TI POWER

Design considerations for 48V batteries in hybrid and electric vehicles

Battery Management Deep Dive Training

October 2020

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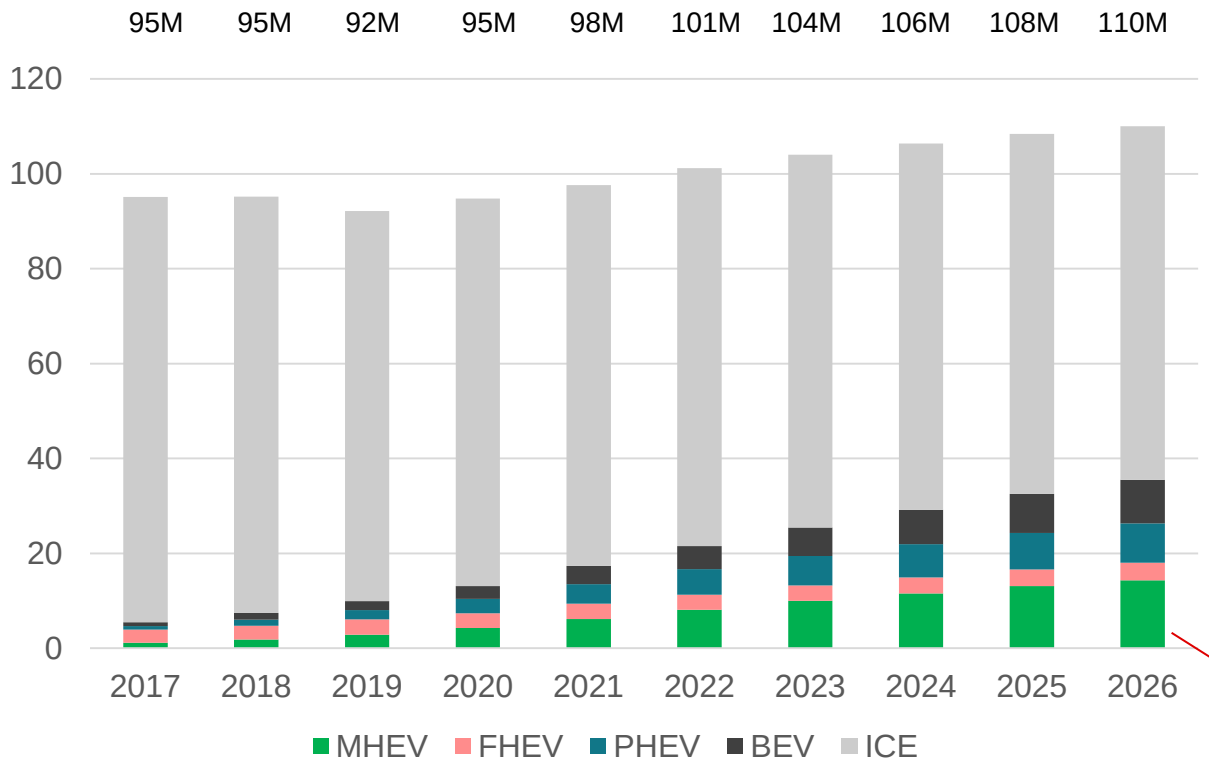
Why 48V system?

- Legislation
  - Electrification is a trend (xEV/ EV) driven by the government commitment to lower the CO_2 (g/km) emission
- Safety
  - Carries a low risk of dangerous electrical shock (low DC voltage)
- Infrastructure
  - No need of home installed, public charging infrastructure
- OEM Cost
  - Lower cost to decrease the fleet carbon footprint

