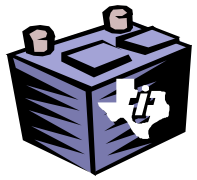
Texas Instruments

Battery Management Solutions

Benchmarq Products from Texas Instruments

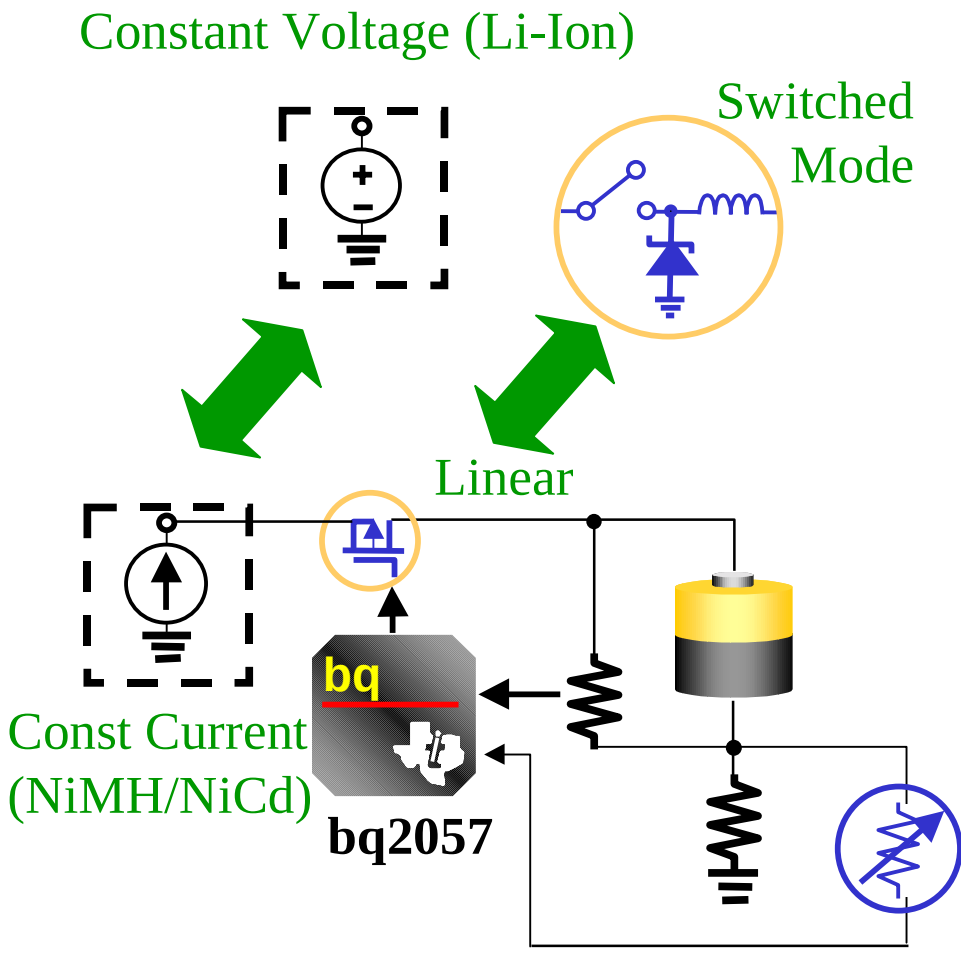


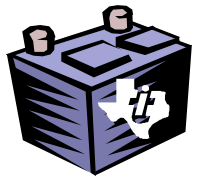
Battery Management Topics

- **Battery Protection**
  - Potential Safety issues with Li-ion batteries used for consumer apps
  - TI Value: Reliable UCC3952/11/57 for Li-Ion people protection
  - Target Market: Li-Ion/Polymer Battery Packs
- **Battery Monitoring**
  - Accurate “fuel gauge” (gas gauge) for indicating battery state of charge.
  - TI Value: All integrated intelligent “fuel gauge” in bq2060; also low cost coulomb counter in bq2018 (works with processor+A/D)
  - Target Market: Battery Packs, Consumer Handhelds, Industrial Power-tools
- **Battery Charging**
  - Chemistry-specific and Multi-Chemistry battery charging solutions
  - TI Value: Range of battery charging know-how through bq2002/00/31 (NiCd; NiMH/Li-Ion/LeadAcid) chargers
  - Target Market: Handheld end-eqpt or handheld accessories

