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Charging systems and Charge storage device - A review

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ABSTRACT- We have been stared to use of the many portable devices, those have no need of direct plug in. These devices operate on electric power stored in batteries, mounted in devices very conveniently. These power storage devices (Batteries/power banks) make these devices portable. In this paper detailed explanation about the charging system for charge storage devices i.e. Batteries/power banks. We will do the study for the basics about the charging system. Charging system should be capable to charge the batteries/power bank in efficient and controlled manner. We will be also discuss about the type of charger, charging mode and method with other required scenario, those are help to make a better understanding about the charging system. As the charging is important, the charge storage devices are double important i.e. Storage capacity.

Keywords- Basics of Charging system, Type of charging systems, Mode of Charging, Charge storage device.

I. INTRODUCTION

Now days, everything we want to operate with minimum or less physical efforts. For this electricity is top of the neat and clean fuel. As in any way electricity is not usable, directly. We use the electricity by converting in the required form, for heating us use electricity in a high resistive conductor coil (heater), for motion supplied to a motor and etc. Electricity uses now first choice as we are able to transport it at fast speed due to high speed of the electrons. Previously commonly usages devices were direct plug in. As we know time is under major changes, many portable devices are in use. These portable devices have no need direct plug in. These devices have their own power source / power banks, in terms of batteries.

As we all know while we will start use any power storage device/ power bank, charging system should be fast, effective and efficient.

To generate the electricity is not an easy task, Due to global warming issues now renewable energy usages to generate the electricity are very popular. While we will try to produce electricity by renewable energy resources (wind or solar) charging system and charge storage devices

II. BASIC CHARGING METHODS

Following are the common charging methods for battery are used those are using now a days-

i.**Constant Voltage-** This method allows maximum current from charger flow to battery till power supply will reaches to preset voltage value. Then current will tapering down to minimum set value after gain that voltage level. Battery may be let connected with the charger, for ready to use and float voltage will provide trickle charging as a compensation for self discharging [1& 2].

ii.Constant Current- This is a very simple method of charging for batteries, with current level is set up to 10% of the battery rating. Charging time may be relatively long as a disadvantage that battery could be overheated if batteries overcharged this lead to battery replacement prematurely. This method suitable to charge Ni-MH batteries. Once battery get charged, should be disconnected manually of can take help of a timer based switch [1 & 2].

iii.Constant Voltage / Constant Current- This battery charging method is a combination of the Constant Voltage and Constant Current battery charging method. In this method charger control the charging to a preset voltage value. The current reduced after battery gets fully charged. This method used to charge lead acid battery. In constant Voltage and constant Current method regulated current rise terminal voltage value till maximum charging voltage limit, at that point where the current reduced due to fullness [1&2].

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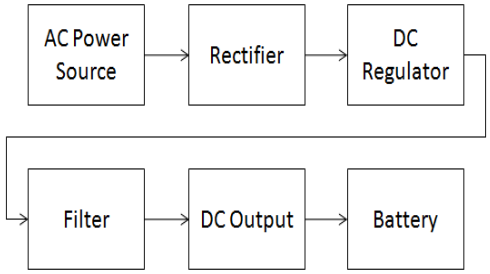
iv.Pulse Charge- This charging forage charge current in battery by pulses. Average charging current that can precisely controlled thru pulse width variations, around one second. While charging rest periods approx 20~30 milliseconds. In battery, this rest period permit to chemical process in action for stabilization by equalizing this action by the bulk of electrode before restarting charging [3].

v.Burp charging- This is also known as Reflex charging, we also know it as Negative Pulse Charging. It is used in combination of pulse charging. It applies short discharge pulses, approximately 2 ~3 times of the charging current in order to 5 milliseconds, throughout the rest period of charging rest period for depolarize the battery cell. These pulses used to protrude the bubbles of gas those are built on electrodes during charging, pace up the immobilization and hence the charging process. The process of diffusion and release of these gas bubbles known as burping [3].