Global HEV/EV vehicle sales and projections



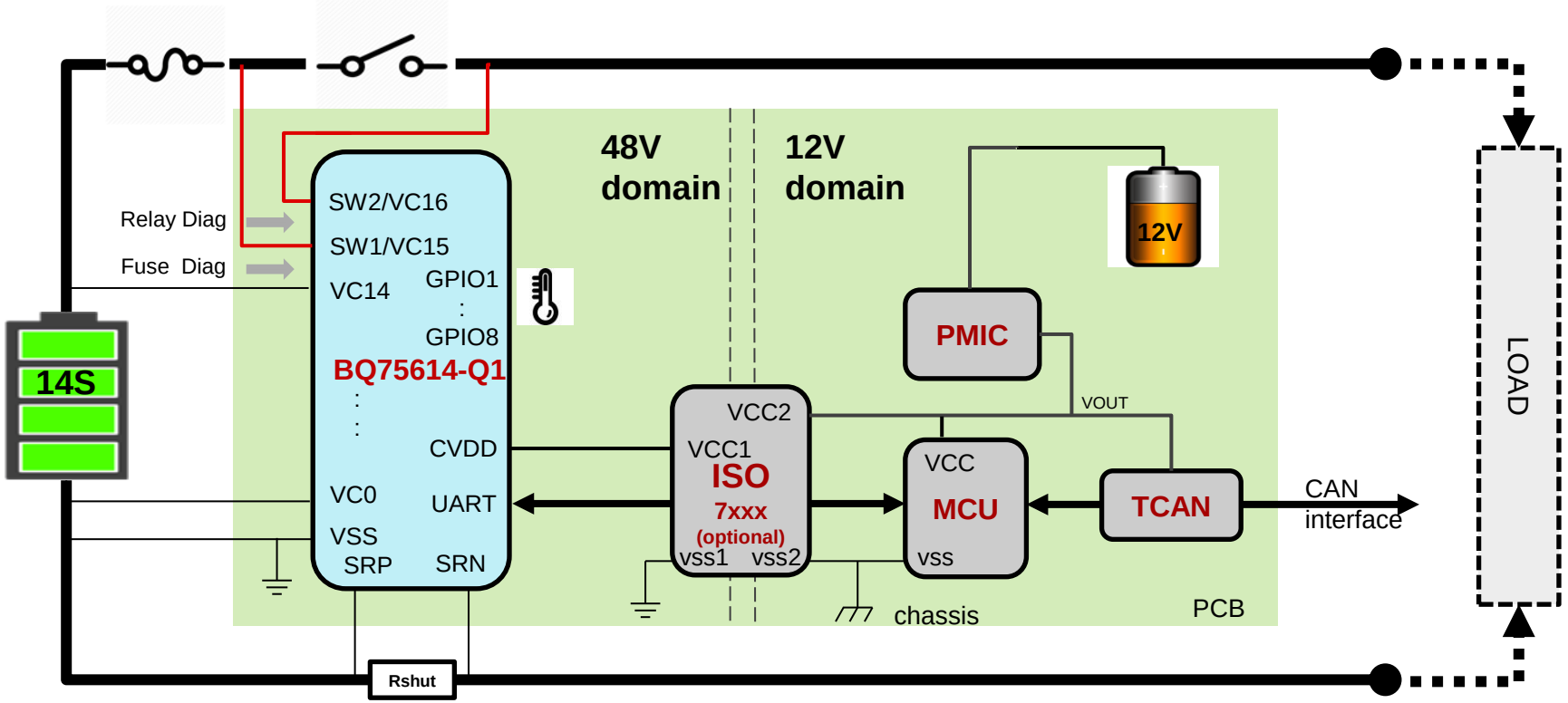
- 70% (75Mu) still standard 12V rail
- 30%+ (35Mu) HEV/EV share by 2026

Battery Electric	9.2Mu, 31% CAGR
Plug-In Hybrid	8.3Mu, 31% CAGR
Full Hybrid	3.7My, 3% CAGR
Mild Hybrid (48V)	14.3Mu, 32% CAGR

