

# Power System Management

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# Cell an Battery

- The Cell. This basic electrochemical unit handles the actual storage of energy in a battery
- A cell contains 3 main components: 2 electrodes and an electrolyte
- 2 electrodes: Anode(-) and cathode(+)
- Electrolyte: Acts as the medium for transferring charge in the form of ions between two electrodes.
- It isn't electrically conductive but is an ionic conductive. It is often referred to as Ionic Conductor.

# Types of Batteries

- Electrochemical cells and batteries are categorised into two basic types:
  - Primary (non-rechargeable)
  - Secondary (rechargeable)

# Types of Batteries – Primary batteries

- Convenient sources of power for portable electronics and devices
- Examples: radios, watches, toys, lights, camera, and more
- Can't be recharged once they run out of power
- Inexpensive, lightweight, and convenient to use with no maintenance
- Cylindrical form:
  - *Alkaline batteries which uses potassium hydroxide electrolyte—a pure alkaline substance*
  - *a chemical composed of zinc (Zn) and manganese dioxide (MnO<sub>2</sub>) & has a power density of 100 Wh/kg*
- Coin-shaped:
  - *Chemical composition is alkaline but contains lithium & silver oxide chemicals*
  - *More efficient, providing steady & stable voltage*
  - *Has a power density of 270 Wh/kg.*

# Types of Batteries – Primary batteries

| <i>Battery Type</i>                         | <i>Characteristics</i>                                     | <i>Applications</i>  |
|---|--|--|
| Alkaline<br>(Zn/Alkaline/MnO <sub>2</sub> ) | Very popular, moderate cost, high performance              | Most popular primary batteries                                   |
| Magnesium (Mg/MnO <sub>2</sub> )            | High capacity, long shelf life                             | Military and aircraft Radios                                     |
| Mercury (Zn/HgO)                            | Very high capacity, long shelf life                        | Medical (hearing aids, pacemakers), photography                  |
| Lithium/Solid Cathode                       | High energy density, low temp performance, long shelf life | Replacement for button and cylindrical cells                     |
| Lithium/Soluble Cathode                     | High energy density, good performance, wide temp range     | Wide range of applications with a capacity between 1 – 10,000 Ah |
| Lithium/Solid Electrolyte                   | Low power, extremely long shelf life                       | Memory circuits, medical electronics                             |
| Silver/Zinc (Zn/Ag <sub>2</sub> O)          | Highest capacity, costly, flat discharge                   | Hearing aids, photography, pagers                                |
| Zinc – Carbon                               | Common, low cost, variety of sizes                         | Radios, toys, instruments  |

# Types of Batteries – Secondary batteries

- Main advantage: Can be recharged and reused meaning rechargeable batteries
- Cost more than primary battery but have can have a longer lifespan
- Application:
- Storage devices
  - *Uninterrupted Power Supplies (UPS) & Hybrid Electric Vehicles (HEV)*
  - *Energy storage devices that are electrically connected to main energy source & simultaneously charged by it, supplying the needed energy*
- Applications where the battery is used and discharged as a primary battery
  - *Can be recharged with a charging mechanism once they're completely or almost discharged*
  - *Smartphone batteries(lithium-ion battery) & Cars/vehicles (lead-acid batteries)*

# Types of Batteries – Secondary batteries

- Other types of rechargeable batteries:
- Nickel – Cadmium Batteries
  - *One of the oldest battery types available today.*
  - *Have a very long life and are also very reliable and sturdy.*
- Nickel – Metal Hydride Batteries
  - *A new type of battery, an extended version of Nickel – Hydrogen Electrode Batteries.*
  - *Ideal use in aerospace applications (satellites).*

# Types of Batteries



Alkaline battery



Lithium battery



Rechargeable battery



Sealed Lead-acid battery



# Calculating Battery Runtime

- Gives a realistic approximation of the battery runtime basing on its capacity and the energy consumption of your device
- Formula:

$$\text{battery life} = \frac{\text{capacity}}{\text{consumption}} \times (1 - \text{discharge safety})$$

- *Capacity: Battery capacity in ampere hours*
- *Consumption: Average current draw of the electronic device in amperes*
- *Discharge safety: Percentage of battery capacity that is never used.*

# How long will a battery last: sleep mode

- Some device that spends most of the time in sleep mode
- Formula:

$$\text{Average consumption} = \frac{\text{consumption1} \times \text{time1} + \text{consumption2} \times \text{time2}}{\text{time1} + \text{time2}}$$

- *Index 1: awake mode*
- *Index 2: sleep mode*

# Wireless Charging AGV

- Inductive wireless charging system AGVs and AMRs can perform contactless battery opportunity charging
- Counts on a stationary active fixed coil on the floor on a wall and on a mobile passive coil on the mobile robot
- active coil generates a magnetic field that induces an alternated current in the mobile coil. This current is used to charge the mobile robot battery
- Main AGV and AMR Wireless Charging Systems manufacturers:
  - B&PLUS, Daihen, Delta energy Systems, In2Power, WiBotic, Wiferion

# Wireless Charging AGV

- Mainly have two different AGV charging systems to manage battery charging:
  - “opportunity charging” a.k.a. “online charging”
  - “battery replacement” a.k.a. “battery swap”

# Wireless Charging AGV-Opportunity Charging

- Permits batteries to be charged several times during its working hours
- The AGV goes to defined charging stations and performs charging while waiting for a new mission to be delivered
- If the battery balance is properly calculated, the vehicle could never need a change of battery.

# Wireless Charging AGV-Battery Swap

- Mobile robot works with a single battery until it is fully drained that need to be swapped with a fully charged one
- Battery swapping can be done manually or automatically as needed or on a schedule