Block diagram representation of a charging system-



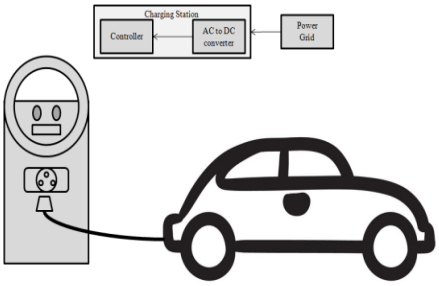
III. CHARGING RATES

Batteries are charged at different charging rates as per requirement; three main types of charging method are as follows-

i.Slow/ Normal Charging- Slow/Normal Charging is comparatively simple charging rate and not a reason of overheating. Once the full charging is done should remove the batteries from charger. This charging method is most common used in past primarily. NICADS batteries are generally most robust batteries respect to overcharging [3 &4]. Slow/Normal charging takes longest time 14~16 hours @ 0.1C rate.

ii.Fast Charging Rate- Currently to improve the efficiency of the charger, charging rate rises. To do so the insecurity about overheating or overcharging has been increased. For prevention of battery from overcharging or overheating, termination of charge while battery get fully charge is become very essential. So charger should be designed with detection ability of battery charge status and to stop charging once battery get fully charged. If is very important for battery life. It takes 3~6 hours @0.3 C rate [3].

iii.Ultra Fast Charging Rate- As now each device becoming smart and for to operate the smart device power source is required. So we need ultra fast charging is required to make the charging process efficiently, specially for battery operated vehicle. It takes less than 1 hr to charge the battery approx 80% @ 1.0 C rate [5].



iv.Charge Termination- As the charging, charging rate is important for a charging system charge termination is also equally important. Few popular charging termination methods for batteries are TCO (Temperature Cut Off), Delta TCO (Temperature Rise above Ambient) & I min (Minimum Current). By these practices charge termination can be done easily and efficiently [2].

IV. CHARGE CONTROL METHOD

In charging system, many different charging control methods have been developed, few of them are described here-

Semi constant current- It is the simplest and economical method as well as most popular also. As we all know low current cannot generate heat but it is slow. [2]

Timer controlled- This charging system is also simple and economical as well. This method looks more trust worthy as this use timer IC. [2]

Negative delta- This is one of the most popular method in rapid charging. Batteries are charged at regular floe of current. Battery voltage reach to peak due to continuous charging and when fully charged fall down subsequently. This voltage reduction is –delta, basically due to polarization.

Some other type of charging control

Methods are dT/dt Charge system, Constant current and constant voltage, Voltage controlled V-

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Tapper control, Failsafe timer, Pre-charging, Intelligent charging, etc [2].

V. CHARGER TYPE

In general way chargers inclusive some kind form of voltage sermon (percept) to command the charging voltage employed to battery. Price plays an important role to choose a charger, as developed technology needs return.

i.Switch Mode Regulator- With the help of PWM (Pulse Width Modulation) we can control voltage. As input contains variation, also in battery voltage. But still with these variations power dissipation is low. Large passive filtering is required to filter out the pulsed waveform. The size of the component depends upon the current to be handling. EMI (Electromagnetic Interference) also rise due to switching heavy current.[1]

ii.Series Regulator- This is known as Linear filter, less complex but losses are more. Heat sink also put in series to dissipate the heat. Difference between input & output voltage is taken by the help of voltage drop transistor. Here no filtering required as we get pure DC as output. This is suitable for radio applications and wireless.[2]

iii.Shunt Regulator- These are commonly used in Photovoltaic Systems, as these are comparatively have low cost to make and design is also simple. A switch or transistor is connected in parallel to control the current, with photovoltaic panel and storage device (battery). Battery overcharging is prevented by short circuiting the PV output through a transistor when the voltage reaches a certain limit.[2]

iv.Buck Regulator- A switching regulator that contains one step-down DC to DC converter. These converters have good efficiency and less heating loss. These are able to handle the high output currents and produces low RF interference than traditional switch mode regulators. Simple without transformer design which have low switch stress and small output filter.[2]

v.Pulsed regulator- A series transistor use that can be switched. If the battery voltage is low, that remains transistor in ON condition and conducts source current straight to battery. As battery voltage approaches to desired regulation voltage, that series transistors pulse the input current to keep the desired voltage. It acts as switch mode power supply of that part of cycle, which dissipates small heat and acts as linear power source for part of the time, allowing smaller output filters. When the charge level gradually increases due to the pulse, the charge increment is low and the battery time stabilizes (recovers). During the rest period, the cell polarization is reduced. This process does not allow the active chemicals to gradually stabilize during charging; allowing faster charging than is possible with a single long, high-level charge that can damage the battery. Pulse chargers usually require a current limit on the input source for safety reasons, which increases cost.[2]

vi.Universal Serial Bus- The USB specifications were developed by the group of computer that replaced the number of multiple mechanical and electrical interconnection for data transferring between computers to external devices. This included the two-wire connected for data transferring, a ground line wire, a 5-volt power line also provided by a host (computer) device that could be used to power external devices. The incidentally use of this USB port was not only to get power directly, but also to provide a 5 volt power supply to charge the batteries attached to these external devices. Here, peripheral device itself must building the charge control circuitry needed to protect battery. The original specification in USB standard, a data ratio of 1.5 Mbits / sec with maximum charging current to 500mA.
Power flows is always from host to device in USB, but data can be flow in either direction. Because of this, USB host connector is different in shape from USB device connector, and there are different connectors on both ends of the USB cable. This eliminates the possibility of applying a 5-volt connection from external USB source to host computer and damaging host machine.[2&3]