Source: Strategy Analytics

48V BMS system architecture

Topology variation:
- MCU on 48V side, isoCAN



*Also supports lithium-titanate battery chemistry

48V system major care abouts

- Integrated 300mA balancing FET
- Dynamic thermal management, pause balancing based on cell/ die temp

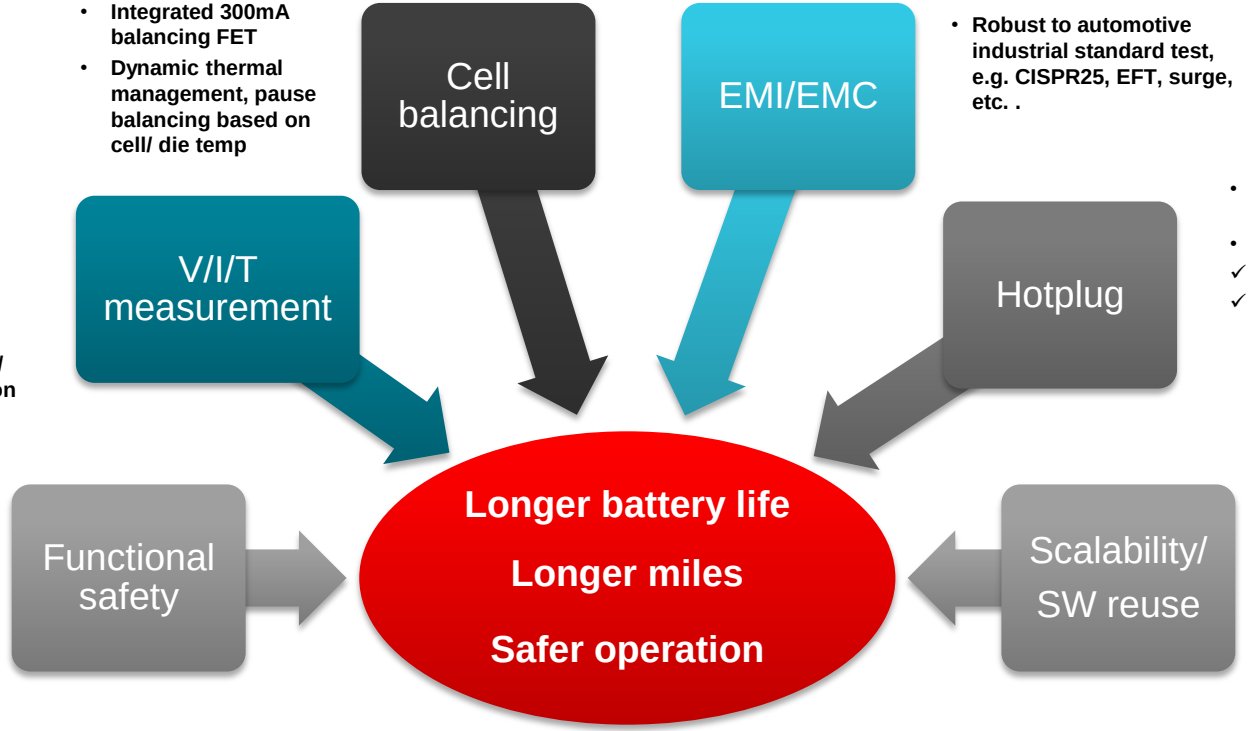
- Robust to automotive industrial standard test, e.g. CISPR25, EFT, surge, etc. .

