BATTERIES


Li-ion Battery
3.7V 3500 mAh


AA 700mAh 1.2V
AA 700mAh 1.2V


AA
12-2024
Energizer


KAYO Ni-MH
AA 1600mAh 1.2V
KAYO Ni-MH
AA 1600mAh 1.2V


Lithium Cell
CR1220
3V

Content

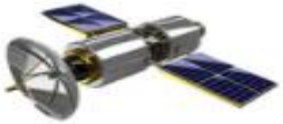
- Fundamentals of Batteries
- Types of Batteries
- Grouping of Cells
- Battery Charging
- Precautions for battery charging
- Care and maintenance
- Types of efficiency of a cell
- Characteristics of a good cell
- Numericals

Fundamentals of a Battery

- Battery is one of the essential components of any electrical system
  - Electrical Stations
  - Electrical Vehicles
  - Aircrafts
  - Domestic and commercial Uninterruptible Power Supply (UPS)
  - Mobile phones
  - Toys...etc

Fundamentals of a Battery (contd.....)

Mining



Space Applications

Consumer Electronics

Power Invertors

Electric Vehicles (EV, HEV, PHEV)

Energy Storage System

Lithium Ion Batteries

Defence /Military Applications

Marines and Submarines

Telecom Towers

Solar and Wind Energy Storage

Railways

Fundamentals of a Battery (contd.....)

- Batteries are used to
  - Start Engines and auxiliary power units
  - provide emergency backup power
  - assure no break power for essential equipments
  - Provide power capability for maintenance

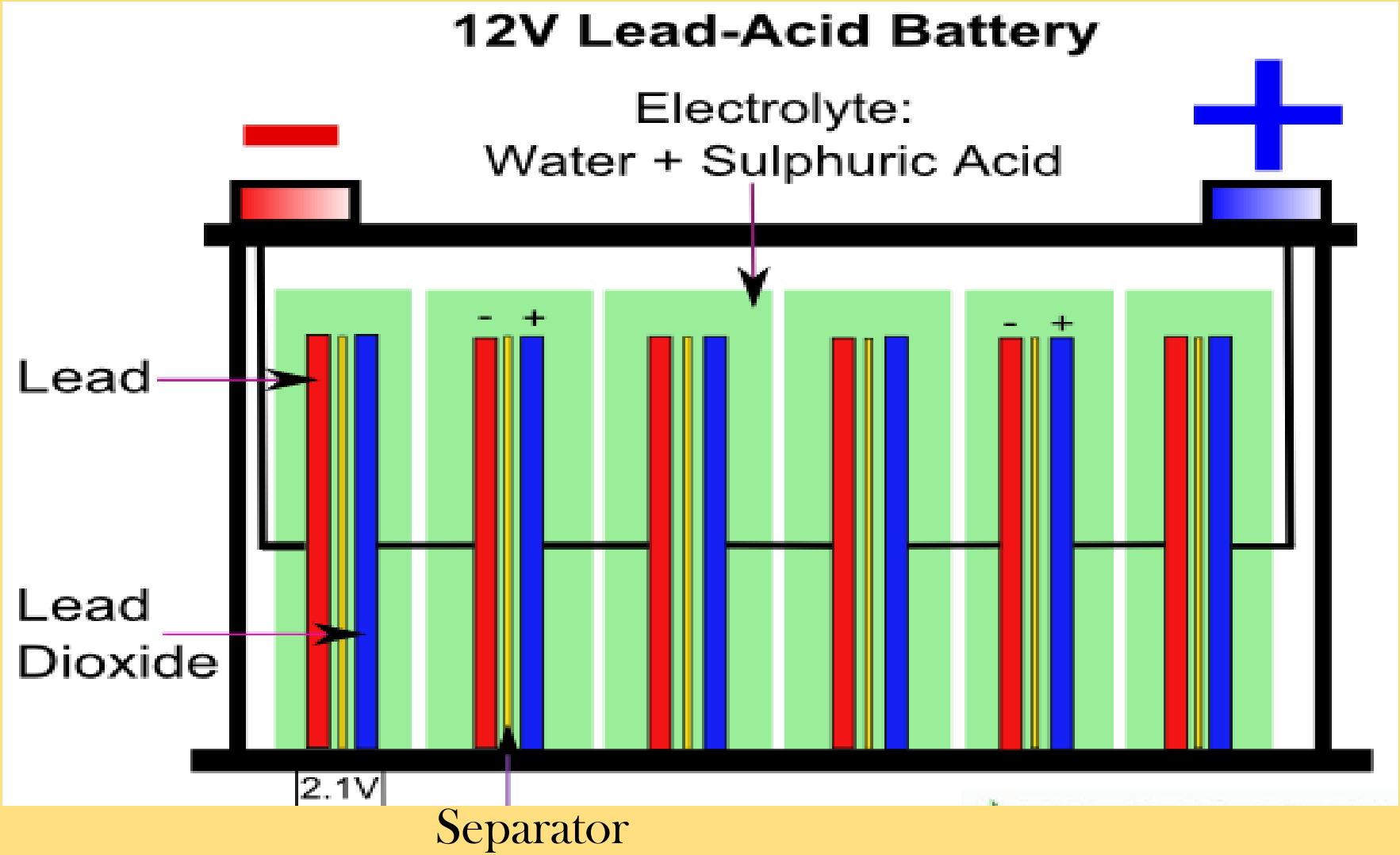
Note: All these functions are of considerable importance for performance and reliability