VI. MODERN CHARGING TECHNIQUE

Inductive charging- Inductive charging not refer to charging process for battery itself. This refers to design of charger. Originally, input side of this type of charger, the part connected with AC mains power, which is connected from a transformer split in two parts. The primary winding is enclosed in unit connected with AC supply, other side secondary winding is enclosed in identical closed unit which accommodate the battery, across with rest of conventional charger. This allows charging the battery without physical connection with mains and without any direct contacts which could be a reason of electric shock.[2&3]

Block diagram representation of a Inductive charging system-

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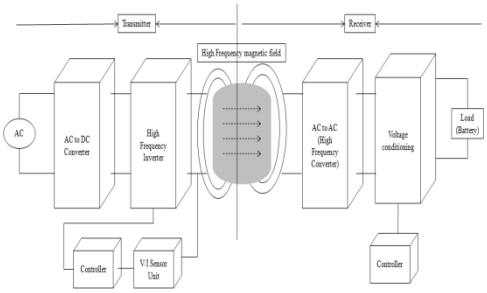


Figure

VII. CHARGER POWER SOURCE

When you specify a charger, you also need to specify the source from where the charger draws its power, availability, voltage and range of the power. The efficiency loss of the charger should keep into consideration. This is especially true for high power chargers, where the loss can be high.[2&3]

i.Controlled Charging- It can be comfortably control, manage and accommodate.

a.AC Mains- Many compact & light weighted power chargers for small appliances such as laptop, computers and cell phones need to work as per international market. Therefore, it automatically detects the mains voltage, and in special cases mains frequency also, and automatically switches to suitable input circuit.
High power applications may require special adjustments. Single-phase mains are typically limited about 3KW. When three-phase power is required to charge a large capacity battery (capacity about 20 KWh) such as that used in EV (Electric Vehicles) that require a charge rate above 3 KW to achieve a appropriate charging time.
DC Battery Supply (Regulated)- It may get by special purpose equipment such as mobile power generators for custom applications. DC battery supplies often used converters to get the required appropriate DC output.[4&5]

b.Special Charges- Special chargers get the energy form the portable sources that may take the power from your car battery, Solar or any sources and provide desired output that use to charge the battery.

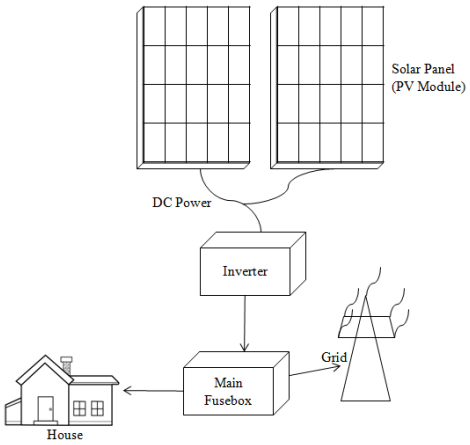
ii.Opportunity Charging- This means charging a battery when power is available. Also in other words we can say after partial discharges, preferably than waiting for battery to get fully discharge. Used in cycle service batteries and applications where energy is only periodically available.

It can affect by large fluctuations in energy availability and huge imbalance in power levels. Special controls are required to protect a battery from overvoltage. By preventing complete drain of the battery, Cycle life of a battery can be increased.

Onboard vehicle charge- In On board vehicle charging the battery get charged by available IEC engine, while engine in running condition. IEC engine and electric motor provide the power to the wheel simultaneous as per written program in the device which control the transmission.[9]

Solar Power- A solar panel converts the solar radiation to electric energy through conversion of chemical energy. In Solar powered charging station large solar panel connected with the charging system to generate required power[6].

Block diagram representation of solar system-



iii.Mechanical Charging- It is used in big size of batteries. Mechanical charging is carried out in minutes; it is quicker than other charging methods. The particular cell chemistries is applicable here. It's not a charging technology, normally. This technology used in Zinc Air & Flow batteries. Zinc Air batteries can recharged with changing the Zinc electrodes. Flow batteries can charge by electrolyte replacing.

