

TI 电池保护及电量计方案详解

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Battery Management: What problem are we solving?

Battery Charging Products

- Faster & Cooler charging
- High efficiency and Flexibility
- Highly integrated
- Low power and high power
- Extend battery life & run time

Battery Gauge Products

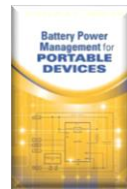
- Longer run time (15%-20%)
- Maximum Life
- 99% Accuracy (Impedance Track™)
- Reports state of charge & state of health
- High cell count precision AFE & cell balancing
- Primary, secondary & total protection
- Enhanced safety
- Counterfeit batteries & accessories

Battery Automotive Products

- High cell count precision AFE & cell balancing for automotive applications
- Primary, secondary & total protection
- Enhanced safety

Industry Leader

- Wireless Power Standard, ISO26262, Smart Battery Data interface and more
- Impedance Track™ and CEDV fuel gauging
- Energy Harvesting
- 100's of patents



Committed to Customers

- Investing more R&D in emerging technologies & applications
- 300 battery engineers world wide
- 500 customers trained yearly
- Online Battery Management University

Better user experience

Application Reference Design

1) 应用描述

2) 参考设计

3) 子系统选择

4) 参考设计

5) 参考设计

6) 优选器件推荐

7) 应用文档及其他

Technical documents
Application notes & user guides
Application Notes (3)

Tools & Software

Similar end equipment solutions

Support & Training

Try our support forums.

Search support resources for this part. Add a new question

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Training & events

Name

Audio Measurements and Results Part 2

Audio Measurements and Results Part 1

Mobile Smart TV training

Audio Measurements and Results

MP430 Capacitive Touch MCUs featuring CapSense® Technology Training Series

See more training & events

1 to 25 Li-Ion Battery Pack Manager Reference Design

Schematic/Block diagram

Reference guide

View reference design

1 to 4 Series Cell Li-Ion Battery Pack Manager Reference Design

Multi-Cell Battery Manager Unit with integrated Charging, Gauging, Authentication and Protection

Power Management (11)

BQ294313 - Overvoltage Protection for 2-Series and 3-Series Cell Li-Ion Batteries

Under row

Online datasheet

Download datasheet

BQ2961 - 2-4S Overvoltage Protection with LDO Output

BQ2962 - Overvoltage Protection for 2-Series, 3-Series, and 4-Series Cell Li-

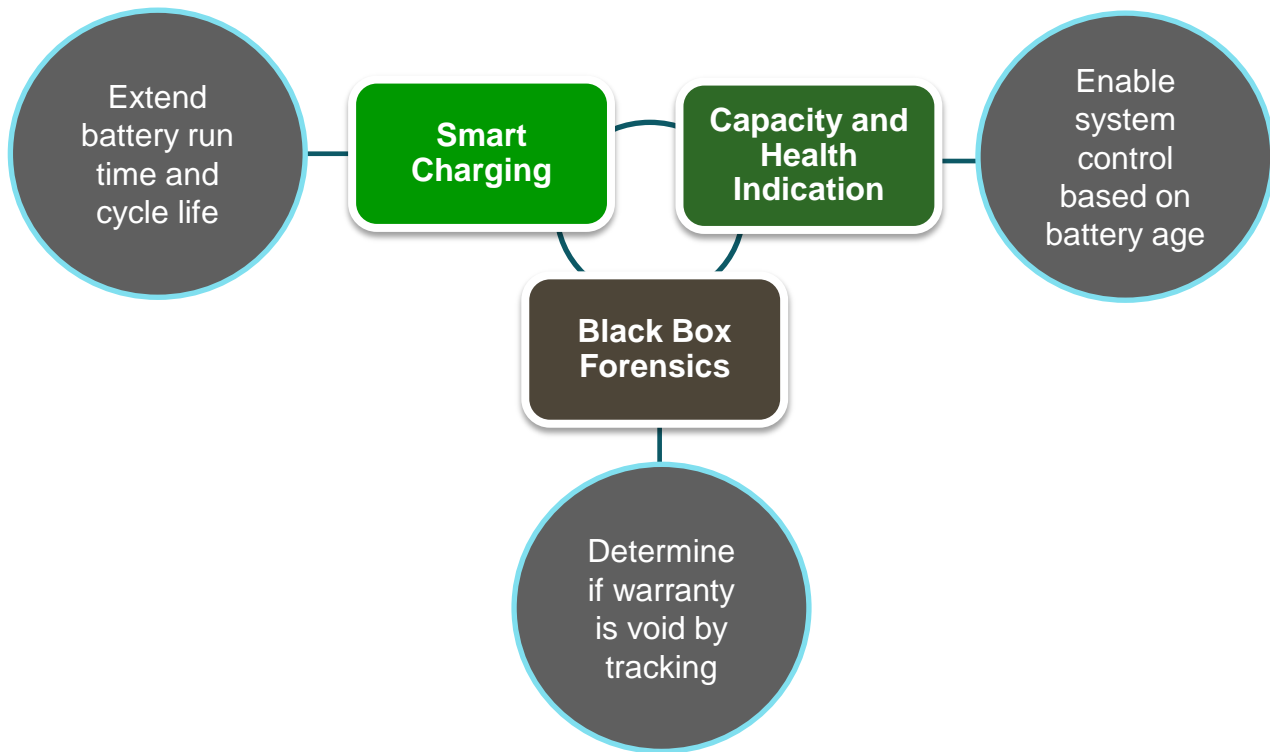
适用笔记本电脑的电池组方案:
http://www.ti.com.cn/solution/cn/battery_pack_for_notebook_pc

其他工业电池组（1节至9节）方案，适用 EPOS、蓝牙扬声器、监控摄像头:
http://www.ti.com.cn/solution/cn/other_industrial_battery_pack_1s9s

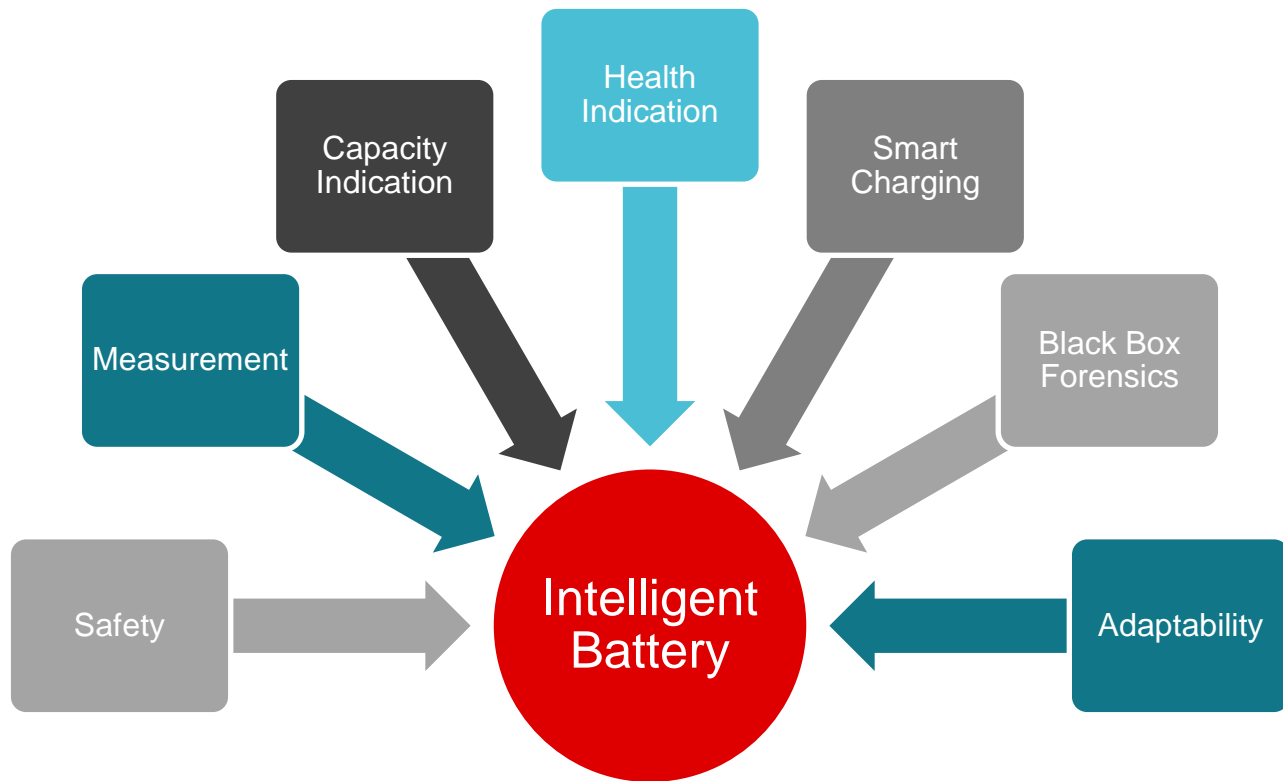
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TEXAS INSTRUMENTS

Why Need A “Intelligent” Battery?



What Makes A Battery “Intelligent”?



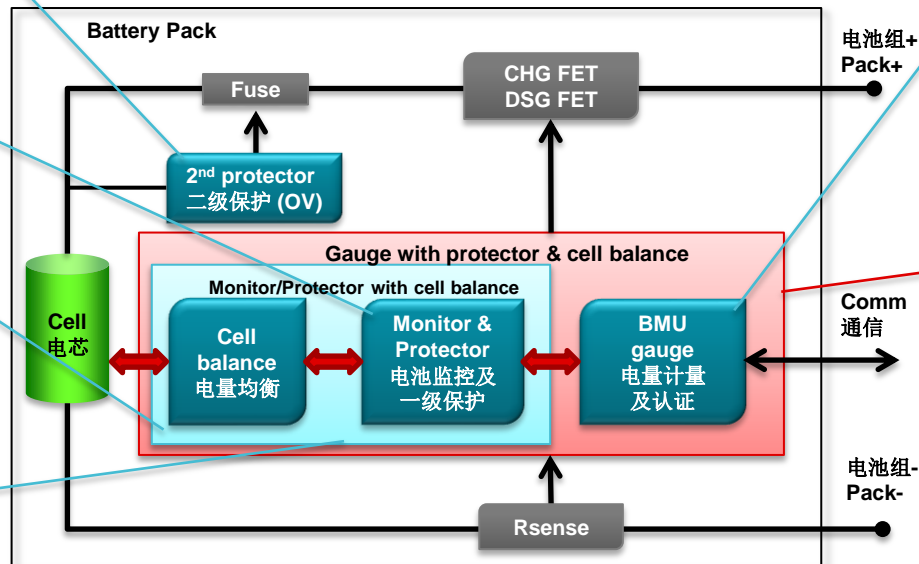
Intelligent Battery Pack Solution

2nd protector (OV)
BQ2947, 2~4s
BQ2961/2, 2~4s with LDO
BQ7718, 2~5s, stackable

Protector
BQ2970, 1s
BQ2980, 1s, fast charge
BQ77905, 3~5s, stackable

Protector with Cell balance
BQ77915, 3~5s, stackable

Monitor with Cell balance
BQ76925, 3~6s
BQ76920, 3~5s
BQ76930, 5~10s
BQ76940, 9~15s
BQ76PL536A-Q1, 6s, stackable
BQ76PL455A-Q1, 16s, stackable
BQ79606-Q1, 3~6s, stackable, ASIL-D



