Lecture 25: Charging Control & Battery Management

Mobile Device

DI05011011: Mobile Communication

Agenda for Today

- 1. Introduction to Mobile Batteries
- 2. Battery Types: Li-Ion vs. Li-Po
- 3. Battery Management System (BMS)
- 4. The Charging Control Section
- 5. Charging Phases (CC / CV)
- 6. Fast Charging Technologies
- 7. Summary

1. Introduction to Mobile Batteries

- Mobile phones require energy storage that is light, compact, and offers high energy density.
- Early phones used Nickel-Cadmium (NiCd) or Nickel-Metal Hydride (NiMH).
- These suffered from the 'Memory Effect' (losing maximum capacity if repeatedly partially discharged).
- Modern devices rely exclusively on Lithium-based chemistries.

2. Battery Types: Lithium-Ion (Li-Ion)

- **Lithium-Ion (Li-Ion):**
- - Uses a liquid solvent as an electrolyte.
- - Encased in a rigid metal shell (cylindrical or prismatic).
- - **Pros:** High energy density, relatively low manufacturing cost.
- - **Cons:** Heavier, rigid shape dictates phone design, liquid electrolyte is flammable if punctured.

Battery Types: Lithium-Polymer (Li-Po)

- **Lithium-Polymer (Li-Po):**
- - Uses a solid or gel-like polymer electrolyte.
- - Encased in a flexible foil pouch.
- - **Pros:** Ultra-thin, lightweight, can be molded into various shapes to fill empty space in a handset. Safer (less prone to leaking).
- - **Cons:** Slightly lower energy density than Li-Ion, higher manufacturing cost.

3. The Battery Management System (BMS)

- Lithium batteries are volatile and easily damaged by overcharging or deep discharging.
- A BMS is a small circuit board physically attached to the battery cell.
- **Functions:**
- - Prevents over-voltage during charging.
- - Prevents under-voltage (over-discharge) during use.
- - Monitors temperature to prevent thermal runaway.

4. The Charging Control Section

- Located on the main motherboard (PMIC - Power Management IC).
- Regulates the power coming from the USB port adapter.
- Communicates with the charger to negotiate voltage and current.
- Dynamically adjusts the charging current based on battery temperature and state of charge.

5. Charging Phases: CC and CV

- Charging a Lithium battery occurs in two main phases:
- **1. Constant Current (CC) Phase:**
- - Used from 0% to about 80% charge.
- - Charger supplies maximum safe current.
- - Battery voltage slowly rises.
- **2. Constant Voltage (CV) Phase:**
- - Used from 80% to 100%.
- - Voltage is held steady (usually 4.2V or 4.35V).
- - Current gradually decreases to near zero as the battery tops off.

Graph: CC-CV Charging Profile

- (Imagine a graph here)
- - **X-Axis:** Time
- - **Y-Axis:** Current / Voltage
- - **Phase 1 (CC):** Current line is flat (high), Voltage line curves upward.
- - **Phase 2 (CV):** Voltage line is flat (max), Current line curves steeply downward.
- When Current drops below a termination threshold (e.g., 50mA), the charging control IC stops charging completely.

6. Fast Charging Technologies

- Standard USB provides 5V at 1A or 2A (5W or 10W).
- Fast charging (Qualcomm Quick Charge, USB-PD, VOOC) negotiates higher voltages (9V, 12V, 20V) to deliver more power (18W, 65W, 100W+).
- Higher voltage means less current for the same power, reducing heat in the charging cable.
- The Charging IC in the phone steps the voltage back down to safely charge the battery.

Summary

- Modern handsets rely on Lithium-Ion or Lithium-Polymer batteries.
- The Battery Management System (BMS) ensures safe operation limits (voltage, temperature).
- The Charging Control IC manages the CC (Constant Current) and CV (Constant Voltage) charging phases.
- Fast charging standards dynamically negotiate voltage to decrease charge times safely.

Next Lecture Preview

- In the next lecture, we will explore:
- **1. The SIM Card:** What is inside it?
- **2. SIM Interface:** How does the phone talk to it?
- **3. eSIM Technology:** The shift away from physical cards.