Fundamentals of a Battery (contd.....)

- Batteries operate by converting chemical energy to electrical energy
  - Electrochemical discharge reactions
- A typical Battery is composed of one or more cells
  - Positive electrode
  - Negative electrode
  - Separator
  - electrolyte

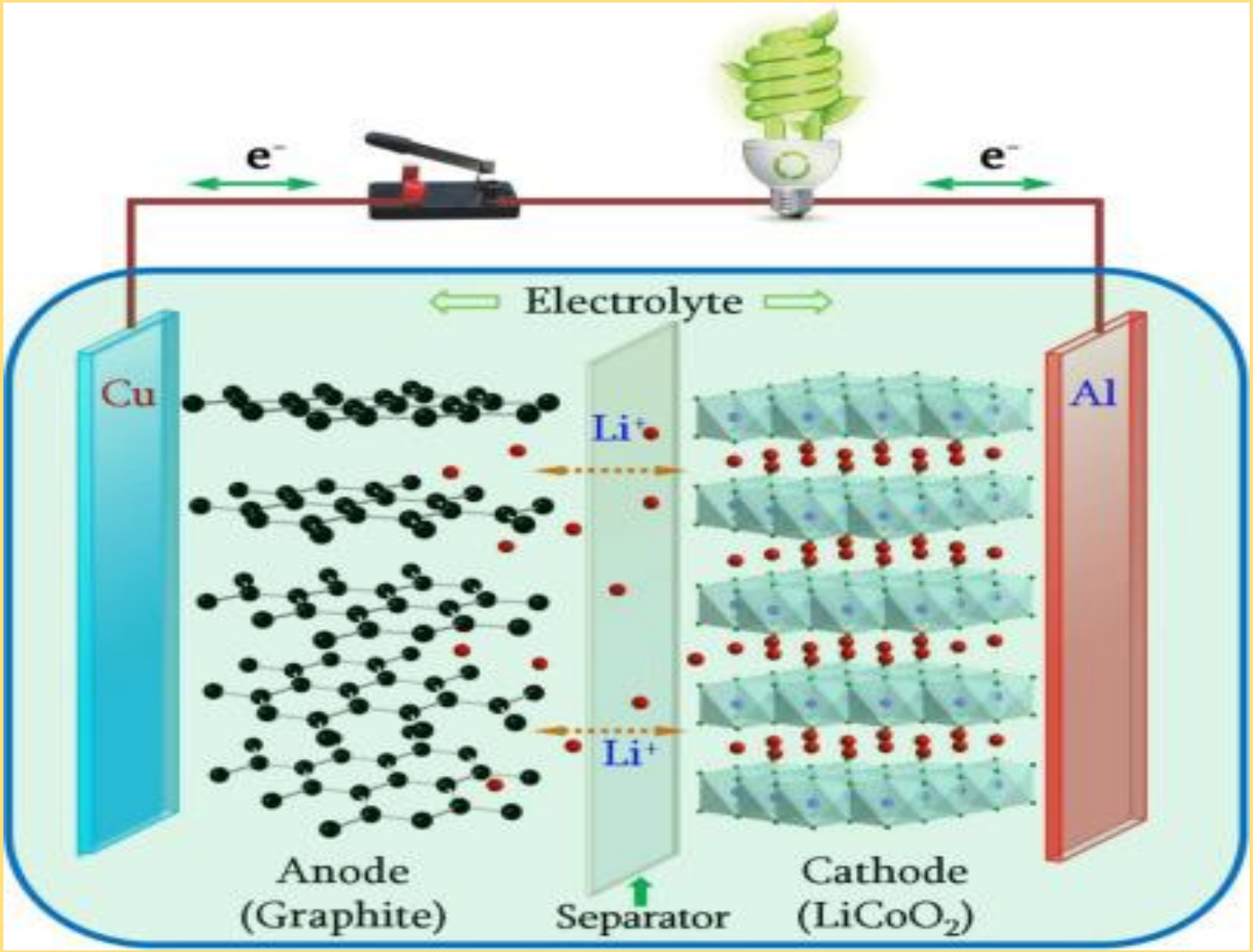
Types of Batteries

- Lead acid Batteries



Types of Batteries

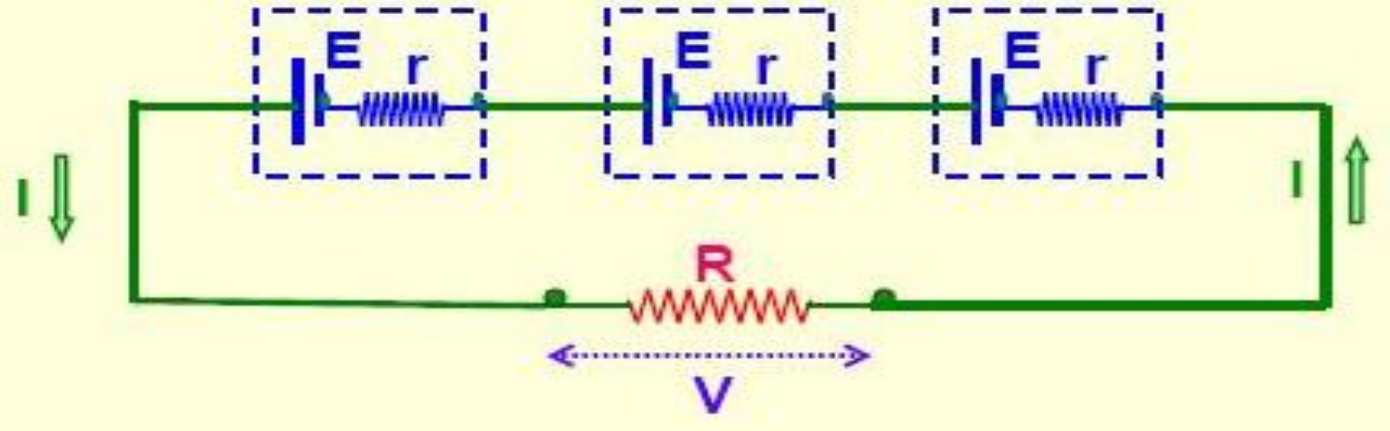
- Lithium Ion batteries



Grouping of cells

- Cells may be grouped in three ways:

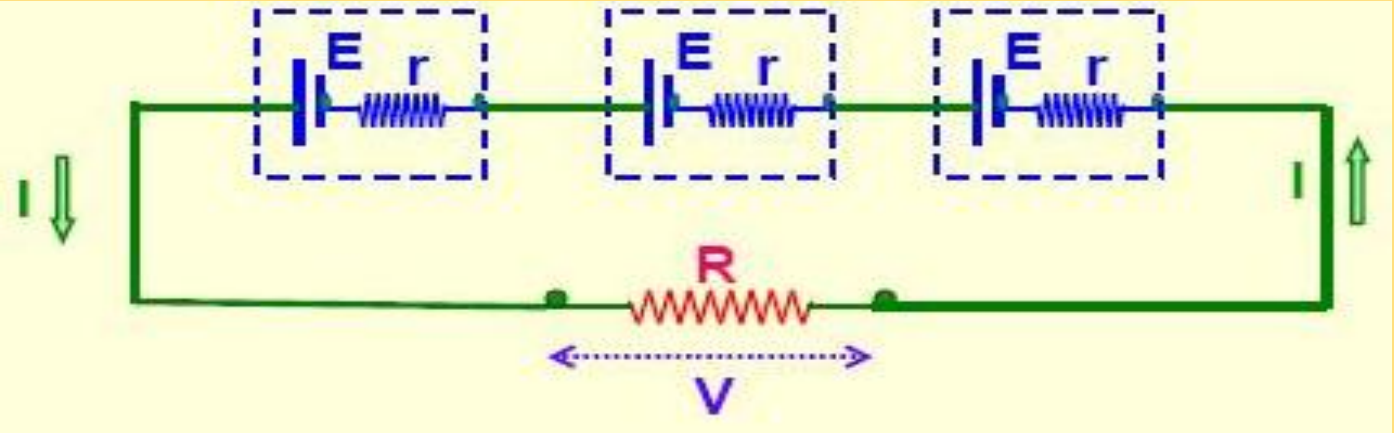
1. Series combination: For **"Higher Voltage"**



- *"n"* number of cells are connected in series
- e.m.f. is " ***E volts*** "
- Internal resistance of " ***r Ω*** "
- Load resistance " ***RΩ*** "

Grouping of cells

- For Series combination



– Total internal resistance of the battery = " $n\,r\,\Omega$ "

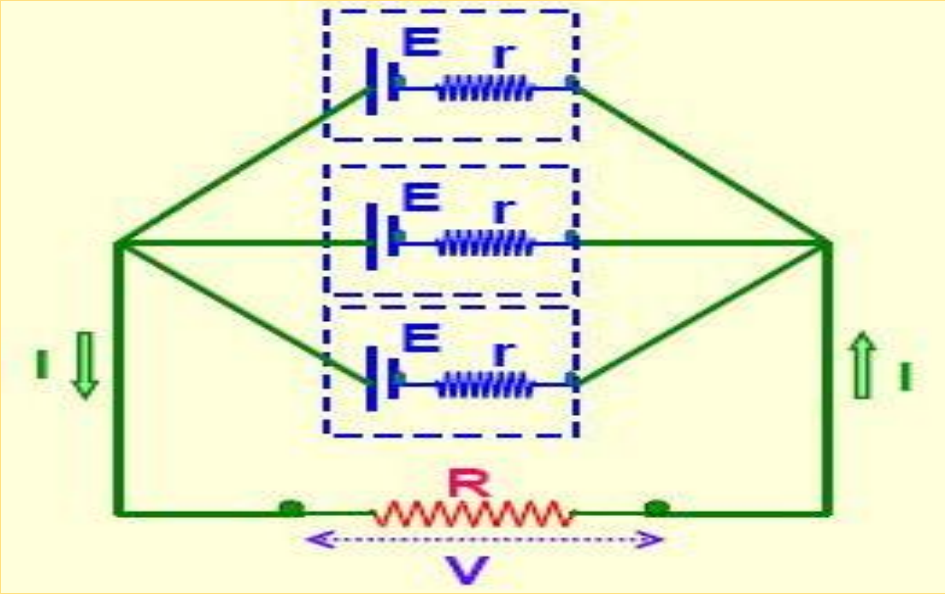
– Total e.m.f. = " $n\,E$ volts "

– Total Resistance = " $R + nr\,\Omega$ "

➢ **Current in load** " $= \dfrac{n\,E}{R + n\,r}$ Amperes "

