KLE Technological University
Creating Value
Leveraging Knowledge

BATTERIES

Chapter 6, Unit - III

Content

1. Fundamentals of Batteries
2. Types of Batteries
3. Grouping of Cells
4. Battery Charging
5. Precautions for battery charging
6. Care and maintenance
7. Types of efficiency of a cell
8. Characteristics of a good cell
9. Numericals




Introduction

Definition:

- A battery is a device consisting of one or more electrochemical cells with external connections for powering electrical devices.

Working Principle:

- Batteries convert chemical energy directly to electrical energy.

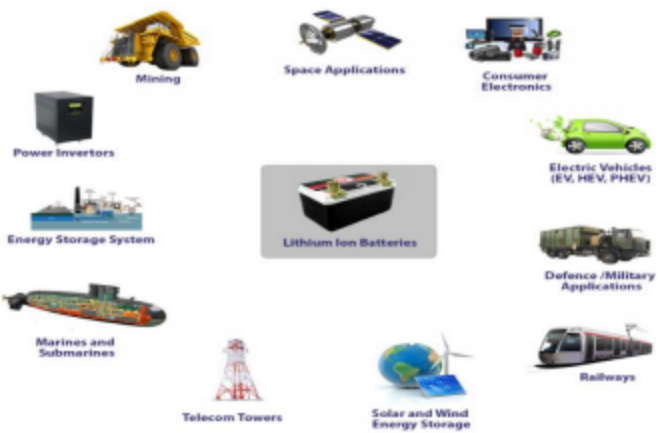
Primary Classification:

- Primary Batteries
- Secondary (Rechargeable) batteries

Applications:

Battery is one of the essential components of any electrical system requiring energy storage:

1. Electrical Stations
2. Electrical Vehicles and Fuel Vehicles
3. Aircrafts
4. Domestic and commercial (UPS)
5. Mobile phones
6. Laptops
7. Toys...etc