- Synchronized V/I measurement
- High accuracy V/I measurement
- Dedicated current ADC
- Main/Aux voltage ADCs
- Integrated post ADC digital low pass filters w/ as low as 6Hz f_{cutoff} option

- Robust for random cell connection
- Optimized for BOM saving:
  - ✓ No external Zener needed
  - ✓ LV cap used instead of HV cap

- Functional Safety-Compliant ASIL-D targeted on V/I/T measurement and communication
- FDTI 100ms

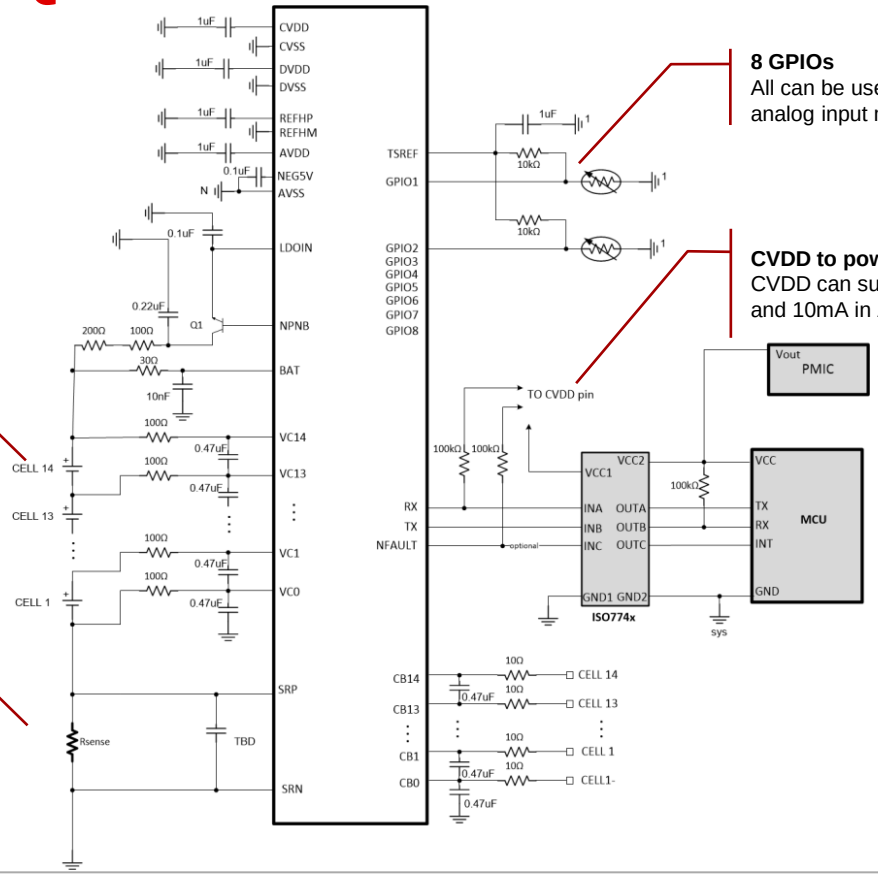
- Learn one, learn all
- Part of the family with 16S, 14S,12S monitor for HV system and 48V system
- All devices share same package/pinout and register map



BQ75614-Q1 reference schematic

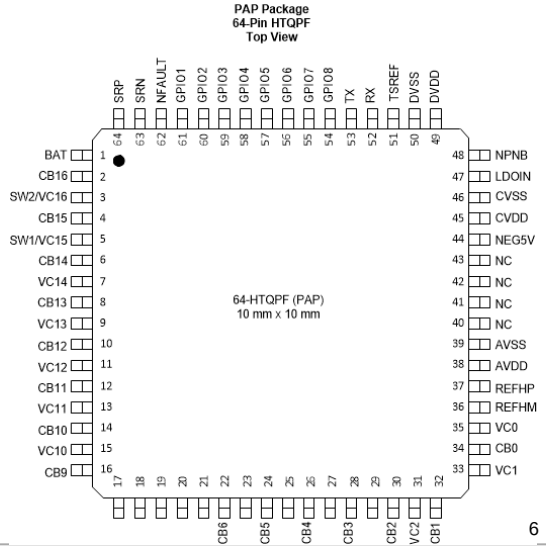
Filtered Vcell measurements
Built-in front end filters + programmable post ADC digital LPF for best SOC/SOH calculation

Integrated current sense
Sync'd current & cell voltages measurements for best SOC/SOH calculation

