Lithium Ion Batteries and Ham Radio

V1.0

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Tonight's Topics

- Presentation Focus
- Lithium-Ion Battery History and Ham Radio
- Types of Lithium-Ion Batteries
- Advantages & Disadvantages
- Batteries for Handheld Radios
- Batteries for Portable Operation
- Safety and Storage
- Recycling Spent Batteries
- Useful Links

Presentation Focus

- Tonight's focus will be about Lithium Ion (Li-Ion) batteries employed in the use of handheld and portable operations
- Discussion will be limited to two chemistry types
- Advantages and disadvantages of these will be covered
- Factory replacement battery packs and other commercially available sources will be discussed
- Safety and storage will wrap up the presentation

Lithium-Ion Battery History and Ham Radio

Lithium Battery Timeline

- **2000 and prior** – NiCad and NiMH was the standard battery pack supplied with handheld radios
- **Early 2000's** – the transition to Li-Ion began with Yaesu, Icom and Kenwood
- **2002** – The Yaesu VX-7R was released with a Li-Ion battery pack
- **2007** - The "iPhone Effect" - The mass production of smartphones drastically lowered the cost of Li-ion technology, leading to it become the standard for nearly all new handheld radios.
- **2010's and beyond** – Mass market adoption continued with Baofeng UV-5R and other lower cost radios equipped standard with Li-Ion battery packs
- **And here we are today…** ☺

Types of Lithium-Ion Batteries

Six Types of Batteries

- These types are distinguished by their specific active materials, which dictate their energy density, lifespan, safety, and ideal applications.
- **Key Lithium-Ion Battery Types:**
- **Lithium Iron Phosphate (LiFePO4/LFP):** Known for long life, high safety, and stability; widely used in electric vehicles (EVs) and energy storage systems and today's ham radio applications.
- **Lithium Cobalt Oxide (LCO):** Highest energy density, typically used in portable electronics like smartphones, laptops, and cameras. LCO was the initial Li-Ion battery type used in handheld radios.
- **Lithium Nickel Manganese Cobalt Oxide (NMC):** A popular, high-energy, versatile, and high-performance option used in power tools, e-bikes, and electric vehicles.
- **Lithium Nickel Cobalt Aluminum Oxide (NCA):** Offers high energy density and long life, often used in specialized high-performance EVs.
- **Lithium Manganese Oxide (LMO):** Known for fast charging and high current, often used in power tools and medical devices.
- **Lithium Titanate (LTO):** Extremely safe and fast-charging, but with lower capacity, used in specialized, rugged, or fast-charging applications.

Advantages & Disadvantages

Lithium Cobalt Oxide

Advantages

- **Lithium Cobalt Oxide**
- **Highest Energy Density**: LCO batteries have one of the highest energy densities among all lithium-ion chemistries. This allows them to store a significant amount of energy in a very small and lightweight package, which is critical for thin modern mobile devices.
- **High Operating Voltage**: They typically operate at a nominal voltage of **3.7V** with a full charge voltage of **4.2V**. This higher voltage platform results in better power usage efficiency compared to chemistries like LFP (3.2V).
- **Superior Power Output**: These batteries can deliver high discharge rates, providing the necessary bursts of energy for high-drain devices. Specialized high-rate LCO cells can achieve continuous discharge rates of up to **50C** and pulse rates up to **150C**, making them ideal for racing drones and power tools.
- **Structural Stability**: Cobalt stabilizes the layered structure of the cathode, preventing it from degrading rapidly during charge and discharge cycles. This structural integrity ensures consistent efficiency and reliability over the battery's lifespan.
- **Fast Charging Capabilities**: LCO batteries are capable of rapid charging, which is a major benefit for consumer electronics that need to be ready for use quickly.
- **Mature Technology**: Introduced in 1991, LCO is a well-understood and highly refined technology with proven performance and established manufacturing processes.

Disadvantages

- **Lithium Cobalt Oxide**
- **Thermal Instability**: LCO batteries have low thermal stability, making them prone to **thermal runaway**—a condition where overheating leads to uncontrollable temperature rises, fires, or explosions.
- **Limited Safety Margin**: They are highly sensitive to "abusive" conditions such as overcharging, physical damage, or extreme heat.
- **Dendrite Formation**: During full charging, excess lithium ions can form "dendrites" (needle-like structures) that may pierce the internal separator, causing a dangerous internal short circuit.
- **Short Lifespan**: LCO batteries typically last only **500–1,000 cycles**, which is significantly shorter than chemistries like LFP that can reach 2,000+ cycles.
- **Low Specific Power**: While they store a lot of energy, they cannot deliver high currents quickly. This makes them unsuitable for high-load applications like electric vehicles or power tools.
- **Temperature Sensitivity**: Performance degrades significantly in extreme cold (capacity loss) and extreme heat (instability).