Standalone gauge
BQ27Z561, 1s, IT,Flash,SHA-256,1mΩ
BQ27542/6, 1s, IT,Flash,SHA-1
BQ34Z100-G1, 1~ns, IT,Flash,SHA-1

Gauge with protector & cell balance
BQ27742, 1s, IT,Flash,SHA-1,CSP
BQ27750, 1s, IT,Flash,SHA-1,QFN
BQ28Z610, 1~2s, IT,Flash,SHA-1,QFN
BQ40Z50-R2, 1~4s, IT,Flash,SHA-1,QFN
BQ4050, 1~4s, CEDV,Flash,SHA-1,QFN
BQ40Z80, 2~7s, IT,Flash,ECC,QFN

IT:Impedance Track Gauge Algorithm(高精度)
CEDV:Compensated EDV Gauge Algorithm
AFE:Analog Front End CB: Cells balancing
SHA-1/SHA-256/ECC 均为安全算法
QFN/CSP/SON/TSSOP/QFP 均为封装类型
-Q1 汽车级

BQ40z50-R2/-R3

1S – 4S SBS 1.1-Compliant Gas Gauge and Protector

Features

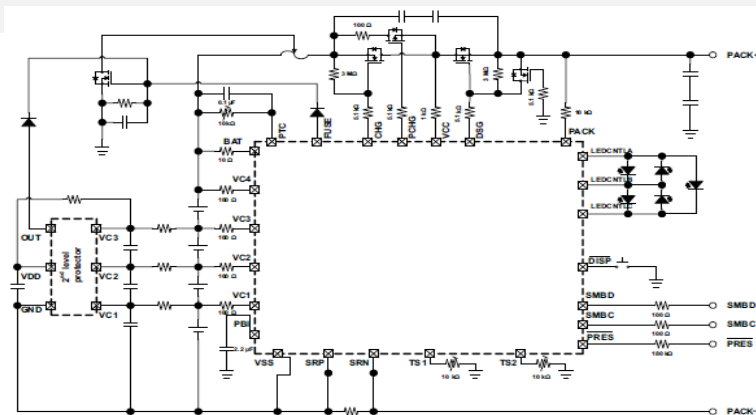
- Integrated AFE Safety Protector
 - Programmable
 - Voltage, Current, Temperature, Cell Imbalance
- Advanced IT gauging with JEITA & additional temp and current sub-ranges & cell balancing at rest or while charging
- Turbo Mode Data Support
- Black box recorder
- N-channel FET drive
- Integrated 1.8v LDO
- SHA-1 Authentication
- LED (up to 5) support option (bq40z50)
- 4mm x 4mm x 0.9mm 32L-QFN

Applications

- Notebook/Netbook PCs
- Medical and Test Equipment
- Portable robotics
- Portable Instruments
- Drones
- Cordless household appliances
- Compatible 2nd Level Protectors: [bq2961/2](#), [bq2947](#), [bq2945](#)

Benefits

- High gauging accuracy & multiple complex charging profile support
- Provides comprehensive protection for multicell safety
- Continuous cell balancing ensures maximum battery capacity is available at all times
- Turbo mode reports maximum power available at any time
- Lifetime/Blackbox supports analysis of returned battery packs
- Reduce BOM count/Lower BOM cost
- Anti-counterfeiting
- Visual display of SOC with LED indication



Safety Features - Protection

1. BQ40Z50 Protection (20 items)

-- notify host, turn off C-FET/D-FET

- Voltages
 - Cell Under Voltage I*R Compensated
 - Cell Under Voltage
 - Cell Over Voltage Temperature Compensated
- Current
 - Short Circuit in Charge
 - Over Current in Charge
 - Short Circuit in Discharge
 - Overload in Discharge
 - Over Current in Discharge
- Temperature
 - FET Over Temperature
 - Cell Over Temperature in Charge / Discharge
 - Cell Under Temperature in Charge / Discharge
- System
 - Host SBS Watchdog timeout
- Charging
 - Pre-Charge Timeout
 - Fast-Charge Timeout
 - Charger Over Current / voltage
 - Pre-charge Over Current
 - Charger Over Capacity

*Each items can be enable or disable individually in DF Settings subclass

Safety Features - Permanent Fails

2. BQ40Z50 Permanent Fails (23 items)

-- notify host, turn off C-FET/D-FET, blow FUSE.

- Voltages
 - Cell Under Voltage
 - Cell Over Voltage
- Current
 - Overcurrent in Charge
 - Overcurrent in Discharge
- Temperature
 - FET Over Temperature
 - Cell Over Temperature
 - PTC (hardware)
- Cells
 - Parallel cell connection (Qmax Imbalance)
 - Internal short (Cell Impedance, Copper deposition)
 - Capacity Degradation
 - Cell Balancing
 - Voltage Imbalance at Rest
 - Voltage Imbalance Active
- System
 - Open Thermistor
 - FUSE fail
 - CHG / DSG FET fail
 - AFE Register
 - AFE Communication
 - External 2nd Level OV protection
 - Memory DF/IF failure
 - Manual Permanent Failure (-R3 new)

*Each items can be enable or disenable individually in DF Settings subclass

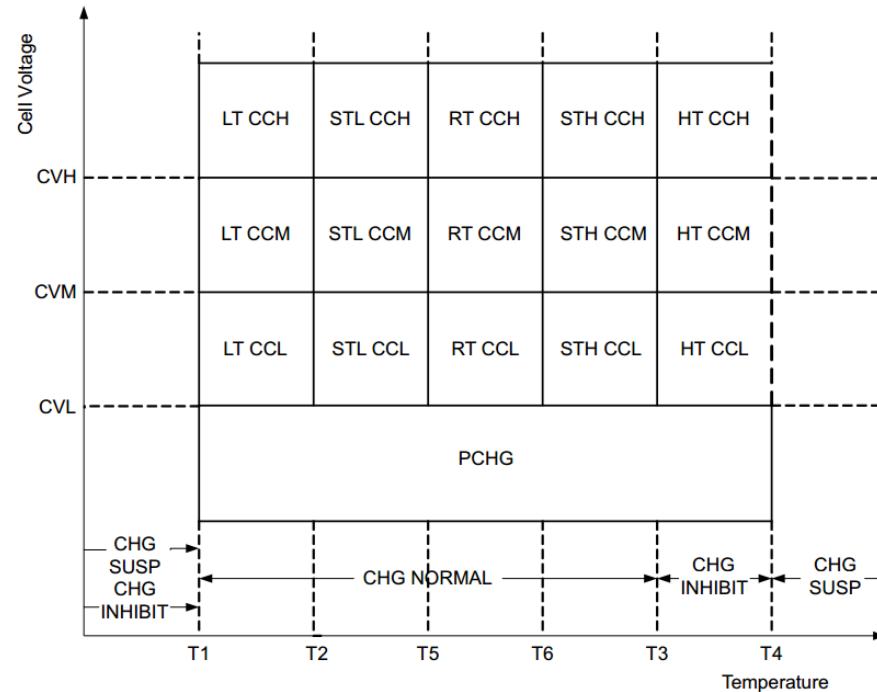
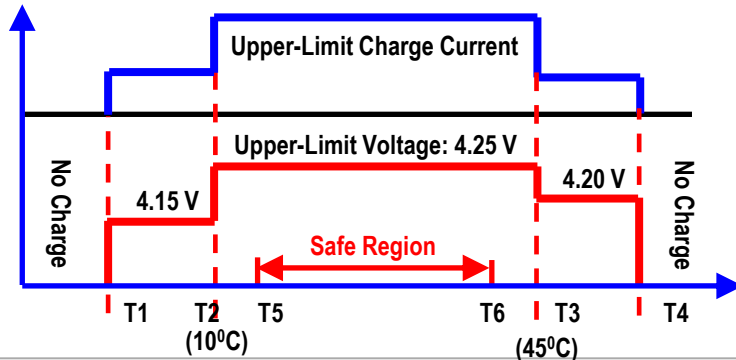
Advanced Charging Algorithm

BQ40Z50 <Smart Charging>

- JEITA
- Fast and safe charge (charging voltage & charging current depending on 7 temp ranges, 4 voltage ranges)
- Charge loss compensation
- Charge Voltage Compensation for System Impedance

Enhanced Battery Life

- Rate of change in charge voltage/current
- Cell Swelling Control (via Charging Voltage Degradation)
- Option to set charging current in C-Rate
- Cell Balancing at rest
- Cell Balancing at charge



Cell Balancing

- Passive VS. Active
 - Passive cell balancing → Resistor bleeding. (BQ40Z50)
 - Active cell balancing → Inductive Charge shuttling. (EMB1499+EMB1428)
- Internal VS. External
 - Internal cell balance → use integrated FET. (BQ40Z50)
 - External cell balance → add external FETs. (BQ40Z50)
- Voltage based VS. SOC based
 - Voltage based → the symptoms. simply to implement, however are affected by impedance deviations and have lower balancing rate. (BQ4050)
 - SOC based → the root. achieve best balancing accuracy and rate, but have to rely on already existing framework of SOC measurement. (BQ40Z50)
- Cell balance current
 - $I = V / R$

Internal Cell Balancing:

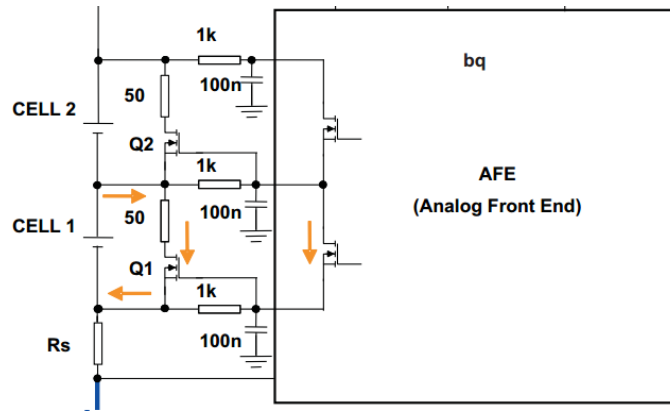
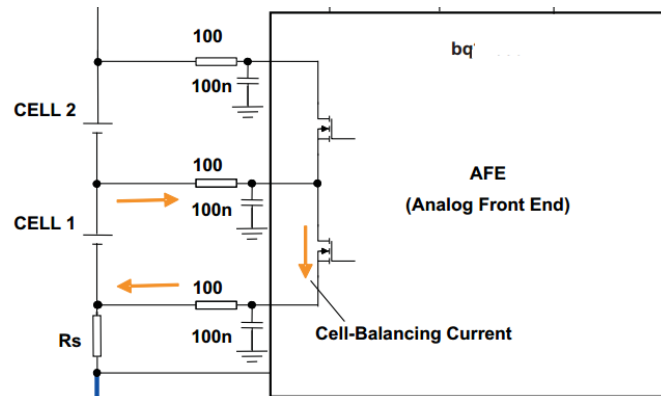
$$\text{Balance Time per mAh Cell 1} = \frac{3600 \text{ mAs} \times (RVCx + Rcb)}{V_{cell} \times \text{Duty}}$$

$$\text{Balance Time per mAh Cell 2 - 4} = \frac{3600 \text{ mAs} \times (2 \times RVCx + Rcb)}{V_{cell} \times \text{Duty}}$$

External Cell Balancing:

$$\text{Balance Time per mAh Cell 1} = \frac{3600 \text{ mAs} \times (RVCx + Rcb) \parallel R_{ext}}{V_{cell} \times \text{Duty}}$$

$$\text{Balance Time per mAh Cell 2 - 4} = \frac{3600 \text{ mAs} \times (2 \times RVCx + Rcb) \parallel R_{ext}}{V_{cell} \times \text{Duty}}$$



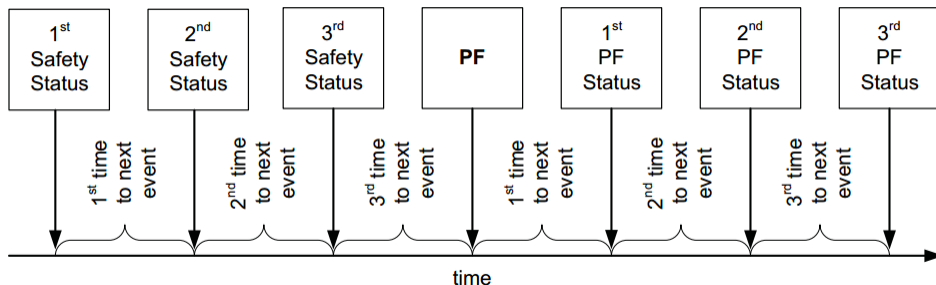
Lifetime Data & Black Box

1. BQ40Z50 Lifetime

- Voltage (Max, Min, delta)
- Current (Max)
- Temperature (Max, Min, delta)
- Charging Events
 - Number of valid Charge Terminations
 - Last Charge Termination
- Gauging Events
 - Number of QMAX updates
 - Last QMAX update
 - Number of RA updates
 - Last RA update
- Power Events
 - Number of Resets, Shutdowns
- Cell Balancing
 - Cell Balancing Time each Cell
- Safety Events
 - Number of Safety Events
 - Last Safety Event
- Time
 - Time spent in different *RelativeStateOfCharge()* – *Temperature()* ranges
 - 8 RSOC * 7 Temp = 56 ranges
 - Total FW runtime

2. BQ40Z50 Black Box Recorder

- PF scene image
- last three *SafetyStatus()*
- first three updates of *PFStatus()*



Security Authentication

- Need for Battery Authentication
- After-market and counterfeit batteries present a host of problems:
 - Discharge rate – cell mismatch
 - Charger – Chemistry mismatch
 - Short circuit, over voltage, under voltage protection
 - Unknown cell quality
- *Authentication ensures that connected devices fulfill the established requirements and are safe for the consumer!*
- Authentication Methods
 - Mechanical fit
 - Easily duplicated
 - Resistor ID
 - Measure voltage drop across resistor internal to the battery on extra pin
 - Also easily duplicated
 - EEPROM ID number
 - Encrypted Handshake with Secret Key
 - SHA-1, SHA-256, ECC

Gauging

BQ40Z50 <Measurement>

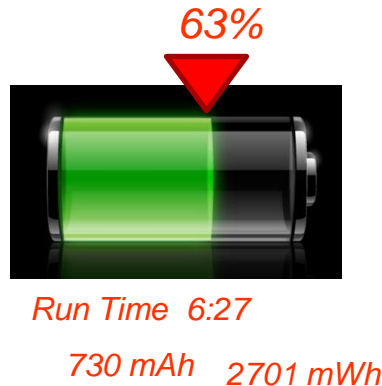
- 16-bit ADC for each cell voltages and temperature
- 16-bit Coulomb Counter for current
- Voltage and Current sample simultaneous

BQ40Z50 <Capacity Indication>

- Impedance Track algorithm,
- Predict the future
 - SOC, RM, FCC
 - Time to Full
 - Time to Empty
- Turbo Mode
- Fast Qmax Update
- Battery Trip Point
- IATA

BQ40Z50 <Health Indication>

- SOH
- Cycle Count



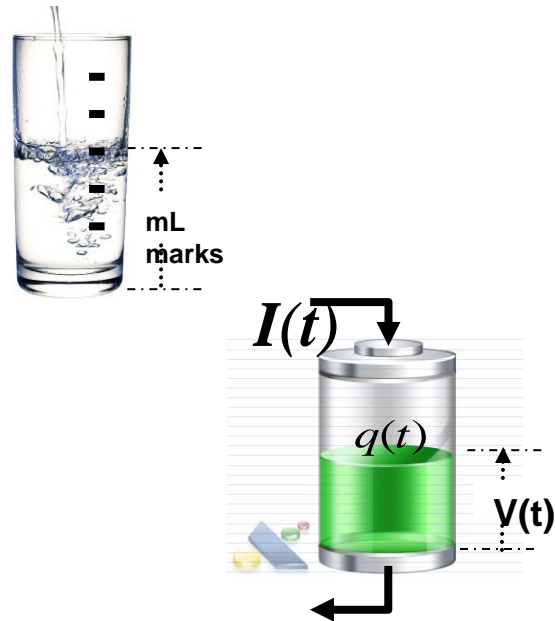
How to estimate battery capacity?

- Measure change in capacity
 - Voltage lookup
 - Coulomb counting
- Develop a cell model
 - Circuit model
 - Table Lookup



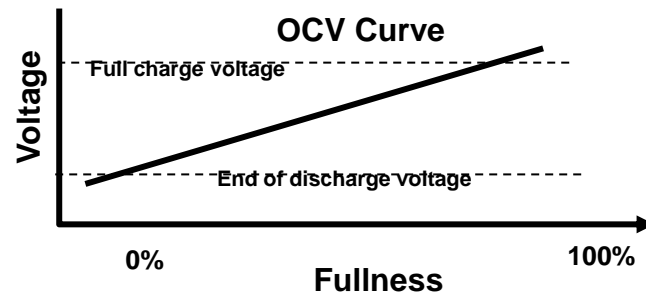
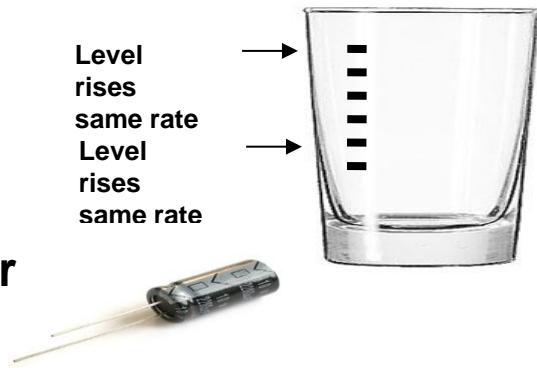
Voltage lookup

- One can tell how much water is in a glass by reading the water level
 - Accurate water level reading should only be made after the water settles (no ripple, etc)
- One can tell how much charge is in a battery by reading well-rested cell voltage
 - Accurate voltage should only be made after the battery is well rested (stops charging or discharging)

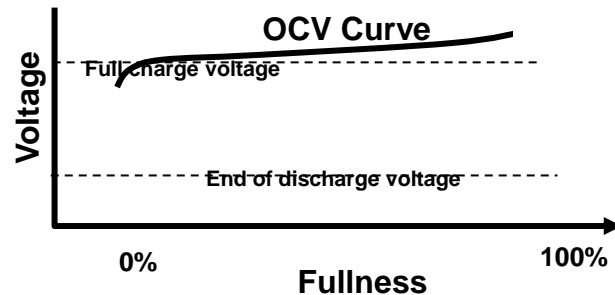
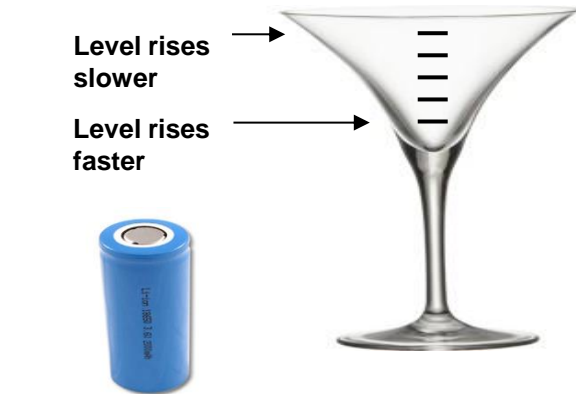


OCV curve

Capacitor



Battery



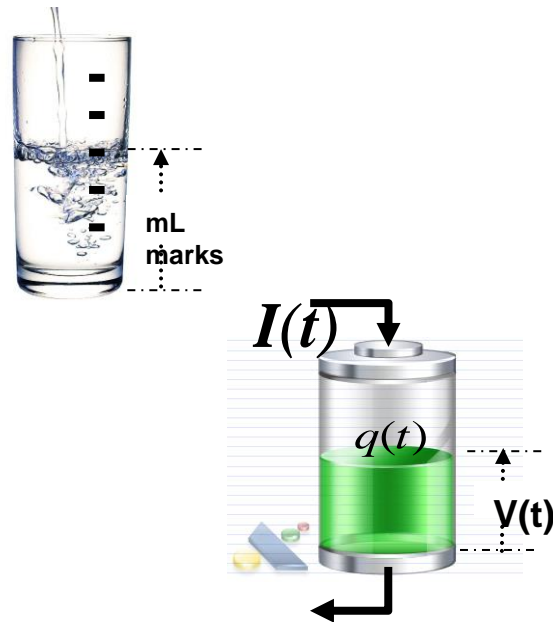
Current integration

- One can also measure how much water goes in and out
- In batteries, battery capacity changes can be monitored by tracking the amount of electrical charges going in/out