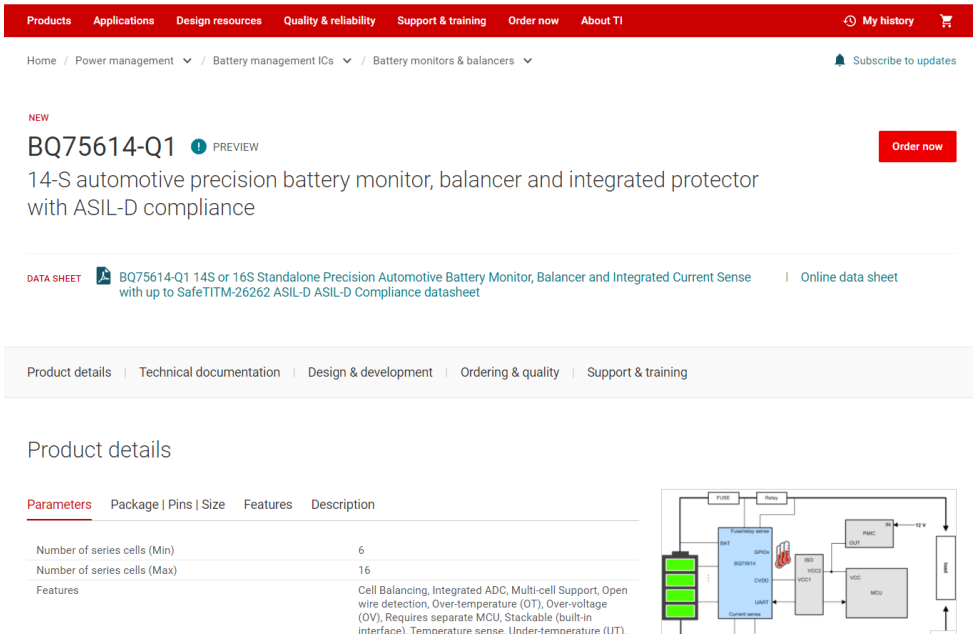


8 GPIOs
All can be used for thermistor connection, or analog input measurement

CVDD to power digital isolator
CVDD can support up to 5mA in SHUTDOWN and 10mA in ACTIVE and SLEEP



Start design with TI solution

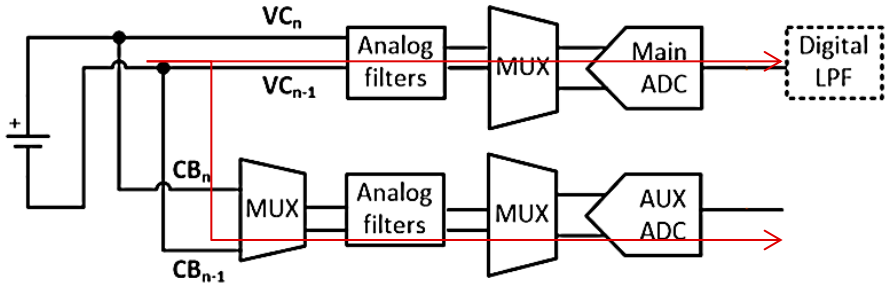


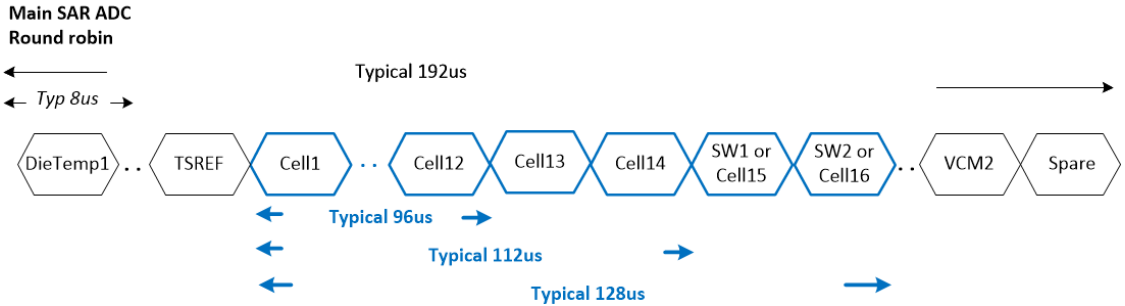
- Click here for product page (samples and EVMs)
- Click here for full datasheet
- To know more about the TI's roadmap and see what is coming, please contact your sales representative to set-up a call