Battery Chargers -- e.g. bq2000

Device	Comments
Multi Chemistry	
bq2000	NIMH/NiCD/LiIOn Sw Mode
Li-Ion	
bq2057	Linear, 1-2cell
bq2954	Sw.Mode
NiMH/NICD	
bq2002	Linear,
bq2004	Sw.Mode+ LED display
Lead Acid	
UC3906	Linear
bq2031	Sw.Mode + LED display

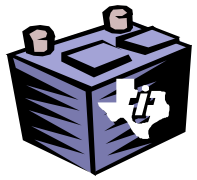




Battery Chemistry Characteristics

TYPICAL, GENERIC VALUES!	Alkaline	NiCd	NiMH	Li-Ion	Lead-Acid
Relative Cost (NiCd = 1)	0.5	1	1.4	1.8	0.6
Self-Discharge (per month @ 25° C)	0.3%	18%	27%	1.75%	3%
Cycle Life	50% @ 25 cycles	80% @ 500 cycles	80% @ 1000 cycles	TBD (~500 – 1000)	50% @ 500 cycles
Overcharge Tolerance	medium	medium	low	very low	high
Energy by volume (watts/liter)	220	100	135	230	70
Energy by weight (watts/kg)	80	45	55	90	30

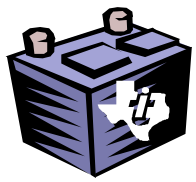
Look for continuing improvement in the green figures

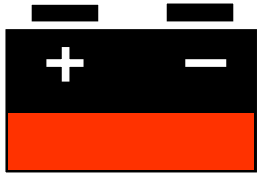


Gas Gauge IC —What and Why?

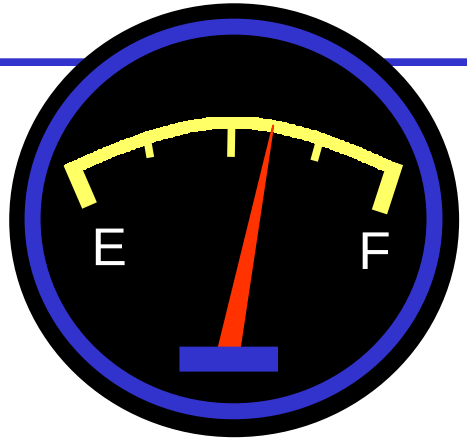
- What is a Gas Gauge IC?
  - Battery capacity monitor
    - State-of-charge measuring device
  - Battery status monitor
    - Voltage, current, and temperature measurement
- Why use a gas gauge IC?
  - Inform user of accurate state-of-charge
    - Increased confidence of use near empty
    - LED indication of state-of-charge when out of system
    - No guessing whether battery is charged
  - Overcharge and over-temperature warnings

Lithium-Ion Battery "Gas Gauges"





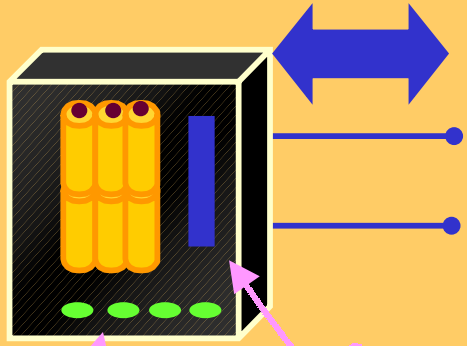
Battery
"State of Charge"



