MnO_2 are consumed during discharge. The alkaline electrolyte of potassium hydroxide remains, as there are equal amounts of OH^- consumed and produced.



Section through an alkaline battery.

The half-reactions are:

$Zn(s) + 2OH^-(aq) \rightarrow ZnO(s) + H_2O(l) + 2e^-$ [$E_{oxidation}°$ = +1.28 V]

$2MnO_2(s) + H_2O(l) + 2e^- \rightarrow Mn_2O_3(s) + 2OH^-(aq)$ [$E_{reduction}°$ = +0.15 V]

Overall reaction:

$Zn(s) + 2MnO_2(s) \rightarrow ZnO(s) + Mn_2O_3(s)$ [e° = +1.43 V]

Lithium-ion battery

A lithium-ion battery or Li-ion battery (abbreviated as LIB) is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. Li-ion batteries use an intercalated lithium compound as one electrode material, compared to the metallic lithium used in a non-rechargeable lithium battery. The electrolyte, which allows for ionic movement, and the two electrodes are the constituent components of a lithium-ion battery cell.

Lithium-ion batteries are common in home electronics. They are one of the most popular types of rechargeable batteries for portable electronics, with a high energy density, tiny memory effect[9] and low self-discharge. LIBs are also growing in popularity for military, battery electric vehicle and aerospace applications.

Chemistry, performance, cost and safety characteristics vary across LIB types. Handheld electronics mostly use LIBs based on lithium cobalt oxide ($LiCoO_2$), which offers high energy density but presents safety risks, especially when damaged. Lithium iron phosphate($LiFePO_4$), lithium ion manganese oxide battery ($LiMn_2O_4$, Li_2MnO_3, or LMO), and lithium nickel manganese cobalt oxide ($LiNiMnCoO_2$or NMC) offer lower energy density but longer lives and less likelihood of unfortunate events in real-world use (e.g., fire, explosion, etc.). Such batteries are widely used for electric tools, medical equipment, and other roles. NMC in particular is a leading contender for automotive applications. Lithium nickel cobalt aluminum oxide ($LiNiCoAlO_2$ or NCA) and lithium titanate ($Li_4Ti_5O_{12}$ or LTO) are specialty designs aimed at particular niche roles. The newer lithium–sulfur batteries promise the highest performance-to-weight ratio.

Lithium-ion batteries can pose unique safety hazards since they contain a flammable electrolyte and may be kept pressurized. A battery cell charged too quickly could cause a short circuit, leading to explosions and fires.[12] Because of these risks, testing standards are more stringent than those for acid-electrolyte batteries, requiring both a broader range of test conditions and additional battery-specific tests.[13][14][15] There have been battery-related recalls by some companies, including the 2016 Samsung Galaxy Note 7 recall for battery fires.

Research areas for lithium-ion batteries include life extension, energy density, safety, cost reduction, and charging speed,[18] among others. Research has also been under way for aqueous lithium-ion batteries, which have demonstrated fewer potential safety hazards due to their use of liquid electrolytes.

Terminology

Battery versus cell

International industry standards differentiate between a cell and a battery. A cell is a basic electrochemical unit that contains the electrodes, separator, and electrolyte. A battery or battery pack is a collection of cells or cell assemblies. These may be made ready for use by providing an appropriate housing, electrical interconnections, and possibly electronics to control and protect the cells from failure. (Failure in this case is used in the engineering sense and may include thermal runaway, fire, and explosion as well as more benign events such as loss of charge capacity.)

For example, battery electric vehicles, may have a battery system of 400 V, made of many individual cells. The term module is often used, where a battery pack is made of modules, and modules are composed of individual cells.

Anode, cathode, electrode

In electrochemistry, the anode is the electrode where oxidation is taking place in a cell, i.e. electrons get free and flow out of the cell (conventional current flowing into it). However, for rechargeable cells, the electrode where electrons flow out during discharging will become the electrode where electrons flow in during charging and vice versa, therefore the anode and the cathode will swap places when the cell switches between charging and discharging states. The less ambiguous terms are positive (cathode on discharge) and negative(anode on discharge) electrodes, which, when connected to the positive and negative terminals of a voltmeter, show a positive reading. For rechargeable cells, the term cathodedesignates the electrode where reduction is taking place during the discharge cycle, even though both oxidation and reduction reactions take place there, depending on whether the cell is in charging or discharging mode. For lithium-ion cells the positive electrode ("cathode") is the lithium-based one.

Fuel cell

A fuel cell is an electrochemical cell that converts the chemical energy from a fuel into electricity through an electrochemical reaction of hydrogen fuel with oxygen or another oxidizing agent. Fuel cells are different from batteries in requiring a continuous source of fuel and oxygen (usually from air) to sustain the chemical reaction, whereas in a battery the chemical energy comes from chemicals already present in the battery.

Fuel cells can produce electricity continuously for as long as fuel and oxygen are supplied.

The first fuel cells were invented in 1838. The first commercial use of fuel cells came more than a century later in NASA space programmes to generate power for satellites and space capsules. Since then, fuel cells have been used in many other applications. Fuel cells are used for primary and backup power for commercial, industrial and residential buildings and in remote or inaccessible areas. They are also used to power fuel cell vehicles, including forklifts, automobiles, buses, boats, motorcycles and submarines.

There are many types of fuel cells, but they all consist of an anode, a cathode, and an electrolyte that allows positively charged hydrogen ions (protons) to move between the two sides of the fuel cell. At the anode a catalyst causes the fuel to undergo oxidation reactions that generate protons (positively charged hydrogen ions) and electrons. The protons flow from the anode to the cathode through the electrolyte after the reaction. At the same time, electrons are drawn from the anode to the cathode through an external circuit, producing direct current electricity. At the cathode, another catalyst causes hydrogen ions, electrons, and oxygen to react, forming water. Fuel cells are classified by the type of electrolyte they use and by the difference in startup time ranging from 1 second for proton exchange membrane fuel cells (PEM fuel cells, or PEMFC) to 10 minutes for solid oxide fuel cells (SOFC). A related technology is flow batteries, in which the fuel can be regenerated by recharging. Individual fuel cells produce relatively small electrical potentials, about 0.7 volts, so cells are "stacked", or placed in series, to create sufficient voltage to meet an application's requirements. In addition to electricity, fuel cells produce water, heat and, depending on the fuel source, very small amounts of nitrogen dioxide and other emissions. The energy efficiency of a fuel cell is generally between 40–60%; however, if waste heat is captured in a cogenerationscheme, efficiencies up to 85% can be obtained.