TI offers automotive solution covering from 12V to 1500V+ application!

VOLTAGE & CURRENT MEASUREMENT

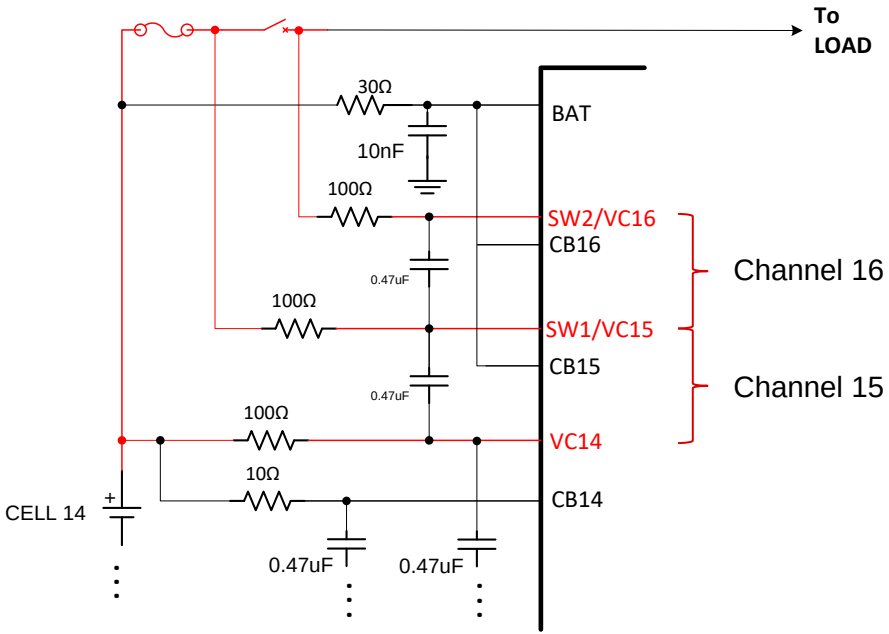
Cell voltage measurement





- ✓ Vcell Accuracy +/-1.5mV @ 25C
- ✓ Main path and redundant aux path for cell measurement
- ✓ Build in anti-aliasing filters
- ✓ Integrated digital low pass filter (6.5Hz, 53Hz, etc. configurable)
- ✓ Cell voltage is synchronized with in 112us
- ✓ Cell voltage is refreshed every 192us