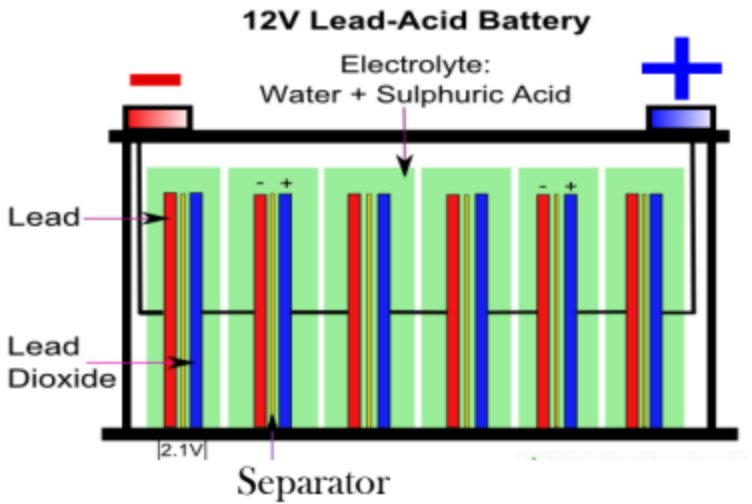


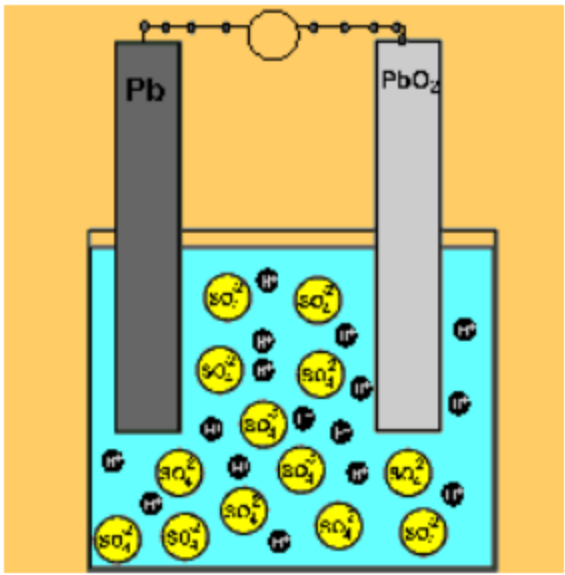
Battery : Structure

- Batteries operate by converting chemical energy to electrical energy
  - Electrochemical discharge reactions
- A typical Battery is composed of one or more cells & consists of:
  1. Positive electrode
  2. Negative electrode
  3. Separator
  4. electrolyte

Types of Batteries

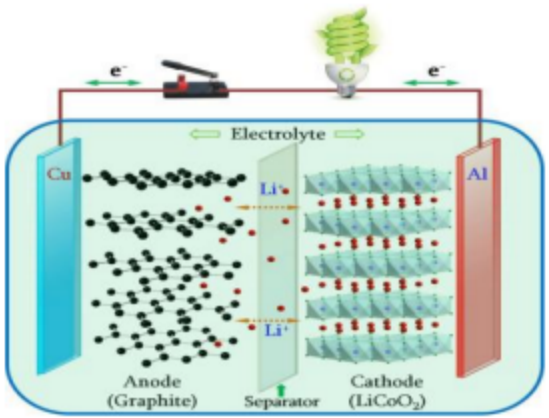
1. Lead acid Batteries

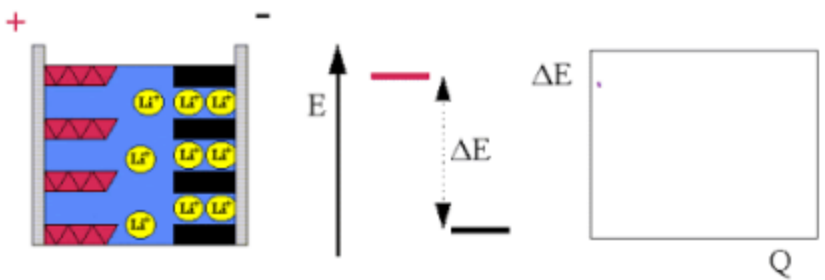




Types of Batteries

2. Lithium Ion batteries



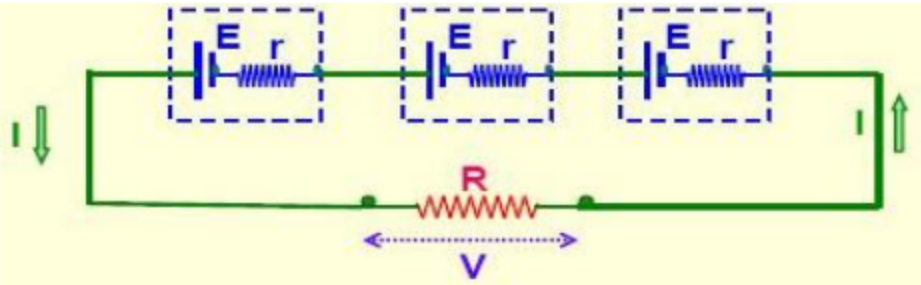


Grouping of cells

Cells may be grouped in three ways:

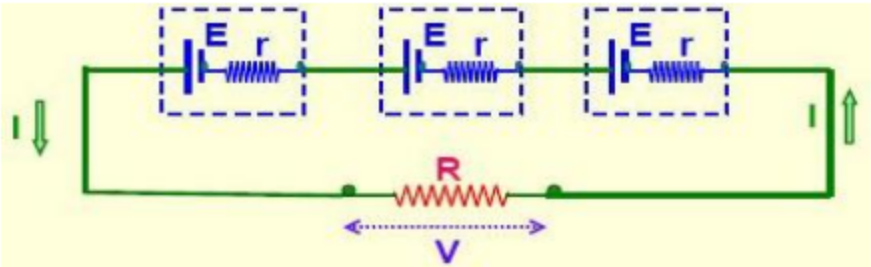
1. Series combination: "Higher Voltage"
2. Parallel combination: "High Current"
3. Hybrid (Series/Parallel) combination: "Required Voltage/current"