Li-Ion Gauges	Comments
General	
bq2050(H)	Basic Gas Gauge
NotePC	
bq2040	SMBus 1.0
bq2060	SMBus 1.1 **(RTP 2Q00)**
Cellular	
bq2018	Analog gas gauge circuitry works with uC

"Coulomb Counting"

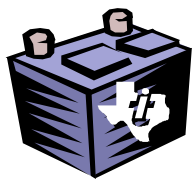
Idea: Keep count of Input & Output Current

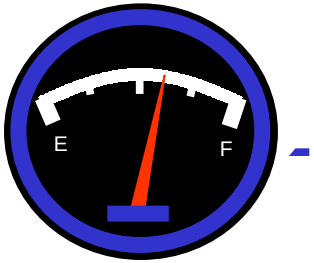


State of charge LED indicators

battery protection ic

Gas Gauges -- Selection Tree





Gas Gauges

NiCd/NiMH 800mAh–5Ah

- **DQ**
  - **bq2010** Basic NiCd/ NiMH Gas Gauge
  - **bq2012** Includes slow charge control output
  - **bq2014** Communicates with bq2004
- **HDQ**
  - **bq2014H** Reports current and remaining energy

NiCd/NiMH/Pb Acid 2Ah–20Ah High Discharge

- **HDQ**
  - **bq2013H** Programmable offset, load, and charge compensations

Li-Ion 800mAh–5Ah

- **DQ**
  - **bq2050** Basic Li-Ion gas gauge
- **HDQ**
  - **bq2050H** Reports current, interfaces protector circuit

NiCd <2Ah High Discharge

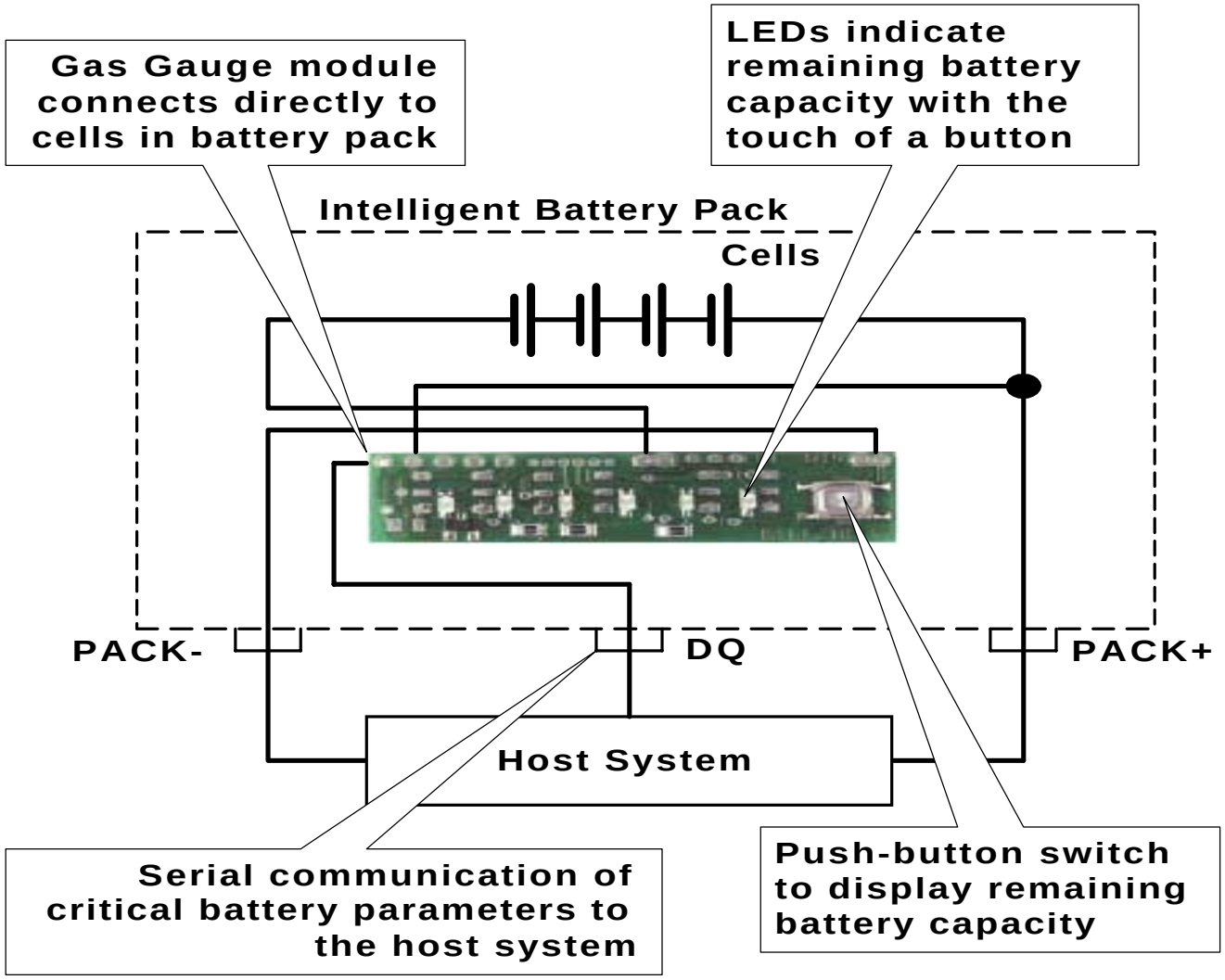
- **DQ**
  - **bq2011** 900–2.1Ah, 5mΩ sense resistor
  - **bq2011J** 900mAh–2.1Ah, 5mΩ sense resistor
  - **bq2011K** 1.1–2.1Ah, 2mΩ sense resistor, automatic 10-sec LED display on discharge