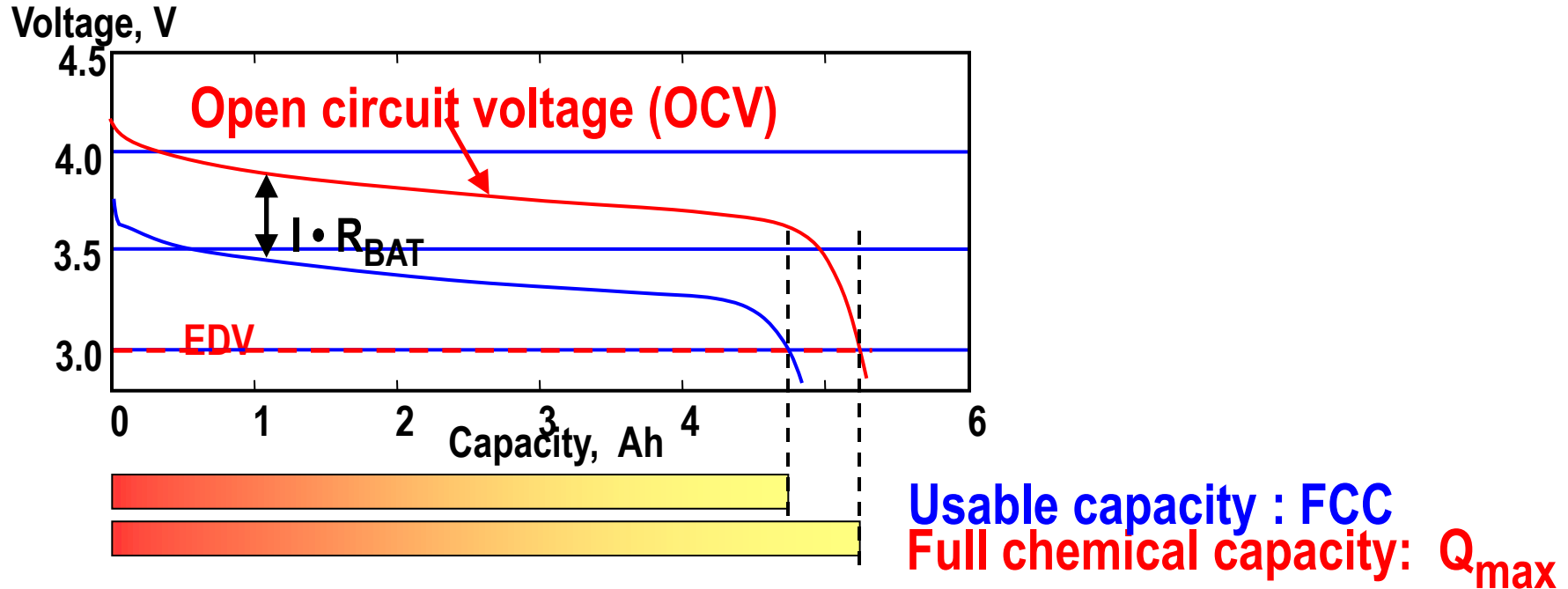
$$q(t) = q_0 + \int I(t) \cdot dt$$

$$q_k = q_0 + \Delta t \cdot \sum_k I_k$$

- But how do you know the amount of charge, q_0 , already in the battery at the start?
- How do you count charges accurately?



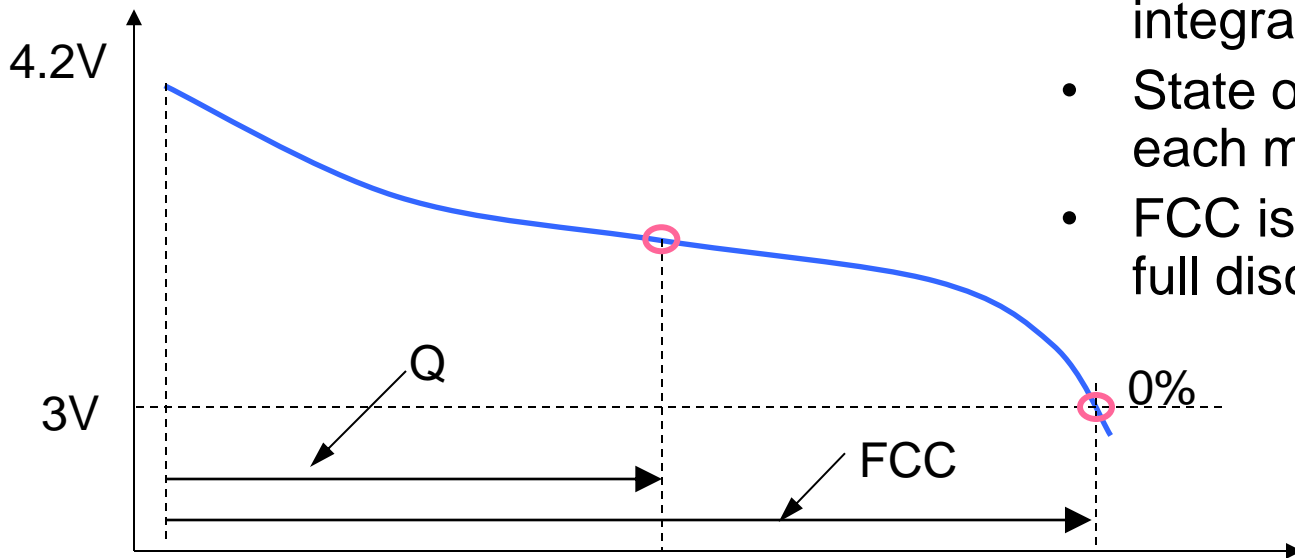
How Much Capacity is Really Available?



- External battery voltage (blue curve) $V = V_{OCV} - I \cdot R_{BAT}$
- Higher C-rate \rightarrow EDV is reached earlier (higher $I \cdot R_{BAT}$)

Current Integration Based Fuel-gauging

- Battery is fully charged
- During discharge capacity is integrated
- State of charge (SOC) at each moment is RM/FCC
- FCC is updated every time full discharge occurs



$$RM = FCC - Q$$

$$SOC = RM/FCC$$

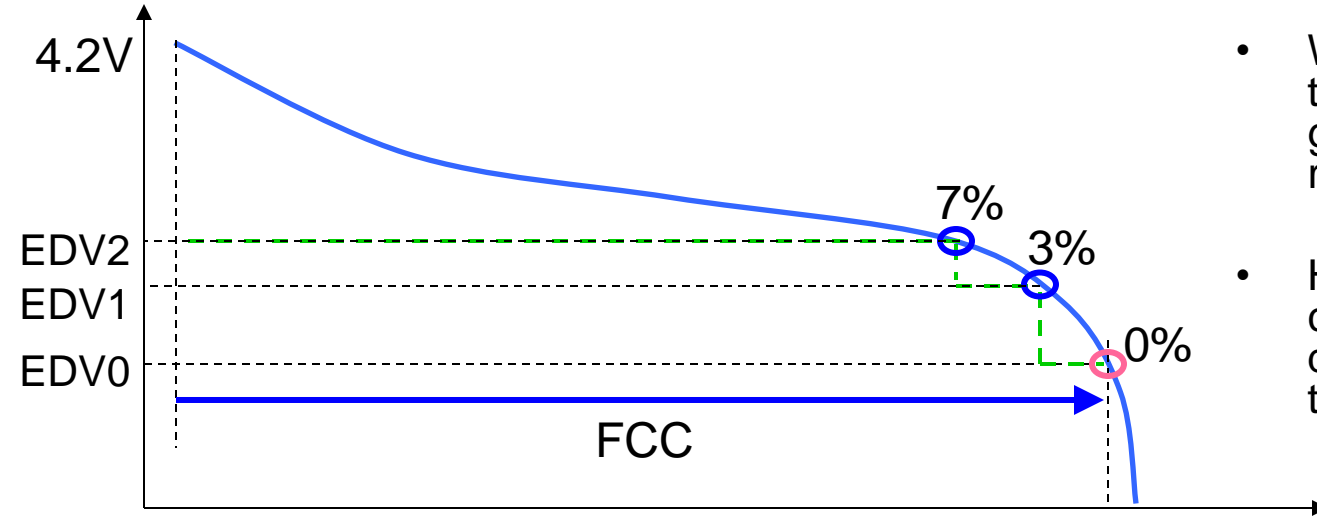
Gauging Algorithm Options

- Impedance Track (IT)
 - Consumer/Industrial/Medical applications, increased gauging accuracy.
- Compensated-End-of-Discharge (CEDV)
 - Industrial applications with highly pulsed loads, applications that do not allow rest periods.
- End-of-Service (EOS)
 - Rarely discharged applications, Li-primary cells.

COMPENSATED-END-OF-DISCHARGE (CEDV)

Learning Before Fully Discharged

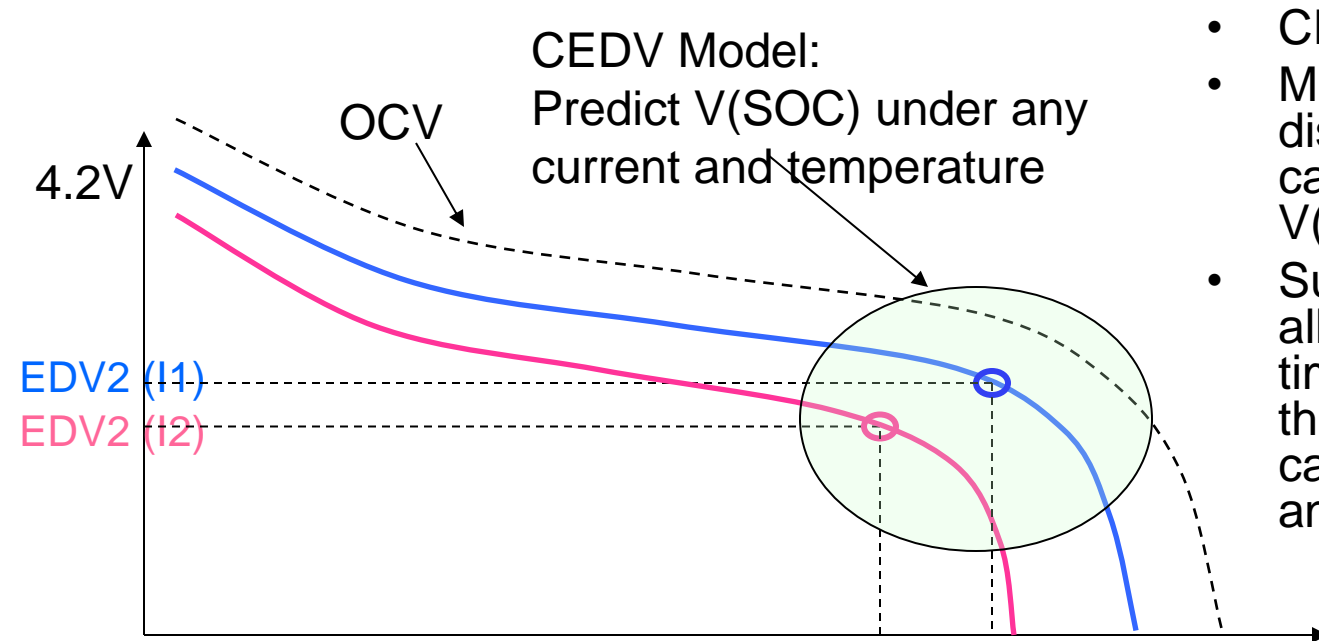
– fixed voltage thresholds



- It is too late to learn when 0% capacity is reached → Learning FCC before 0%
- We can set voltage threshold that correspond to given percentage of remaining capacity
- However, true voltage corresponding to 7% depends on current and temperature

