Advanced Battery Charger Considerations for Portable Devices

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Battery Charge Management
Texas Instruments
Li-Ion Charge CC-CV Profile

- **Constant Current**: 20-30% charging time, 70-80% capacity
- **Constant Voltage**: 70-80% charging time, 20-30% capacity
Battery Charger Topologies
Charger Requirements for Portable Devices

Input Power Source

- Adapter: 5V, 9V, and 12V up to 2A (24W)
- USB2.0: 5V@100mA/500mA (many systems)
- USB3.0: 5V@150mA/900mA/1.5A

Battery System Performance:

- Support dynamic system pulsating power
- Fast and high efficiency charging
- Supporting all kinds of battery chemistry
- Thermal management
Charging with an Active System Load

Charger output current is shared:
\[ I_{CHG} = I_{BAT} + I_{SYS} \]

Issues:
- Operate system and charging simultaneously
- Safety Timer
- Termination
Linear Charger with DPM Architecture

- Separate charge current path from system current path
- Charge current controlled by Q2
- Powering System from adapter through Q1
- Simultaneously powering system and charging battery
- Linear Charger
Switch-Mode Battery Charger with DPM

- Maximize use of the input current
- Current sharing between system & charger
- Minimize the AC adapter size and power rating

How to avoid adapter crash if its current is NOT Known?
Consideration 1: How to Support unknown Adapter?

Input Voltage Regulation DPM

- If \( V_{IN} < V_{INDPM} \); \( D \rightarrow I_{CHG} \rightarrow I_{IN} \rightarrow VIN = V_{INDPM} \)
- Automatically Track Adapter’s Max Current.
- Perfect for third party adapter
Consideration 2: How to Support Pulsating Load?

Supplement Mode Operation

Pre-charge: Q4 -- Linear Mode, Fast Charge: Q4 = ON

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Consideration 3: How To Reduce the Battery Charging?

- High Current Charging
- IR Compensation
  1. Extending the Constant Current mode
  2. Reducing the Constant Voltage charging time
Battery Charging Time

Goal:
VREG = 4.2V + IR  (R = Rdson + Rsense + Trace resistance)
Battery Charging Profile with IR Compensation

- Longer constant current phase and shorter constant voltage phase reduces total charge time.

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Consideration 4: How To Support USB OTG?

- Bidirectional Synchronous Buck:
  a. Charge in Buck
  b. Discharge in Boost for USB OTG

- Save an additional Boost converter
Design Examples
4A I2C Single Cell Battery Charger

Support DC Adaptor, USB2.0 and USB 3.0 up to 3A

Input 3.9V – 17V

D+/D- Detection

I2C Interface

USB On-The-Go Default USB Current

USB: 3.4V-4.4V

Up to 4A Charge Current and 6A Discharge Current

Input Current Setting

Integration of power path and switching MOSFETs

Dual battery pack Thermistor Monitoring

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Thermal Performance (IC Case Temperature)

bq24190 PG10 Case Temperature

- VBUS=5V, VBAT=3.8V
- VBUS=9V, VBAT=3.8V
- VBUS=12V, VBAT=3.8V

VBAT=3.8V, Ta= 31ºC
System Efficiency

- Measured on EVM

![Graph showing system efficiency vs. charge current for VBUS 5V, 9V, and 12V.]

*V BAT* = 3.8V with 2.2uH inductor

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Summary

• Charger Topology: Linear vs Switching Mode charger
• How to Support all kinds of Power Source and USB?
• Fast Charging: high charge current and IR Compensation
• Design Examples