Grouping of cells

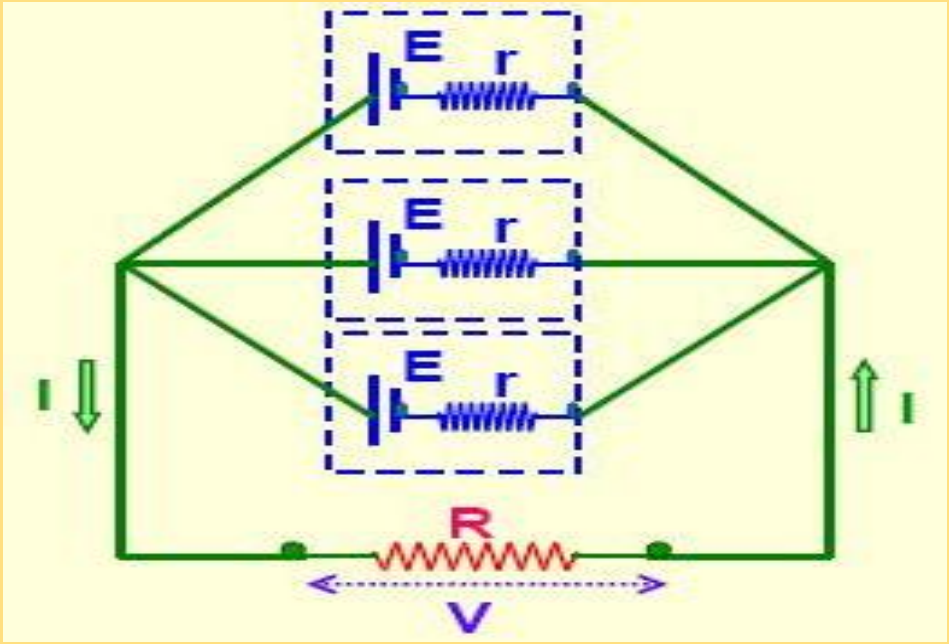
2. Parallel Combination: For "Higher Current"



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

Grouping of cells

- For Parallel Combination:



Total Resistance

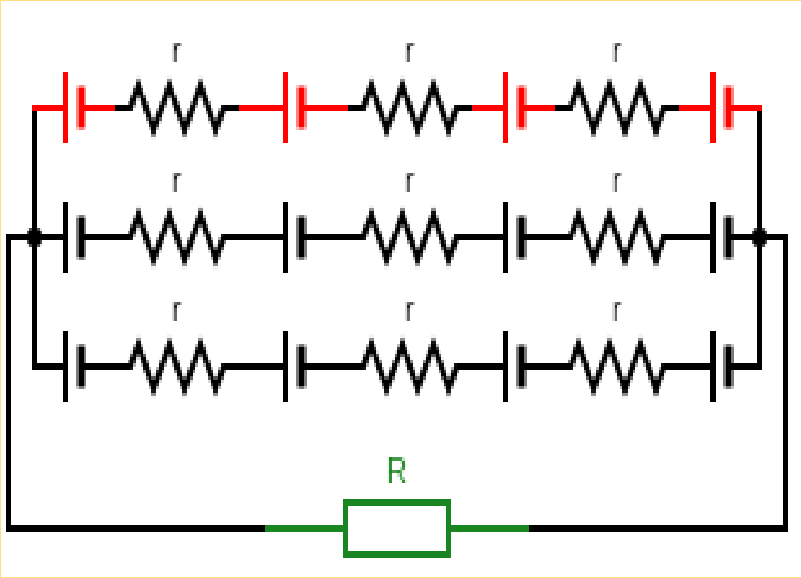
" $= R + \frac{r}{n} \Omega$ "

➢ **Current in load**

" $= \frac{E}{R + \frac{r}{n}} = \frac{nE}{nR + r}$ *Amperes* "