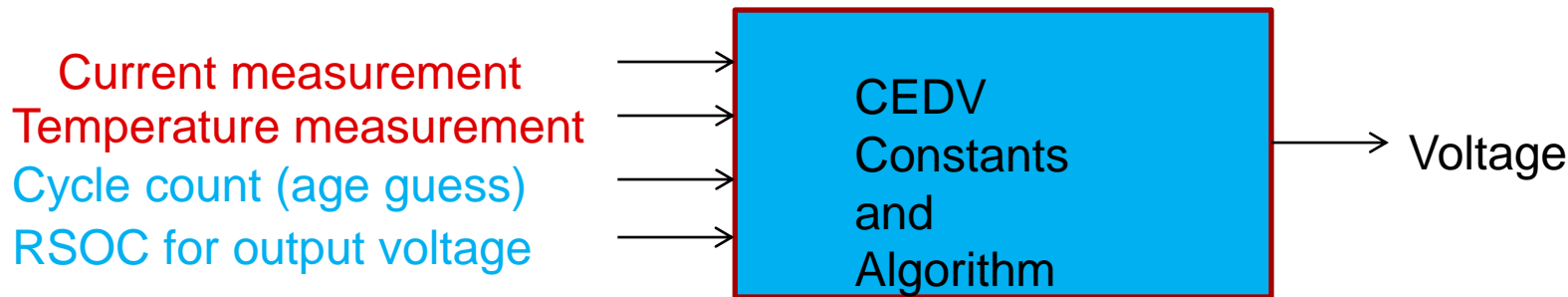
Learning before fully discharged

with current and temperature compensation



- CEDV
- Modeling last part of discharge allows to calculate function $V(\text{SOC}, I, T)$
- Substituting $\text{SOC}=7\%$ allows to calculate in real time CEDV2 threshold that corresponds to 7% capacity at any current and temperature

CEDV Summary



The seven constants describe:

- OCV curve shape
- Temperature effect on OCV
- Resistance
- Temperature effect on resistance
- Low temperature effects
- Aging properties
- Reserve capacity

BQ4050

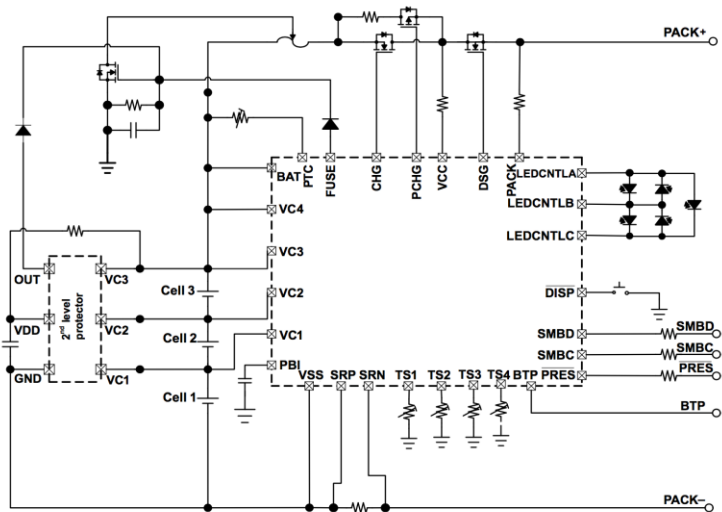
1S – 4S CEDV Fuel Gauge for Li-Ion Packs

Features

- High-Side Protection N-CH FET Drive Allows Serial Bus Communication During Fault Conditions
- Cell Balancing with Internal Bypass Optimizes Battery Health
- Diagnostic Lifetime Data Monitor and Black Box Recorder for Failure Analysis
- Full Array of Programmable Protection Features Voltage, Current, Temperature
- JEITA Charge Algorithms Support Smart Charging
- Analog Front End with Two Independent ADCs
 - Simultaneous Current and Voltage Sampling
 - High-Accuracy Coulomb Counter with Input Offset Error < 1 μV (Typical)
- Supports Battery Trip Point (BTP) Function for Windows® Integration
- LED Display for State of Charge and Battery Status Indication
- 100-KHz SMBus v1.1 Communications Interface for Programming and Data Access with Alternate 400-KHz Mode
- SHA-1 Authentication
- Compact 32-pin VQFN Package (RSM)

Applications

- Notebook/Netbook PCs
- Medical and Test Equipment
- Portable Instruments



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IMPEDANCE TRACK (IT)

Fuel Gauging – Impedance Track™

Cell Voltage Measurement

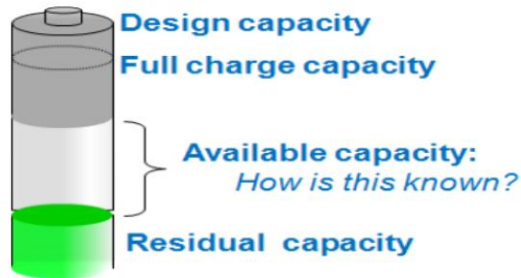
- Measures cell voltage
- Advantage: Simple
- Not accurate over load conditions

Coulomb Counting

- Measures and integrates current over time
- Affected by cell impedance
- Affected by cell self discharge
- Standby current
- Cell Aging
- Must have full to empty learning cycles
- Must develop cell models that will vary with cell maker
- Can count the charge leaving the battery, but won't know remaining charge without complex models
- Models will become less accurate with age

Impedance Track™

- Directly measures effect of discharge rate, temp, age and other factors by learning cell impedance
- Calculates effect on remaining capacity and full charge capacity
- No learning cycles needed
- No host algorithms or calculations



What is Impedance Track?

1. Chemistry table in Data Flash:

$$OCV = f(dod)$$

$$dod = g(OCV)$$

2. Impedance learning during discharge:

$$R = \frac{OCV - V}{I}$$

3. Update Max Chemical Capacity for each cell

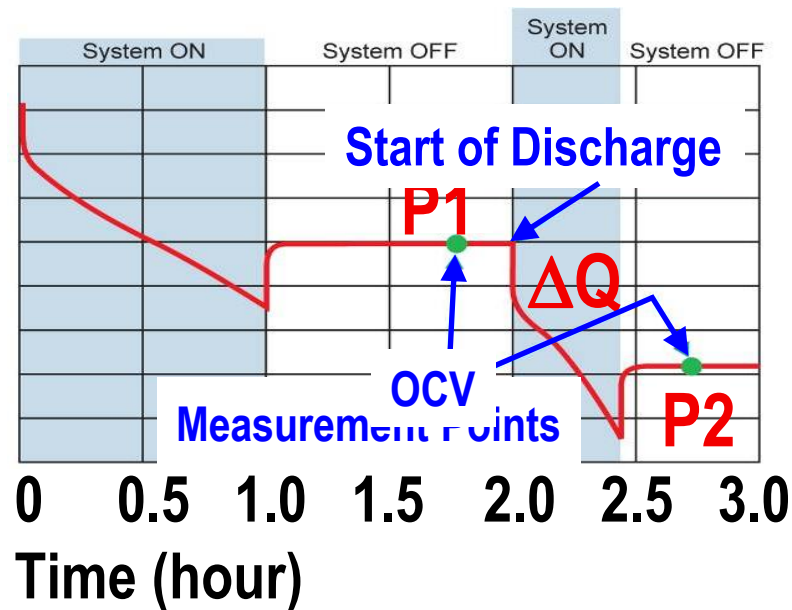
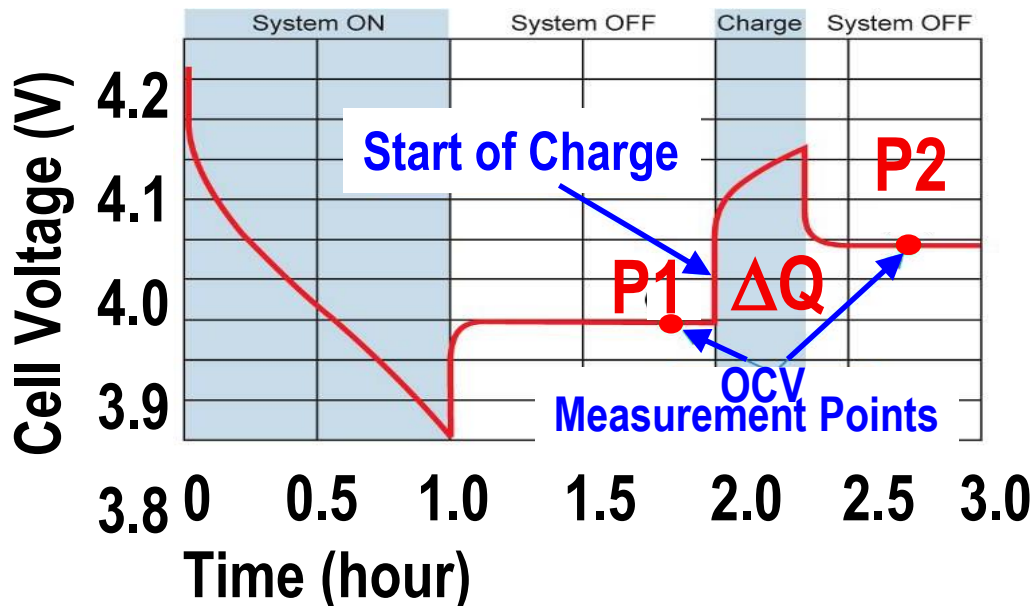
$$Q_{max} = \text{PassedCharge} / (\text{SOC1} - \text{SOC2})$$