Chemistry Independent

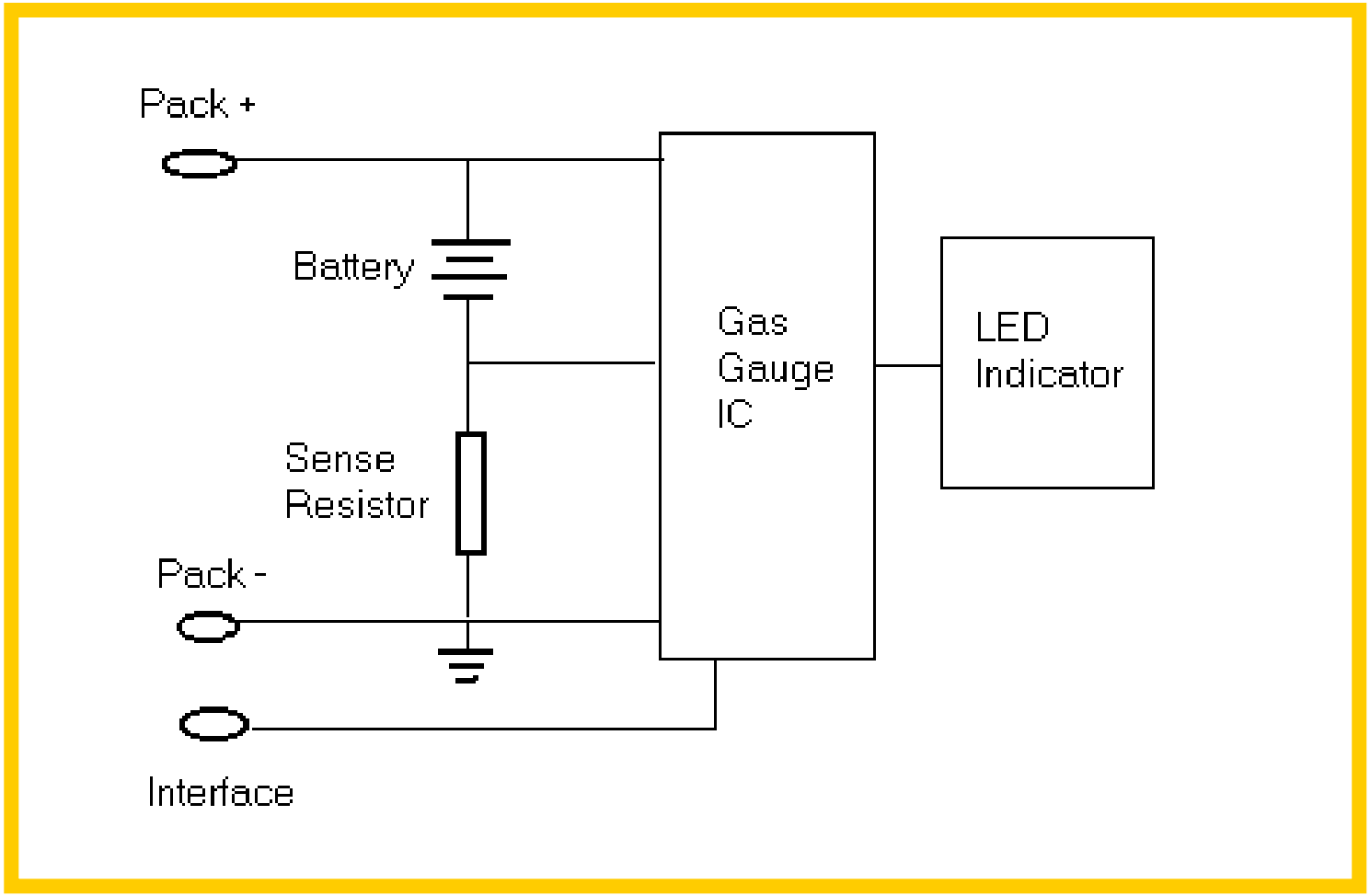
- **HDQ**
  - **bq2018** Analog peripheral, works with µC
- **SMBus** — **Communication Protocol ***
  - **v.1.0**
    - **bq2040** Smart Battery Data set, 4 LEDs
    - **bq2945** Smart Battery Data set, 5 LEDs
  - **v. 0.95**
    - **bq2092** Most of the Smart Battery Data set, 4 LEDs