VIII. CHARGING PERFORMANCE

Charger performance is depending on the battery type, charger and application where it is going to use. The requirement of the charging performance should meet.
Output purity- The output purity it the ability of charger to supply a pure & clean output voltage.

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Pure & Clean output is free from ripple, spikes, noise and other impurities those could cause trouble for battery. For high power uses, design of a charger is responsible.

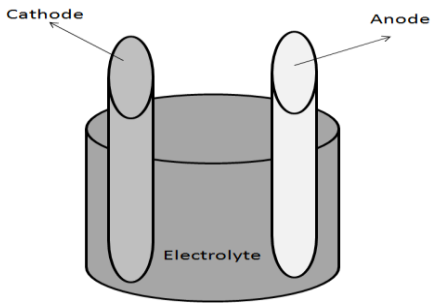
Inrush Current- While we switch ON the charger and connect with a empty battery, the inrush current higher in comparison of maximum limit current. Here it is important to control this inrush current; charger is design to control this.

Efficiency- Efficiency of a charger is also important, all charger have approximately 90% efficiency. During charging of the battery losses in the charger add remarkably.

Power factor- This also an important parameter of a charger, in case of high rating charger this is a very important parameter.

IX. BASICS OF BATTERY

In recent years battery technology is becoming good choice for portable appliances and devices, electric Vehicles and power storage at grid. Battery contains collection of cells. Chemical reaction originates electron flow in a circuit. Battery has three basic elements, Electrolyte (Chemical substance react with anode and cathode), positive side (Cathode) and negative side (Anode), each battery have these three basic elements. [7]



Cathode is positive or we known as oxidizing electrode, this acquires the electrons from charging external circuit and reduced during electrochemical reaction.

Anode is negative or we known as reducing electrode this releases electrons to load circuit and oxidizes during and electrochemical reaction.

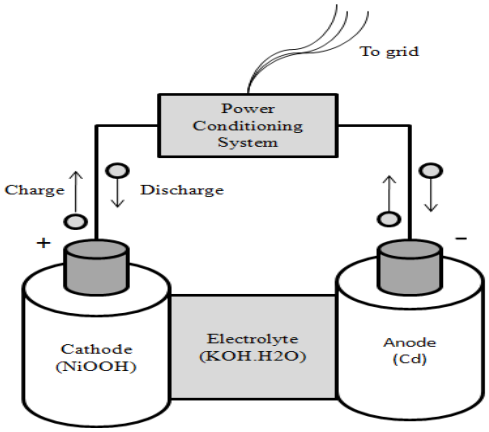
Electrolyte is medium that provides ion movement mechanism between cathode and anode of the battery. Electrolyte is often thought of liquids (like water or similar solvents, with can dissolved salts, alkalis of acids these are basic requirements for ionic conduction.

Battery has two varieties, Primary cell & secondary cell. Primary Cell is Single use power source. We cannot recharge these types of batteries. Whereas secondary Cell is Rechargeable batteries, these can be recharged.

X. TYPE OF BATTERIES

Batteries are divided into types on the basis of material used to do the fabrication of a battery.

i.Nickel Cadmium battery- Nickel Hydrogen (NiOOH) used at positive side and cadmium (Cd) use at negative side. For electrolyte reaction potassium Hydrogen (KOH) used. The active component in this battery is nickel hydroxide (HiOOH). This type of battery is able to supply very high currents and can recharge quickly.
Block diagram representation of NiOOH battery-



ii.Nickel Metal hybrid battery - Nickel Hydrogen (NiOOH) used at positive side and storing metal (MH) use at negative side. For electrolyte reaction potassium Hydrogen (KOH) used. The active component in this battery is nickel hydroxide (HiOOH). This type of battery is containing high energy density.

iii.Lithium Ion battery- This is a rechargeable battery, here anode (-ve terminal) and cathode (+ve terminal), work as a host for lithium ion. During discharge Lithium ion travel from anode to cathode and interpose in voids of cathode. The ions get reversed during charging process. The lithium battery is made by layers of anode and cathode, and these are separated by separator made of porous.[7]
Block diagram representation of Lithium Ion Battery-