4. Run periodic simulations to update predictions of Remaining and Full Capacity

Definitions (part 1)

- OCV – open circuit voltage
 - relaxed or predicted voltage with no load
- DOD – depth of discharge
 - 0% is charged to the brim, 100% is completely empty of energy
 - Does not depend on load or temperature or system characteristics
- RM – Remaining Capacity in mAh
 - Usable capacity of the battery from current DOD to empty
- FCC – Full Charge Capacity in mAh
 - Usable capacity of the battery from full to empty
- SOC – state of charge, 0% - 100%
 - Full and empty points depend on the system
 - Can change with load and temperature
 - $SOC = RM / FCC$

Qmax updating



- Charge passed is determined by exact coulomb counting
- SOC1 and SOC2 measured by its OCV
- Method works for both charge or discharge exposure

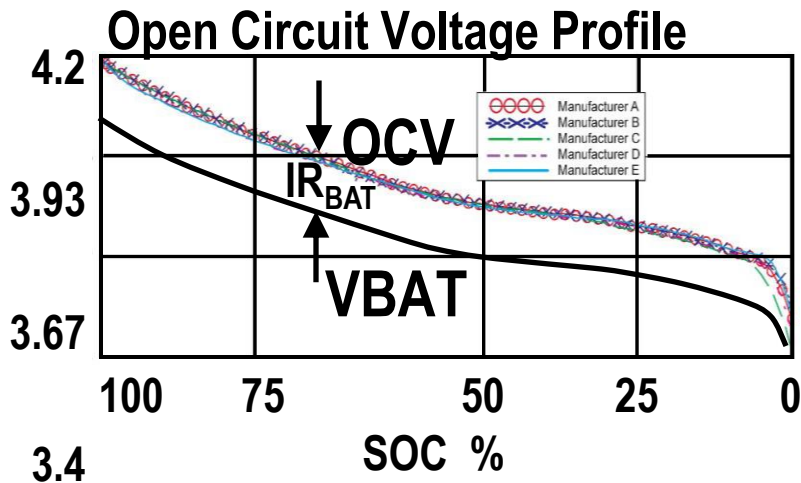
$$Q_{max} = \frac{\Delta Q}{SOC1 - SOC2}$$

Measuring resistance

- Data flash contains a fixed table: $OCV = f(SOC, T)$
- IT algorithm: Real-time measurements and calculations during charge and discharge.

$$R_{BAT} = \frac{OCV - V_{BAT}}{I_{AVG}}$$

$$V = OCV(T, SOC) - I * R(T, SOC, \text{Aging})$$



Definitions (part 2)

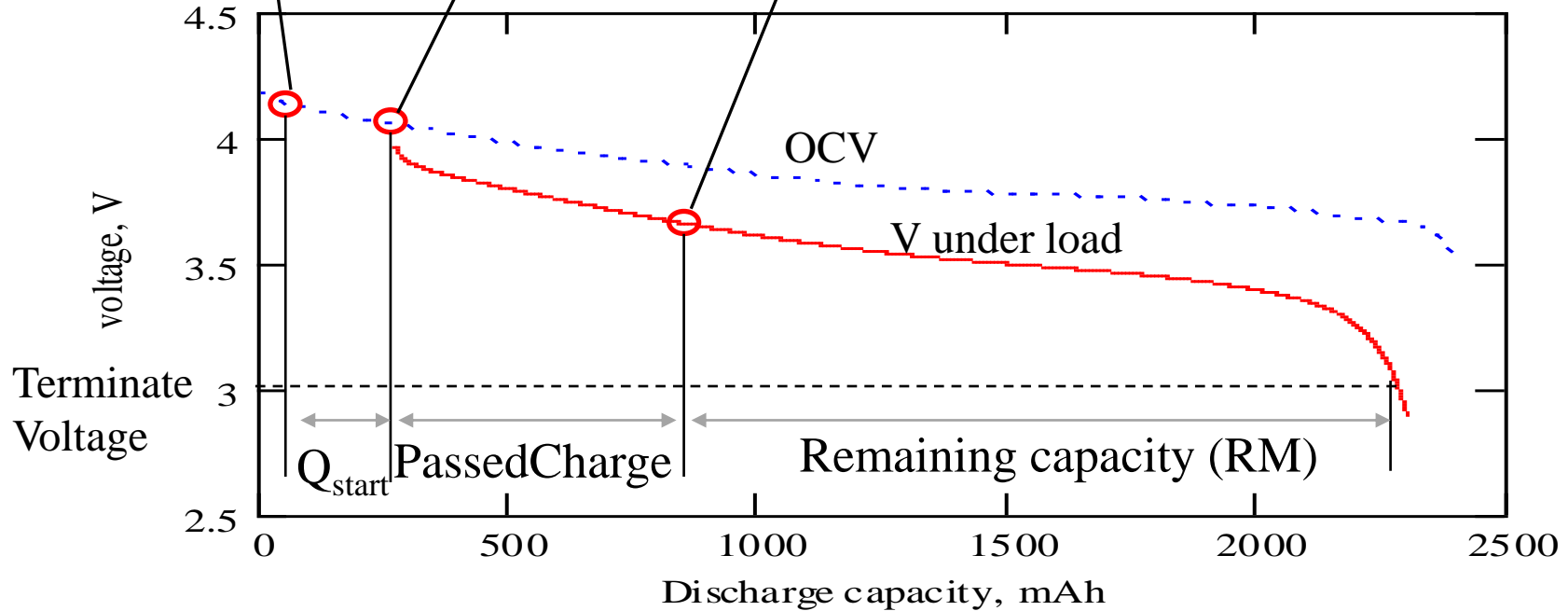
- DOD0
 - last DOD point measured directly by the gauge
- DODatEOC
 - DOD at End of Charge representing SOC = 100% for a particular system
- Qstart
 - capacity between DODatEOC and DOD0
- Qpass
 - accumulated passed charge since last DOD0 update
- Terminate Voltage
 - voltage at which the system can no longer operate; target for SOC = 0%
- Taper Current
 - Current level at which charger shuts off

Simulation to find RemCap and FCC

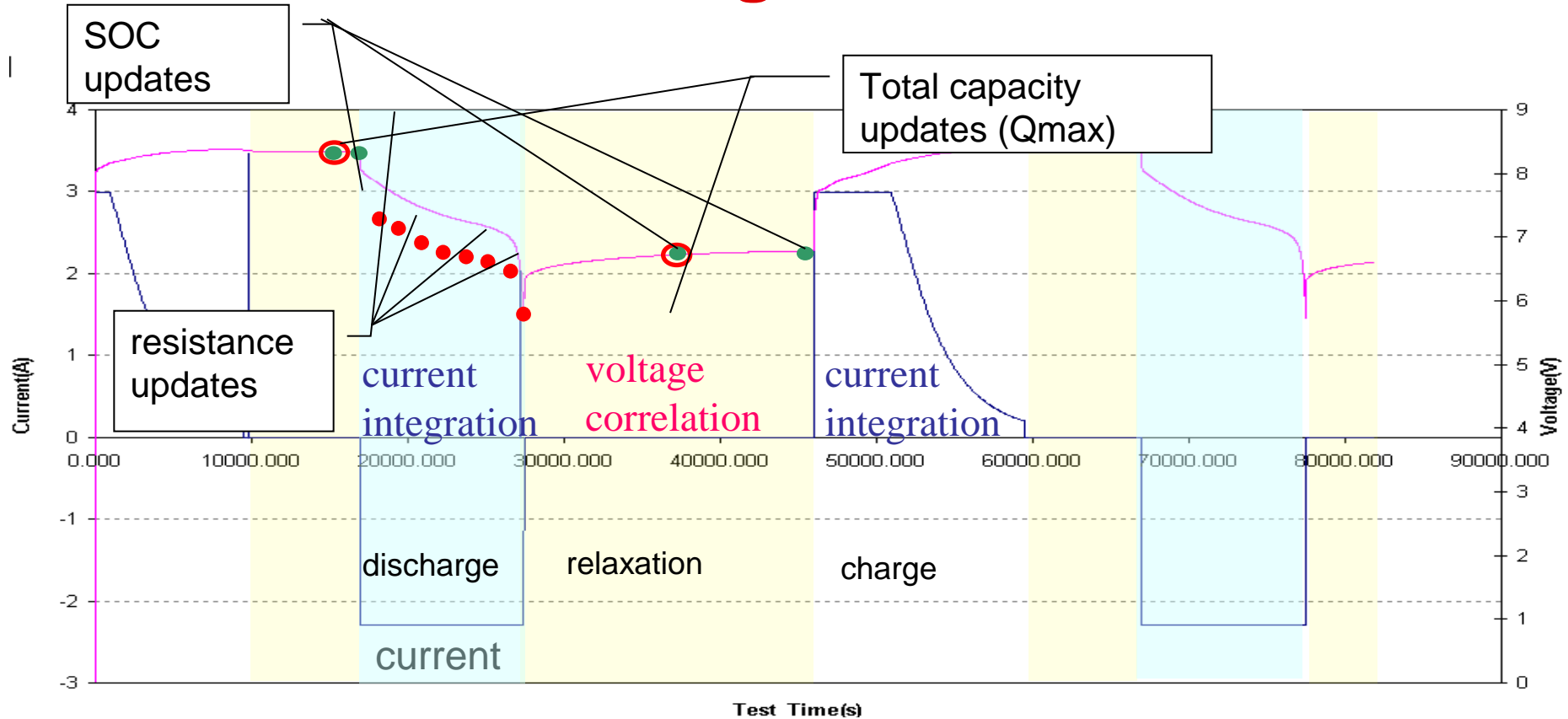
DOD at EOC

DOD₀

RM and FCC calculation at a grid-point



Combination of integration and correlation



BQ27Z561

Single Cell Fuel Gauge for Fast Charging

Features

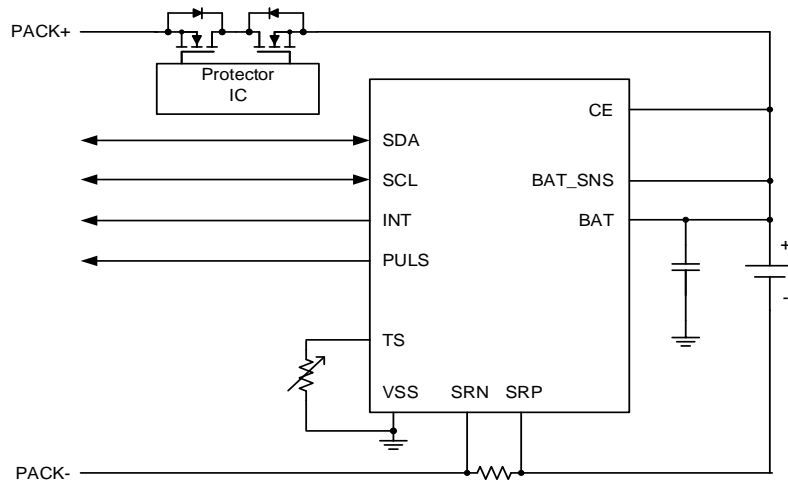
- Battery Fuel Gauge for 1 S Li-Ion applications
 - Supports Rsense down to 1 mΩ
 - <10uA sleep mode with gauging capabilities
 - Support for simultaneous current and voltage Sampling
 - Internal or external temperature sensor
 - SHA-2/HMAC Authentication
 - Lifetime Data Logging when used on pack side
- Lower voltage operation down to 2 V
- Battery Fuel Gauging based on patented Impedance Track™ Technology
 - Models Battery Discharge Curve for Accurate Time-To-Empty Predictions
 - Automatically Adjusts for Battery Aging, Battery Self-Discharge, and Temperature/Rate Inefficiencies
- HDQ and I²C communication with Host System
- Small 12 ball 1.67 mm x 2.05 mm WCSP