*** DQ = 1-wire 333 bits/sec**
HDQ = 1-wire 5k bits/sec
SMBus = 2-wire 100 kHz

Typical Battery Pack with Gas Gauge IC



Gas Gauge System Implementation

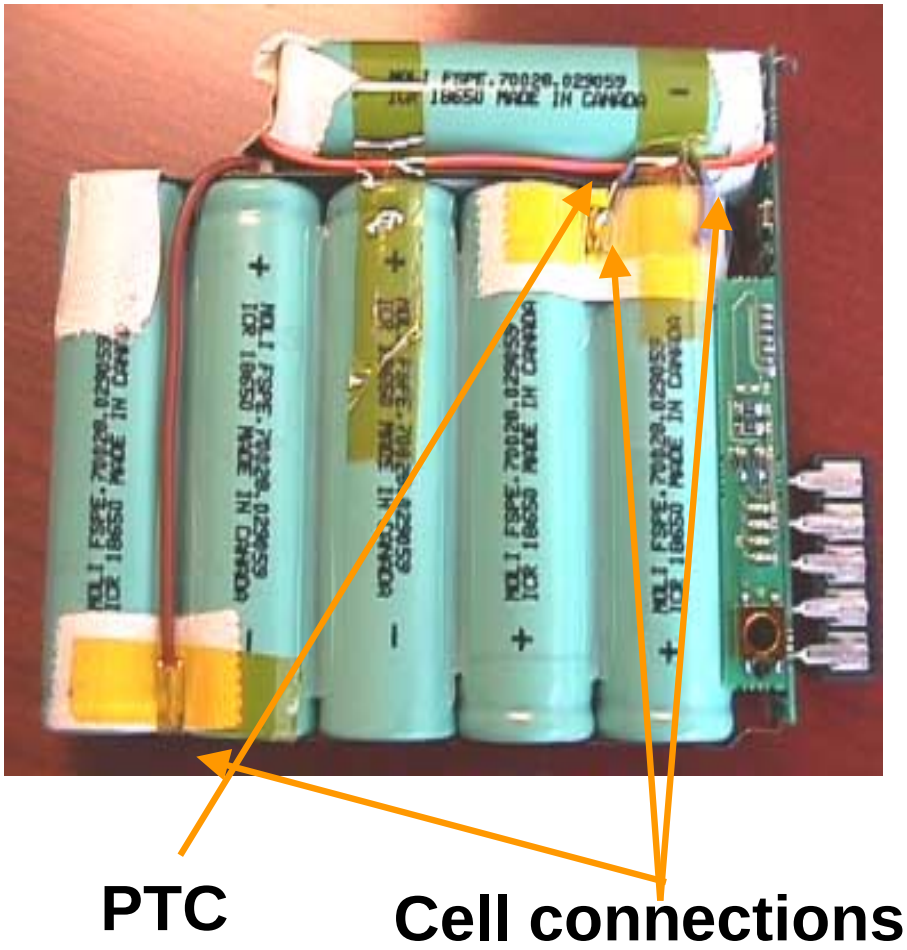


bq2040/2060 SMBus Gas Gauge in Typical Computer Battery Pack

- 8-series cells
- 5-terminal connector (minimum connector)
  - Pack +
  - Pack -
  - SMB Clock
  - SMB Data
  - Safety Signal
- Typical capacity between 37 and 40 Wh

Battery Pack, 3S2P Li-Ion

- Complicated interconnect
- Safety devices
  - PTC
    - Limits current
  - Safety IC
    - Limits charge V
    - Limits discharge V
  - GG for redundancy
    - Disables charge on overvoltage



Li-Ion Battery Protection -- e.g. UCC3952

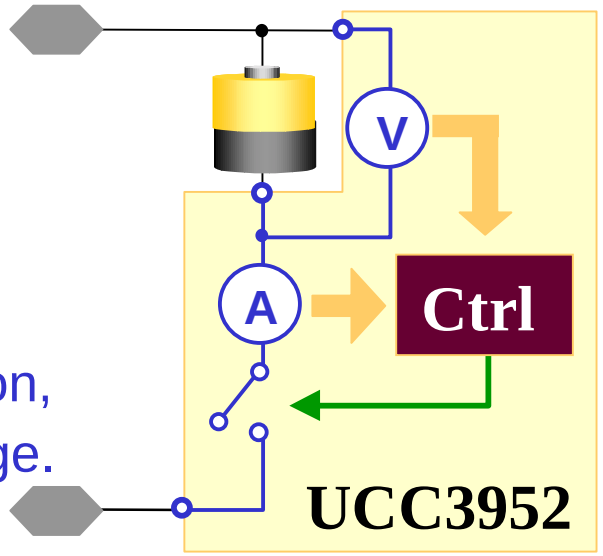
What

•Safety issues with Li-Ion or Li-Polymer batteries commonly used in consumer apps (e.g. Venting)

• UCC3952/11/57 for people protection

• Provides Short-circuit and over-current protection, and prevents battery overcharge or over-discharge.

• Low 5uA quiescent current for long battery life

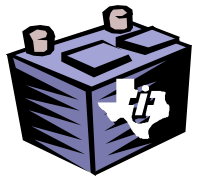


Target Market

• Battery pack manufacturers

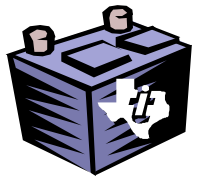
Device	#Cells	Comments
UCC3952	1	***Integrated FET*** reduces external
UCC3911	2	components and size (Important!)
UCC3957	3, 4	External FET

Li-Ion: 50% the weight, +50% longer use time vs NiMH



What does the Battery Protector do?