Grouping of cells

3. Series-parallel combination (SPC) :

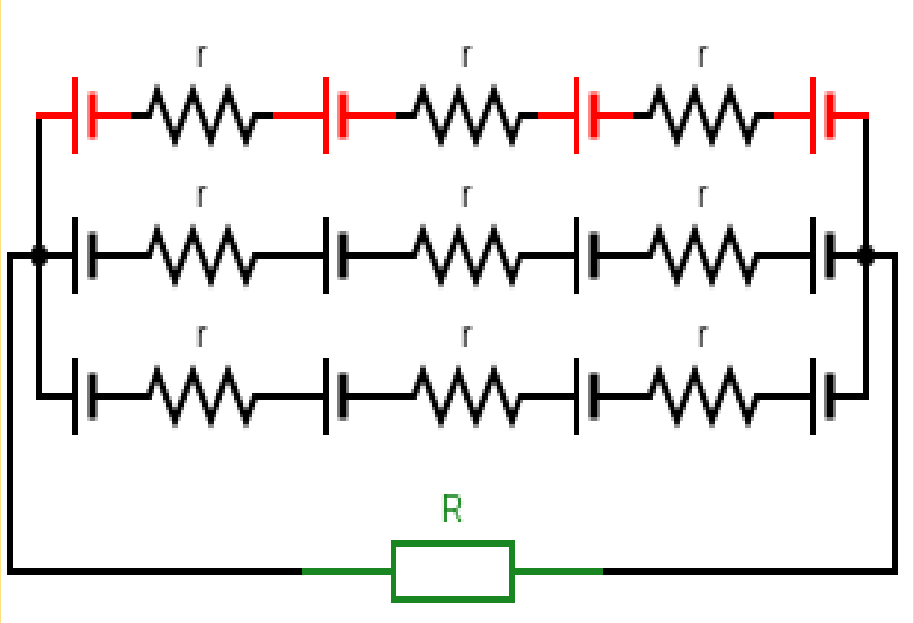


- *"m"* sets of cells in SPC
- Each set with *"n"* no. Cells in series
- E.m.f. is " nE volts "
- Load resistance " $R\,\Omega$ "

- Total internal resistance of *"n"* cells in series = " $nr\Omega$ "
- Total internal resistance of *"m"* set of battery = " $\frac{nr}{m}\Omega$ "
- Total resistance = " $R+\frac{nr}{m}\Omega$ "

Grouping of cells

- Series-parallel combination (SPC) :



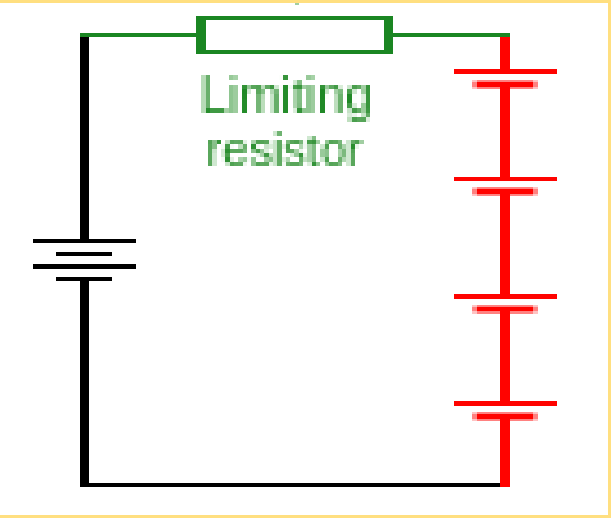
– **Current in load resistance R**

$$= \frac{nE}{R + \frac{nr}{m}} = \frac{mnE}{mR + nr} \; Amperes$$

Charging a battery

- Three systems of battery charging

1. Constant current charging system:
    - Charging current is controlled by
        - Carbon filament lamps or
        - 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
- Total Voltage of the battery should not increase supply voltage
    - Or else the battery would discharge

Charging a battery

- 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

Charging a battery

2. 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 but back emf will be very low
  - After some time the process is reversed
    - Charging current decreases to a very small value
    - Back emf of the battery increases on being charged

Charging a battery

2. Constant potential charging:

Advantage:

– Time required to charge a battery is less than constant current charging method but this reduces efficiency

Disadvantage:

– This system reduces the life of battery upto some extent

Charging a battery

3. 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

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)
- Positive and negative terminals should be

Types of efficiency of Cell

- Two types of efficinety
  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