Advantages & Disadvantages

Lithium Iron Phosphate

Advantages

- **Lithium Iron Phosphate**
- **Advantages of LiFePO Batteries**
- **Batteries:**
- **Exceptional Safety:** LFP chemistry is highly stable, significantly reducing risks of fire or explosion, even if damaged, making them safer for indoor and residential use.
- **Long Cycle Life:** These batteries can last for 3,000 to over 5,000 cycles, providing a much longer lifespan than traditional lead-acid or even some other lithium-ion types
- **High Thermal Stability:** They perform reliably in high-temperature environments, unlike other chemistries that may degrade quickly under heat.
- **Rapid Charging:** LFP batteries support faster charging rates, which improves efficiency in electric vehicles and portable applications.
- **Environmental Friendliness:** They contain no toxic, hazardous metals (like cobalt), making them safer for the environment.
- **Deep Depth of Discharge (DoD):** They can be discharged to 100% without damage, unlike lead-acid batteries that usually recommend 50% depth of discharge.
- **Constant Voltage:** They maintain a higher voltage throughout the discharge cycle, which means more consistent power output.

Disadvantages

- **Lithium Iron Phosphate**
- **Disadvantages of LiFePO4 Batteries**
- **Lower Energy Density:** Compared to NMC (Nickel Manganese Cobalt) batteries, LFP has lower energy density, making them less ideal for compact or lightweight, high-performance applications like long-range electric vehicles or aerospace.
- **Poor Cold Weather Performance:** LFP batteries experience significantly reduced efficiency and capacity at low temperatures, making them less suitable for cold climates without heating systems
- **Higher Initial Cost:** While offering lower cost-per-cycle over their lifetime, the initial, upfront purchasing cost is higher than lead-acid alternatives.
- **Battery Management System (BMS) Dependency:** LFP batteries are very sensitive to deep discharge and overcharging, making a protective BMS mandatory to prevent premature failure or damage.
- **Inaccurate Charge Estimation:** Their flat discharge voltage curve makes it difficult for traditional battery monitors to accurately predict the remaining charge (State of Charge), which can lead to abrupt power loss.
- **Weight and Size:** They are generally heavier and bulkier than other lithium-ion batteries with similar energy capacity.
- **Despite these disadvantages, LiFePO4 is considered one of the safest lithium battery chemistries because they do not easily experience thermal runaway**

Batteries for Handheld Radios

Handheld Radio Battery Packs

- Today, most OEM's in the handheld radio market supply battery packs with Li-Ion batteries standard.
- One battery comes with the radio.
- Additional batteries are available from the OEM's with some offering higher capacity for longer talk/standby time.
- Some like the Yaesu FT-60 provide NiMH ONLY packs and optional alkaline battery trays. *This radio has No Li-Ion option*.
- Others may provide Li-Ion standard and Alkaline optionally
- Make sure you *know* what comes in the box!

Handheld Radio Battery Packs

- Verify how the batteries can be charged as there is frequently more than one way
  - Drop-in chargers require an AC adapter – usually additional cost
  - Many radios include an AC adapter that connects directly to the radio for charging but may not be compatible with an optional drop-in charger.
  - There are also cigarette lighter plug equipped charge cords as optional
  - **NEVER** charge **ANY** battery with a charger or cord other than the OEM supplied accessories or *approved* aftermarket products

Batteries for Portable Operation

Batteries for Portable Operation

- The battery industry now produces Lithium-Ion batteries that are well suited for 12-volt applications in the field.
- They are great for portable operations like camping, POTA, SOTA, IOTA, etc.
- They are Lithium Iron Phosphate (LiFePO4) chemistry like the handheld radio battery packs.
- They cost more than traditional lead-acid batteries and are much lighter
- A product-specific battery charger is required and is not included
- There are several smaller batteries well suited for HF QRP operation as well as higher capacity for larger power needs
  - QRP = 5W output for CW, AM/FM and digital modes with 10W PEP or less for SSB
  - QRPp = 1W output or less

Batteries for Portable Operation

12 Volt – 6AH LiFePO chemistry with charger
About $100

12 Volt – 3AH LiFePO chemistry with charger
About $70

Safety & Storage

Safety & Storage

- LiFePO4 batteries should be stored in a cool, dry, well-ventilated area, ideally between 59 and 77 degrees, F.
- For safety, store them away from flammable materials, direct sunlight, and extreme temperatures, checking voltage every 3–6 months to prevent over-discharge.
- Storage voltage should be 3.2 – 3.4 volts per cell
  - 6.4 – 6.8 volts for a 2 cell battery pack
  - 12.8 – 13.2 volts for a 12 volt battery
- Maintenance: Check voltage every 6–12 months and charge if it drops below 3.0V per cell.
  - 6 volts for a 2 cell (6.4V) HT battery pack
  - 12 volts for a 4 cell (12V) battery

Recycling Spent Batteries

Recycling Spent Batteries

- Consumers should **never** place Li-Ion batteries in household trash or recycling bins, as they cause fire risks
- *Instead*, tape the terminals (using non-conductive tape) or bag individual batteries, then drop them off at dedicated electronics retailers like Best Buy, Home Depot, local household hazardous waste (HHW) facilities, or utilize mail-back programs, according to the US EPA and Earth911
- Be a responsible recycler!

Useful Links

- Supplier Websites
  - DX Engineering
  - Powerwerx
  - Ham Radio Outlet
  - Bridgecom Systems
  - Batteries America
- Radio Manufactuer Websites
  - Icom
  - Yaesu
  - Kenwood
  - Baofeng
  - AnyTone

Lithium Ion Batteries and Ham Radio

Thanks for checking in to the CORC TechNet this evening!

73 until next time!