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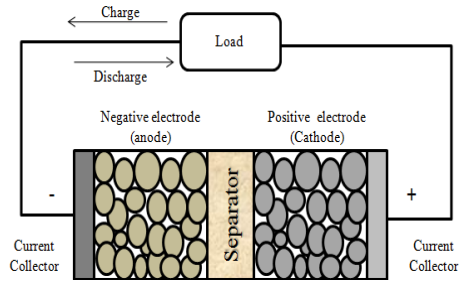
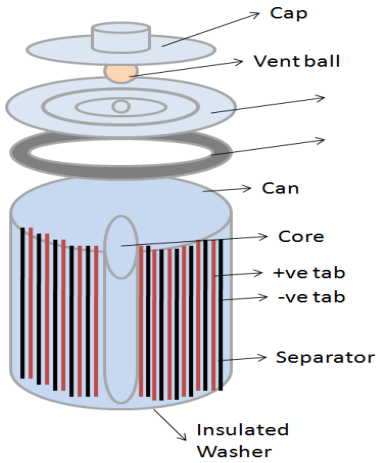


iv.Small Sealed lead acid battery- These are valve regulated based lead acid battery, this is also a rechargeable batteries. These batteries no need to add water to cells. These are also known as maintenance free batteries, have reduced venting is also an advantage.

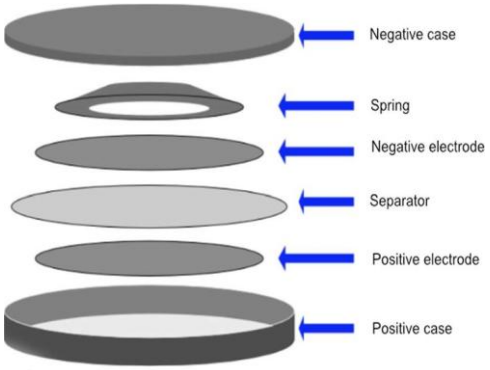
XI. STRUCTURE OF BATTERIES

Cylindrical Cell- Safety is enhanced by adopting an outer housing that can withstand high inner pressure without any deformation. Today's cylindrical battery cells have a pressure release mechanism or membrane seal that bursts under high pressure to reduce other related safety issues.



Button Cell- Button batteries are using in small electronic devices, like wrist watch and pocket calculators. Wider variants are commonly referred to as coin batteries. Devices that use coin cell batteries are typically cell-centric and offer a long service life, typically well over a year, in some applications

Structure of the Button cell



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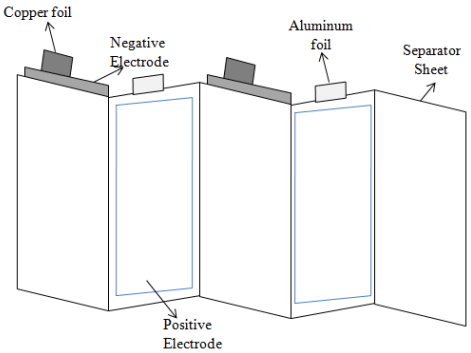
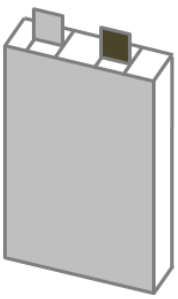
Prismatic cell- Prism cells are known for their huge storage capacity and prismatic shape, which allows you to easily connect four cells to create a 12V battery pack. A prismatic cell is composed by sandwiching of a large number of positive and negative electrodes.





Pouch cell- Lithium pouch cells, mainly referred to lithium polymer cells, are flexible and lightweight. Considered one of the maximum cell types are available, the pouch cell offers packaging efficiency up to 95%. Pouch cells are ideal for applications that require high load currents and commonly used for energy storage systems, mobile phones, automobiles and robots. This format is suitable for high target capacities where cylindrical cells are limited by standardized metal housing constraints.[8]

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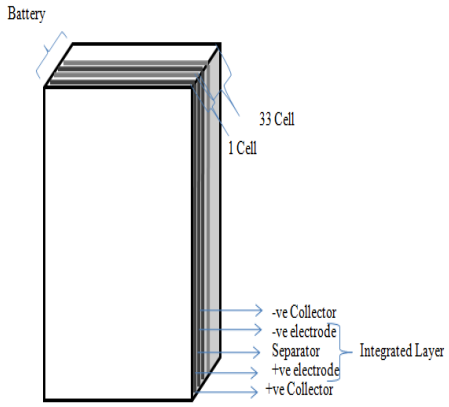

XII. CONCLUSION

It is required to have an appropriate charging system for current scenario, as uses of electrical devices is increasing day by day and industries are doing pace up their design and development to make the charging and charge storage system more efficient and effective. As we all know energy saving in nothing only an energy generation. So we should choose and use the efficient and effective charging and charge storage system.

Considering the availability of wide range of chagrining and chare storage device we should choose as per our requirement.

Improvement in the charging system and charge storage device may increase the average charging duty cycle that would help mainly in portable devices and Electric vehicles.

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