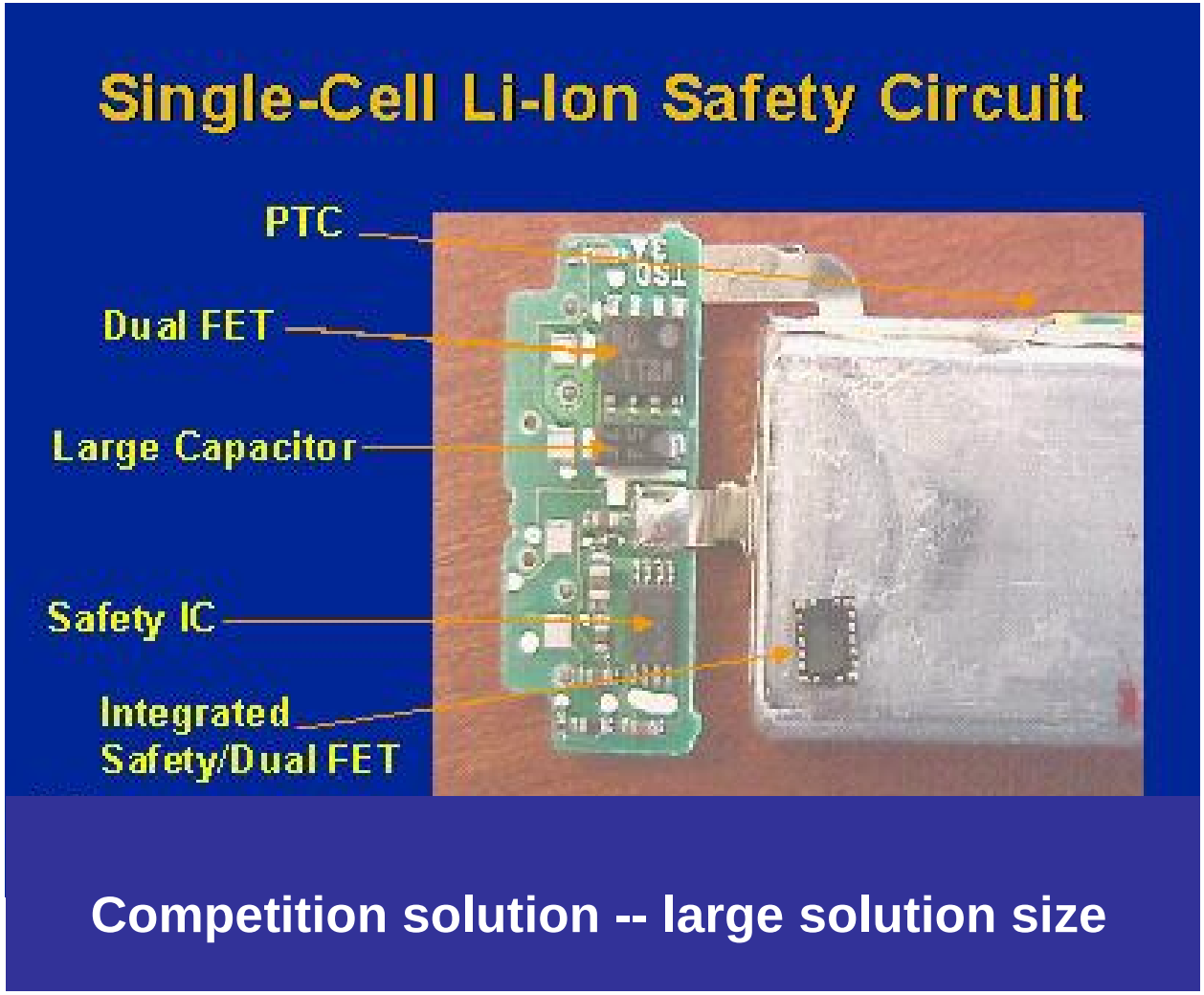
- Monitors all cell voltages
- Stops charge current if a cell reaches ***over-voltage***
- Stops discharge current if a cell is ***over discharged***
- Goes into “sleep” mode during over discharge
- Wakes-up when a charger is applied
- Responds rapidly to an ***overcurrent*** by opening circuit
- Draws very little current from the battery during operation