Grouping of cells: Series Combination



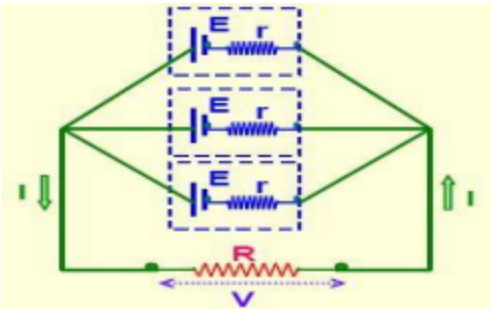
- *"n"* number of cells are connected in series
- e.m.f. is " E volts "
- Internal resistance of " $r\ \Omega$ "
- Load resistance " $R\Omega$ "

Grouping of cells: Series Combination



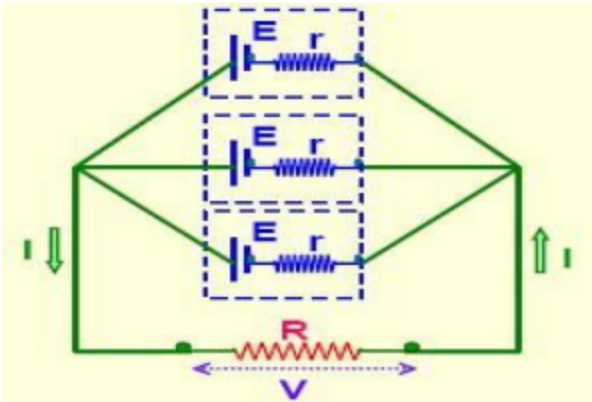
- Total internal resistance of the battery = " $n\,r\Omega$ "
- Total e.m.f. = " $n\,E$ volts "
- Total Resistance = " $R + nr\Omega$ "
- Current in load " $= \dfrac{n\,E}{R + n\,r}$ Amperes "

Grouping of cells: Parallel Combination



- *"n"* number of cells are connected in parallel
- e.m.f. is " E volts "
- Load resistance " $R\,\Omega$ "
- Total internal resistance of the battery = " $\frac{r}{n}\,\Omega$ "

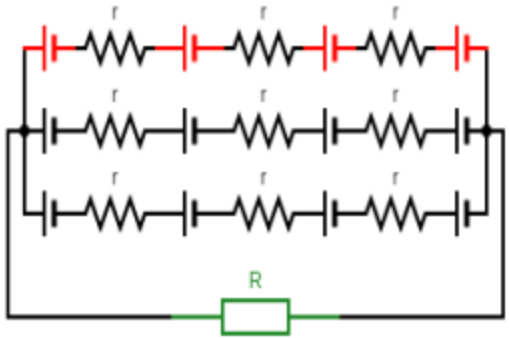
Grouping of cells: Parallel Combination



- Total Resistance : $= R + \frac{r}{n} \Omega$

- Current in load : $= \frac{E}{R + \frac{r}{n}} = \frac{nE}{nR + r}$ *Amperes*

Grouping of cells: Series-parallel Combination



- *"m"* sets of cells in SPC
- Each set with *"n"* no. Cells in series
- E.m.f. is " nE volts "
- Load resistance " $R\Omega$ "
- Total internal resistance of *"n"* cells in series = " $nr\Omega$ "
- Total internal resistance of *"m"* set of battery = " $\frac{nr}{m}\Omega$ "
- Total resistance = " $R+\frac{nr}{m}\Omega$ "
-

$$\text{Load Current} = \frac{nE}{R+\frac{nr}{m}} = \frac{mnE}{mR+nr}\ Amperes$$

Battery Charging:

Three systems of battery charging

1. Constant current charging system
2. Constant potential charging
3. Trickle charging method

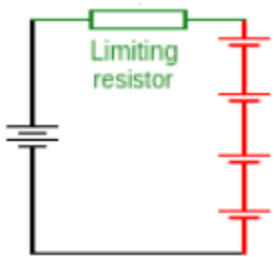
Battery Charging: Constant current charging

- Charging current is controlled by

    1. Carbon filament lamps or

    2. Rheostat in series with battery

    (*Note: It helps in varying supply voltage to over come increased back emf of batteries*)

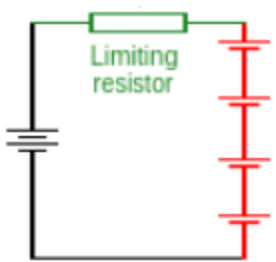


- Many batteries are connected in series for charging
- Total Voltage of the battery should not exceed supply voltage for un-interrupted charging.

Battery Charging: Constant current charging

- Charging current is given by $$I = \frac{V - E_b}{R + r} \; Amperes$$

  Where,
  - V = Charging applied voltage
  - E_b = Total counter emf of the battery
  - R = external resistance of lamp or rheostat
  - r = Internal resistance of the battery
  - I = charging current



- Advantage: this system increases the life of battery
- Disadvantage:
  - It takes longer time to charge
  - Needs constant observation for charging current

Battery Charging: Constant potential charging

- The voltage to be kept constant at 10 % higher than the battery
- Charging current is varied by controlling the field regulator
- Initially charging current will be very high because back emf will be very low
- After some time the process is reversed, charging current decreases to a very small value as back emf value increases due to charging
- Merit: Charging time is less than constant current charging method
- Demerit: It reduces life expectancy of the battery comparatively

Battery Charging: Trickle charging method

- Continuous charging of a battery at a low rate and
- Keeping the battery ready in good working condition
- Value of charging current is approx. 2% of full charging current of the battery

Battery Technical Specifications:

- Nominal Voltage: Normal voltage of the battery
- Cut-off Voltage: It is this voltage that generally defines the “empty” state of the battery.
- Capacity or AH rating: The total Amp-hours available when the battery is discharged at a certain discharge current from 100 percent state-of-charge to the cut-off voltage.

Precautions for battery charging

These precautions must be observed while charging

- Topping up : Distilled water
- DC voltage : 10% higher than the full charged battery
- Ventilation: Gases liberated are flammable (Well ventilated room)
- Charging rate : charged at a low rate 0.75A per plate (5%)

Care and maintenance

- Terminals and electrodes should be kept thoroughly cleaned and deposit some petroleum jell
- Strength of the depolarizer should be maintained
- Distilled water should be observed and put once in three months

  (if it is less than 10 mm or 15 mm: Usually comes with indicator)
- Positive and negative terminals should be

Types of efficiency of Cell

- Two types of efficiency
  1. Quantity efficiency or ampere hour (Ah) efficiency

$$Ah\ efficiency\ (\eta_{Ah})\% = \frac{Amperehours\ on\ discharging}{Amperehours\ on\ charging} \times 100$$

  2. Energy efficiency

$$Energy\ efficiency\ (\eta_{E})\% = \frac{Energy\ during\ discharging}{Energy\ during\ charging} \times 100$$

$$Energy\ efficiency\ (\eta_{E})\% = \frac{Watt\ hours\ on\ discharging}{Watt\ hours\ on\ charging} \times 100$$

Characteristics of a good cell

A good cell should have

- High and constant emf
- Very small internal resistance
- Completely inactive when circuit is opened
- Able to give constant current for a long time
- Free from polarization
- No emission of corrosive fumes during chemical action
- Inexpensive and of durable materials
- Good mechanical strength

Thank You