RAFAY AAMIR GULL
BSEE19047
PE-ASSIGNMENT 5

Q1: Describe following types of batteries:

a) Lithium-ion batteries

A lithium-ion battery or Li-ion battery is a type of rechargeable battery composed of cells in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge and back when charging. Li-ion cells use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. Li-ion batteries have a high energy density, no memory effect (other than LFP cells). Generally, the negative electrode of a conventional lithium-ion cell is made from carbon. The positive electrode is typically a metal oxide. The electrolyte is a lithium salt in an organic solvent. The electrochemical roles of the electrodes reverse between anode and cathode, depending on the direction of current flow through the cell. Life of a lithium-ion battery is typically defined as the number of full charge-discharge cycles to reach a failure threshold in terms of capacity loss or impedance rise. Manufacturers' datasheet typically uses the word "cycle life" to specify lifespan in terms of the number of cycles to reach 80% of the rated battery capacity.

b) Lithium polymer batteries

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly, lithium-poly), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this electrolyte. These batteries provide higher specific energy than other lithium battery types and are used in applications where weight is a critical feature, such as mobile devices, radio-controlled aircraft, and some electric vehicles. LiPos work on the principle of intercalation and de-intercalation of lithium ions from a positive electrode material and a negative electrode material, with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a microporous separator is in between which allows only the ions and not the electrode particles to migrate from one side to the other. The voltage of a single LiPo cell depends on its chemistry and varies from about 4.2 V (fully charged) to about 2.7–3.0 V (fully discharged).

c) Lithium Phosphate Iron batteries

The lithium iron phosphate battery (LiFePO 4 battery) or LFP battery (lithium ferro phosphate) is a type of lithium-ion battery using lithium iron phosphate (LiFePO 4) as the cathode material, and a graphitic carbon electrode with a metallic backing as the anode. The energy density of an LFP battery is lower than that of other common lithium ion battery types such as Nickel Manganese Cobalt (NMC) and Nickel Cobalt Aluminum (NCA), and also has a lower operating voltage; CATL's LFP batteries are currently at 125 watt hours (Wh) per kg, up to possibly 160 Wh/kg with improved packing technology, while BYD's LFP batteries are at 150 Wh/kg, compared to over 300 Wh/kg for the highest NMC batteries. Cell minimum discharge voltage is 2.5V, working voltage is between 3.0 to 3.2V and maximum charge voltage is 3.65V. Some electronic cigarettes use these types of batteries. Other applications include marine electrical systems and propulsion, flashlights, radio-controlled models, portable motor-driven equipment, amateur radio equipment, industrial sensor systems.

d) Lead Acid Batteries

The lead–acid battery is a type of rechargeable battery first invented in 1859 by French physicist Gaston Planté. It is the first type of rechargeable battery ever created. Compared to modern rechargeable batteries, lead–acid batteries have relatively low energy density. Despite this, their 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 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. Most of the world's lead–acid batteries are automobile starting, lighting, and ignition (SLI) batteries, with an estimated 320 million units shipped in 1999. In 1992 about 3 million tons of lead were used in the manufacture of batteries. Wet cell stand-by (stationary) batteries designed for deep discharge are commonly used in large backup power supplies for telephone and computer centers, grid energy storage, and off-grid household electric power systems. Lead–acid batteries are used in emergency lighting and to power sump pumps in case of power failure.

Q2: Explain following parameters of above discussed batteries:

Charge and discharge rates of a battery are governed by C-rates. The capacity of a battery is commonly rated at 1C, meaning that a fully charged battery rated at 1Ah should provide 1A for one hour. Some high-performance batteries can be charged and discharged above 1C with moderate stress.

a) **Lithium-ion batteries**

self-discharge rate of 1.5-2% per month, charging rate (0.5 and 1.0 C). Energy density 250–693 W·h/L

b) **Lithium polymer batteries**

Charging rate Between 30 and 70 %, discharging rate 5% per month and instantaneous charging rate of lithium polymer battery is 15C. charge density of lithium polymer battery is 90-160 Wh/kg.

c) **Lithium Phosphate Iron batteries**

It has a charging rating of 1C and a discharging rate of up to 25C. Stage 1 charging is typically done at 10%-30% (0.1C to 0.3C) current of the capacity rating of the battery or less. Charge density of Lithium Phosphate Iron batteries is 170mAh/g.

d) **Lead Acid Batteries**

Charging rate of Lead Acid Batteries is between 10-30% of its nominal capacity. Discharging rate is the current that the battery can provide in 20 hours discharged to a final voltage of 1.75 volts per second.

Q3: What are UAV drones and EVs? What batteries you recommend for these and why?

An unmanned aerial vehicle (UAV), commonly known as a drone, is an aircraft without any human pilot, crew, or passengers on board. UAVs are a component of an unmanned aircraft system (UAS), which includes adding a ground-based controller and a system of communications with the UAV.[1] The flight of UAVs may operate under remote control by a human operator, as remotely piloted aircraft (RPA), or with various degrees of autonomy, such as autopilot assistance, up to fully autonomous aircraft that have no provision for human intervention. Electric vehicles (EVs) are still cars, and anyone who has driven an automatic vehicle will feel immediately at home behind the wheel of one.

LFP, lithium ferro-phosphate is the alternative cell chemistry being used by Tesla in some models but has been around for a long time. It is more commonly used in China and often used with high power low range applications (buses/trucks). LFP is different to conventional li-ion but neither worse nor better. Its charges/discharges very easily, has an exceptional cycle life (you can charge/discharge many times with very little degradation) but at a cost of being less energy dense, so you need more volume to fit the same capacity of battery. You can very roughly equate cycle life to total lifetime mileage of the car – more cycles is more miles before pack needs replacing.

Most drones use Lipo powered batteries because they are better than other types. They can store larger amounts of power than Nicad batteries. Therefore, it is important to consider a reliable battery because the fun of flying a drone is through extended battery life which will enable you to have longer flights.

Q3: Describe battery management system

In simple words, a Battery Management System, popularly known as BMS, is an embedded system that monitors battery voltage, state of charge (SOC), state of health (SOH), temperature and other critical parameters and controls charging and discharging of a battery.

In general, the BMS does the following tasks:

- ❖ Detects unsafe operating conditions and ensures the safety of the host application and its user.
- ❖ Protects the cells of the battery from abuse.
- ❖ Enhances the life of the battery.
- ❖ Maintains the battery in a state which can fulfill the host application’s requirements.

All these are targeted towards the main motive of making the best use of the battery that is currently available. There are five major functionalities of BMS:

- Sensing and High Voltage Control
- Protection against Over Voltage, Under Voltage, Over Current, Short Circuit and High Temperatures
- Interface with the Host Application
- Performance Management
- Diagnostics