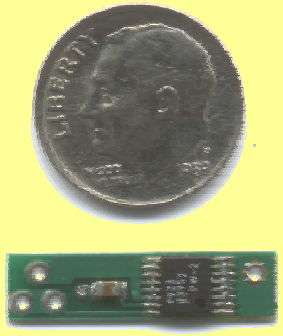
UCC3952 Single Cell Protector

- Integrated 50 mOhm FET - No external FETs required!
  - ***The only part on the market with internal FET***
- Built-in filter and time delay before declaring a fault
- Bypass cap provides hold-up in case of hard short
- Controlled FET turn-off time to minimize inductive effects
- 3 Amp capability (steady-state)
- Proven short circuit protection
- Thermal Shutdown
- 5µA supply current
- Test clock input speeds up customer testing

Li-Protector Comparison: Competitor Solution vs TI solution

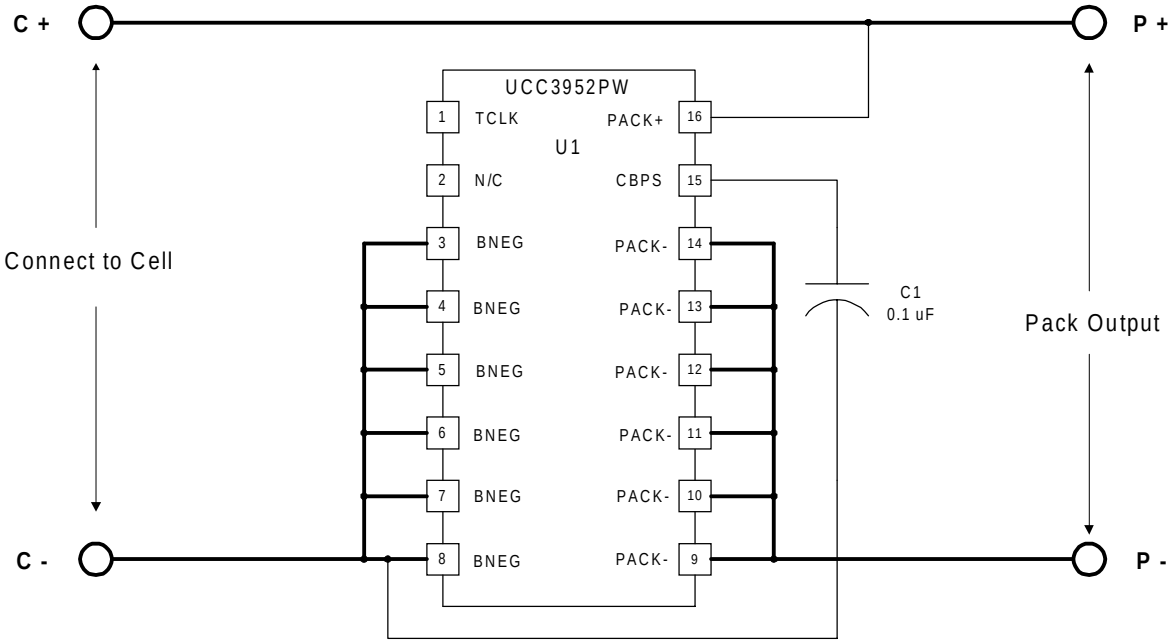


Competition solution -- large solution size



TI solution -- few components, good reliability

UCC3952 Application Circuit



TI solution: TSSOP-16 device, with 1 to 3 small capacitors