Applications

- Smartphones
- Digital Still and Video Cameras
- Tablet Computing
- Portable and Wearable Devices
- Portable Audio Devices

Benefits

- Fully configurable gauge for maximum accuracy/performance
- Host relived of charge/gauge coordination overhead
- Large scratchpad enables manufacturer information storage
- Lifetime data log record supports warranty claim verification
- HDQ interface saves on connector cost with 1 wire comm.
- SHA-2/HMAC authenticates only legitimate packs



BQ2980

1S High Side Protector with Ext. Sense R for Fast Charging

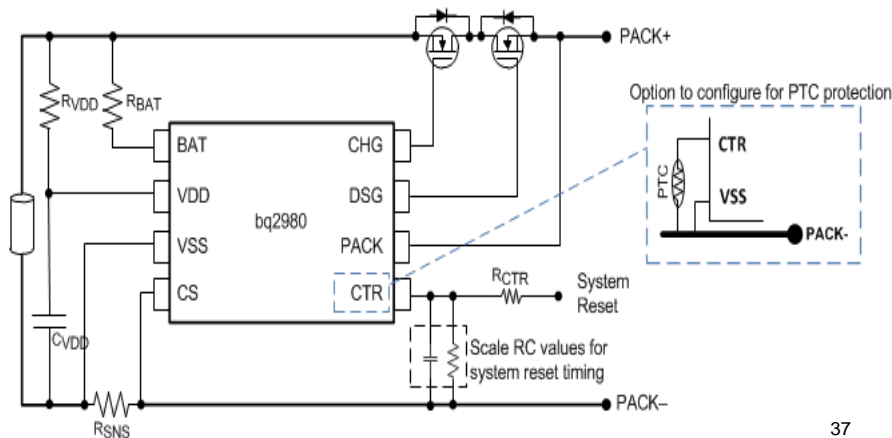
单节支持 1mΩ 检流电阻的快充保护芯片;
高边开关控制的快充保护芯片

Features

- **High side FET driver** with built-in charge pump, **reduce FET R_{sson}**
- Current sensing via **external R_s (down to 1mΩ)**
- **High accuracy** on current detection
 - **+/-1mV @ <20mV range current detection accuracy** across temp
- Support the newest 4.4V cell OVP protection
- **Low power** consumption : **4uA typ**
- Protections incl. **OV, UV, OCC, OCD, SCD, OT**
 - **OV**: 3.75V to 4.8V (50mV step)
 - **UV**: 2.0V to 3.0V (100mV step)
 - **OCC**: 6mV to 64mV (2mV step)
 - **OCD**: 6mV to 64mV (2mV step)
 - **SCD**: 10/20/30/40/60/120mV/200mV
 - **Internal OT**: 70°C, 80°C, 90°C, 100°C **and/or external PTC** via CTR pin
- **FET driver override** allows system POR initiated by host
- Package: 8ld X2QFN (1.5 x 1.5 x 0.37)

Benefits

- **Improve thermal performance** by reducing hot spot power dissipation by driving FET R_{dson} to its lowest range
- **Support down to 1mΩ R_s with fine threshold step option**
 - Reduce hot spot power dissipation
 - Easy to share R_s with pack side gauge
- **System reset pin** allow host uC to force system POR via open & close power FETs
- **Over-temperature protection** via internal temperature sensor or external PTC



Portable/Wearable Audio battery pack

- Portable audio speakers
 - Accurate state of charge under dynamic audio loads.
 - Extend run-time.
 - Safety.
- TWS charging case and headphone
 - Extend run-time.
 - Safety.
 - Small size.
 - Accurate state of charge.
- Solution (BQ40Z50, BQ28Z610, BQ27Z561, BQ27426, BQ2980)
 - Impedance Track gauging algorithm to achieve accurate SOC.
 - With accurate SOC, charge more full and discharge more empty, to extend run-time.
 - Advanced charge algorithm to achieve fast & safe charge.
 - With accurate voltage and current sensing, system can do more safety strategy.
 - For multi-cell, smart cell balance is integrated.

	BQ27Z561	BQ27426	BQ28Z610	BQ40Z50
Size (mm)	1.72 x 2.09	1.62 x 1.58	4 x 2.5	4 x 4
Current consumption (uA)	Nml 60 / Slp 11/ DSlp 9 / Off 0.5	Nml 50 / Slp 9 / SD 0.6	Nml 250 / Slp 100 / SD 0.5	Nml 336 / Slp 75/52 / SD 1.6

BQ40z80

2S – 7S Battery Gas Gauge with Protector

Features

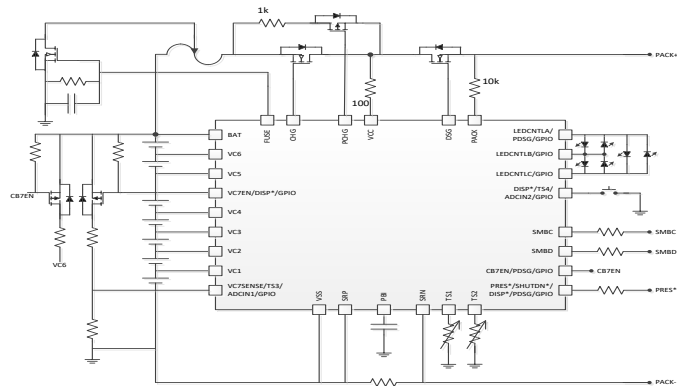
- Battery Manager with 2-Series to 7-Series Capability
- Advanced Impedance Track Gauging with JEITA Charge Control and Cell Balancing During Charge or at Rest
- Suitable for Li-Ion, LiFePO4 and NiXX Chemistries
- Integrated Safety Protector with High-side NMOS FET Drivers
 - Voltage, Current, Temperature, Cell Imbalance
- LED Support (up to 6)
- Pre-charge and Pre-discharge Modes Included
- Integrated Flash Memory and Lifetime/Blackbox Support
- Elliptic Curve Cryptography (ECC) Authentication
- Precision Analog Front End with Two Independent ADCs
 - – High-Resolution, 16-Bit Coulomb Counter
 - – 15-Bit Delta-Sigma ADC with Multiplexer
 - – Support for Simultaneous CC and ADC
- QFN 32pin Package (4mm x 4 mm x 0.9mm)

Applications

- UPS, Backup, and Energy Storage Systems
- Cordless Appliances
- Non-Military Drones
- Portable Robotics
- Compatible 2nd Level Protectors: [bq7718](#), [bq7716](#)

Benefits

- High gauging accuracy & multiple complex charging profile support
- Provides comprehensive protection for multicell safety
- Continuous cell balancing ensures maximum battery capacity is available at all times
- Lifetime/Blackbox supports analysis of returned battery packs
- Anti-counterfeiting
- Visual display of SOC with LED indication



BQ40z80 functions

<h1>Gauging</h1> <ul style="list-style-type: none">• Impedance Track Gas Gauging• <u>Scaling for higher current</u>• Support for up to 32V stack voltage (35V abs max)• Support for 1mΩ sense resistor	<h2><u>Flexible I/O</u></h2> <ul style="list-style-type: none">• Up to 4 TS inputs• ADC Inputs• /DISP• /PRES• GPIO• PDSG• LED Pins• CB7EN	<h2><u>GPIO INT Modes</u></h2> <ul style="list-style-type: none">• Battery Mode• Battery Status• Charging Status• Temp Status• Gauging Status• IT Status• Safety Status• PF Status	<h2>Protection</h2> <ul style="list-style-type: none">• Voltage, Current, Temperature, and Cell Imbalance• High-Side NFET Drivers• Fuse Drive Capability• Pre-charge and Pre-discharge Modes Included	
	<h2><u>Authentication</u></h2> <ul style="list-style-type: none">• Elliptic Curve Cryptography (ECC) or SHA-1	<h2>Charging</h2> <ul style="list-style-type: none">• JEITA-based Charging OR Dynamic Charge Adjustment Based on Cycle Count or State of Health• SMBus Broadcast to a Smart Charger	<h2>Calibration</h2> <ul style="list-style-type: none">• CELL Gain• <u>VC6-VSS Gain</u>• PACK Gain• <u>7th CELL Gain</u>	
				<h2>Logging</h2> <ul style="list-style-type: none">• Lifetime Data• BlackBox Functionality

BQ7718

Ultra Low Power Over-voltage Protector for 2S – 5S+

Features

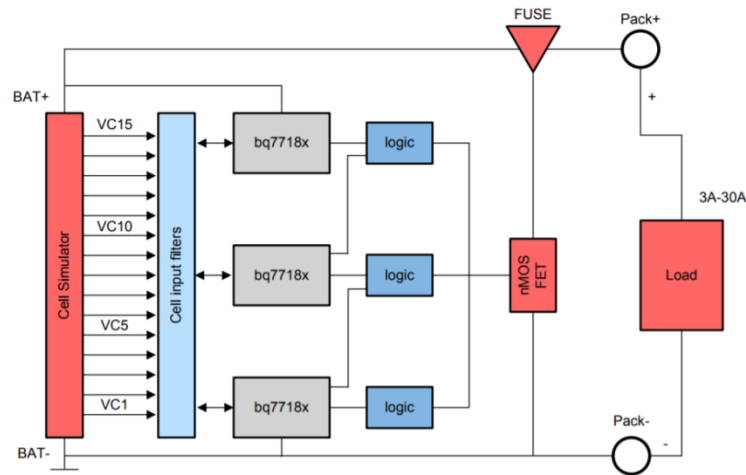
- **2S to 5S** Over-voltage (OV) Protection Device
- Supports **20S or more** battery packs thru external components interface
 - [TIDA-00108](#)
- **Low power** consumption (1 μ A typical, 2uA max)
- TI-programmable output drive for **Fuse Blow** secondary protection
- TI-programmed (EEPROM) – contact TI for specific configurations

Applications

- Power tools and garden tools
- Handheld vacuum cleaner
- Robotic Cleaner
- Robotic Lawnmower
- eBike and eScooter
- UPS and Energy Storage
- Drones

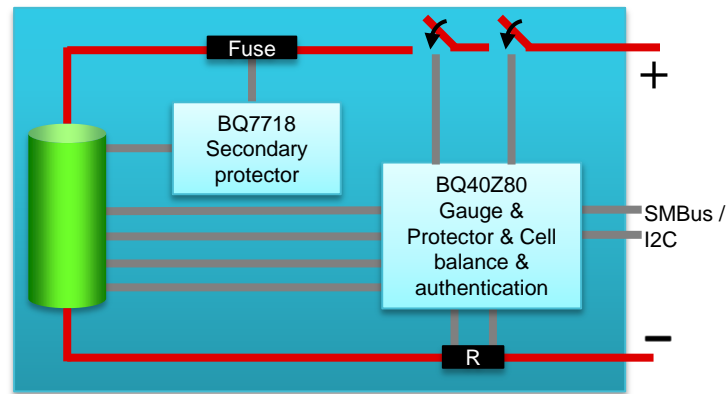
Benefits

- **Cost-effective** for any pack size
- **Add Redundant OV Protection easily** by stacking bq7718
- **Reduced customer production time** due to TI programmed EEPROM



Vacuum/Robot battery pack

- Protection is a big topic in vacuum cleaners since it is an indoor appliance
 - Built in HW / FW protection
 - Equipped with fuse blow capability for 2nd level protection or permanent failure
 - Cell balancing, with built in cell balancing algorithm
- Since a vacuum cleaning robot / stick is already on the wall adapter li-ion battery will degrade if left at 100% for the majority of time.
 - Impedance Track algorithm
 - Charging Algorithm that enables gauge to control a smart charger (i.e. JEITA)
- Single Chip solution from 2S up to 7S
- LED driving up to 6
- Multi purpose pins
- Multiple ADC inputs and / or Thermistor inputs
- High side NFET driving to maintain communication with the system and the battery



E-bike battery pack

- **Extend runtime and life cycle**
 - Ensure the battery running at comfortable situations to extend battery life cycle #
 - Accurate capacity info allows users to ride the e-bike longer without the concerns of damage to the battery
- **Minimize the system current consumption, especially at standby and shipping mode**
 - Enable longer storage time before sold to end users
 - Extend the idle & runtime
- **System robustness**
 - Over voltage protection, under voltage protection, discharge over current protection, short circuit protection, over temperature protection.

13S 48V Li-ion Battery Pack Reference Design

<http://www.ti.com/tool/tida-010030>

Features

- Impedance Track™ based gauging solution: **with 2% SOC accuracy** @room temperature.
- **Robust and programmable protection**, including:
 - cell over voltage, cell under voltage, overcurrent discharge, short circuit.
 - over temperature, under temperature.
- System current spec: **9mA @operation mode, 50uA @standby, 5uA @shipping mode**
- High-side charge/discharge MOSFETs and supports pre-discharge
- Supports 100mA cell-balancing
- Add-on secondary protection

Target Applications

- Battery pack - e-bike/e-scooter/LEV
- Other industrial battery pack (>=10S)

Tools & Resources

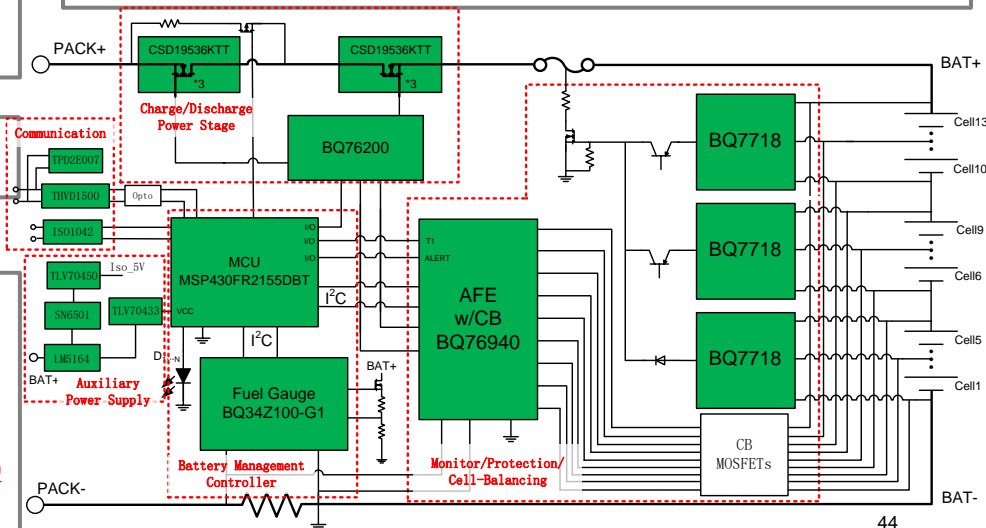
Board Image



- **TIDA-010030 and Tools Folder**
- **Design Guide**
- **Design Files:** Schematics, PCB, BOM, Gerber
- **Device Datasheets:**
 - [BQ34Z100-G1](#), [BQ76940](#), [BQ76200](#), [BQ7718](#)
 - [MSP430FR2155](#), [LM5164](#), [ISO1042](#), [THVD1500](#)
 - [SN6501](#), [TLV704](#), [CSD19536](#), [TPD2E007](#)

Benefits

- **IT gauge accuracy can update even not full discharge**
- **Longer runtime per each charge**
- **Longer storage time & idle time**
- **Robust systems.** And hardware OV/UV/OCD/SCD
- High side charge and discharge control
- Cell balancing



BMS-BGP Industrial Reference Designs

Key Apps	Title	TI Designs #	BMS Content
<ul style="list-style-type: none"> • LEV • eScooters • ESS 	Industrial Battery Management Module for 20S applications Reference Design	TIDA-01093	bq76930 (x2)
<ul style="list-style-type: none"> • Power Tools • Garden Tools • Vacuums • ESS 	Stacked Overvoltage Protector Solution with bq7718	TIDA-00108	bq7718 (x2)
<ul style="list-style-type: none"> • 36-48V ESS • eBike/eScooter 	Complete Battery Management for 36-48V Systems	TIDA-00792	bq76940, bq76200, bq78350-R1
<ul style="list-style-type: none"> • Power Tool • Garden Tool • Robotics/Drones • Cordless Vacuum • eBike • 36V ESS 	10-Cell (36V) Power Tool BMS with Monitoring, Balancing and Protection	TIDA-00449	bq76930
<ul style="list-style-type: none"> • 48V ESS • eBike/eScooter 	15-Cell Battery Controller Analog Front End	TIDA-00255	bq76940
<ul style="list-style-type: none"> • eBike/eScooter 	Accurate gauging & 50mA standby current 13S 48V Li-ion Battery Pack Reference Design	TIDA-010030	bq76940, bq7718, bq34z100, bq76200

BMS resource

<http://www.ti.com.cn/battery>

BMS
University

Videos

Datasheets

Samples &
EVM

TI Designs

E2E

概述 Featured products 应用 参考设计 工具与软件 技术文档 支持与培训

电池管理解决方案

进一步发挥电池的潜力

借助 TI 电池管理解决方案、工具和专业支持，工程师们可更轻松设计效率更高、使用寿命更长、更可靠的电池供电应用。



充电速度更快且发热更少的电池充电器



准确的电池电量监测计和监控 IC

准确且实时的电压、电流和



精确保护和安全管理 IC

为了检测各种故障情况，以



应用

选择您的应用，查看最适合您的终端设备的电池管理解决方案。

Datasheet (1)

Title	Type	Size (KB)	Date
bq40z50-R2 1-Series, 2-Series, 3-Series, and 4-Series Li-Ion Battery Pack Manager datasheet (Rev. A)	PDF	2548	09 Oct 2017


User guides (3)

Title	Type	Size (KB)	Date
bq40z50-R2 Technical Reference Manual (Rev. B)	PDF	1553	12 Oct 2018
bq40z50-R2 v2.08 Required Changes	PDF	17	11 Oct 2017
bq40z50EVM Li-Ion Battery Pack Manager Evaluation Module (Rev. B)	PDF	789	20 Sep 2016

Software (4)

Name	Part#	Type
Bq40z50-R3 Gauging Embedded Firmware v3.09 (ZIP 4261 KB)	25 Feb 2019	
bq40z50-R2 Gauging Embedded Firmware v2.08 (Rev. A) (ZIP 4249 KB)	11 Sep 2018	
bq40z50-R2 Gauging Embedded Firmware v2.11 (ZIP 4243 KB)	09 Feb 2018	
Gauging Parameter Calculator: Match chemistry for Impedance Track gauges	GPCHEM	Application Software & Frameworks

Application Reference Design



1) 应用描述

2) 参考设计

3) 子系统选择

4) 子系统设计

5) 参考设计

6) 优选器件推荐

7) 应用文档及其他

Technical documents
Application notes & user guides
Application Notes (3)

Tools & Software

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Training & events

Name

Audio Measurements and Results Part 2

Audio Measurements and Results Part 1

Mobile Smart TV training

Audio Measurements and Results

MP430 Capacitive Touch MCUs featuring CapSense® Technology Training Series

See more training & events

1 to 25 Li-Ion Battery Pack Manager Reference Design

Schematic/Block diagram

Reference guide

View reference design

1 to 4 Series Cell Li-Ion Battery Pack Manager Reference Design

Multi-Cell Battery Manager Unit with integrated Charging, Gauging, Authentication and Protection

Power Management (11)

3Q294313 - Overvoltage Protection for 2-Series and 3-Series Cell Li-Ion Batteries

Under row

Online datasheet

Download datasheet

3Q2961 - 2-4S Overvoltage Protection with LDO Output

3Q2962 - Overvoltage Protection for 2-Series, 3-Series, and 4-Series Cell Li-

适用笔记本电脑的电池组方案：
http://www.ti.com.cn/solution/cn/battery_pack_for_notebook_pc

其他工业电池组（1 节至 9 节）方案，适用 EPOS、蓝牙扬声器、监控摄像头：
http://www.ti.com.cn/solution/cn/other_industrial_battery_pack_1s9s

Q&A

Thank you!

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