Fuse and relay diagnostic

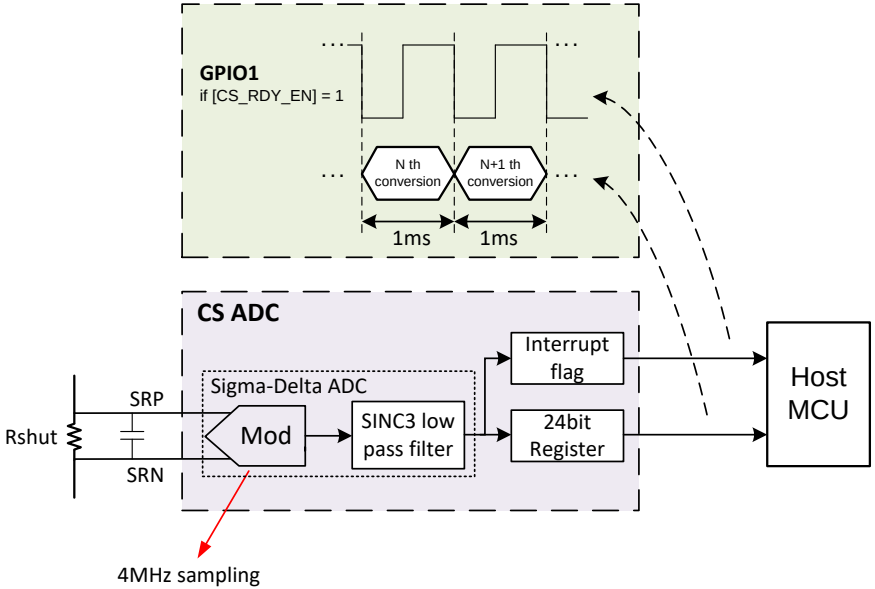


- Channels 16/15 can be used to diagnose the state of fuse and switch

Diagnostic	Open/Blown	Close
Fuse	(SW1-VC14) <<0V • SW1 will be pull down by the load	SW1-VC14 = ~0V • depends on current flow and fuse impedance (e.g. +/-0.3V)
Relay	(SW2-SW1) <<0V • SW2 will be pull down by the load	(SW2-VC1) = ~ 0V • depends on current flow and fuse impedance (e.g. +/-0.3V)

back

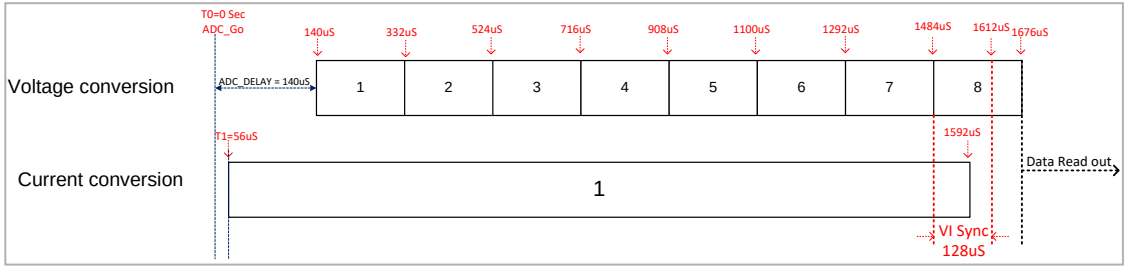
Current measurement



Parameter	Value	Comment
Input range	+/- 125mV	
Offset drift	+/- 1.5uV	
Gain error drift	+/- 0.3%	
ENOB	16.5 bits	@ 1ksps
Data rate	1ksps	Configurable
Resolution	14.6nV/LSB	24bit result

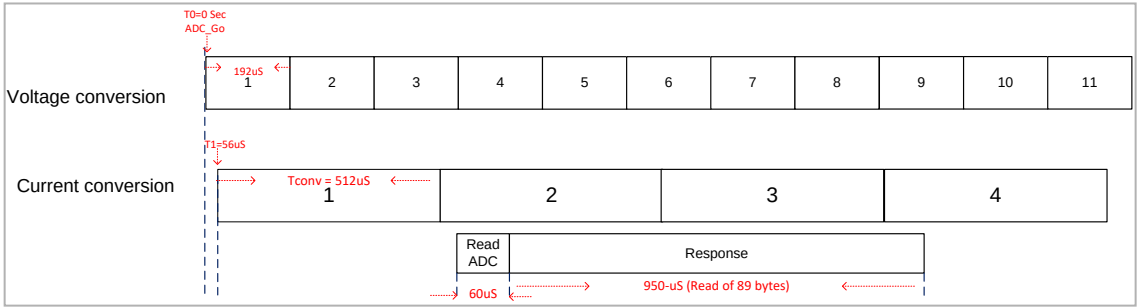
Voltage/current synchronization

Single ADC conversion



T_V/I sync = 128us

Continuous ADC conversion



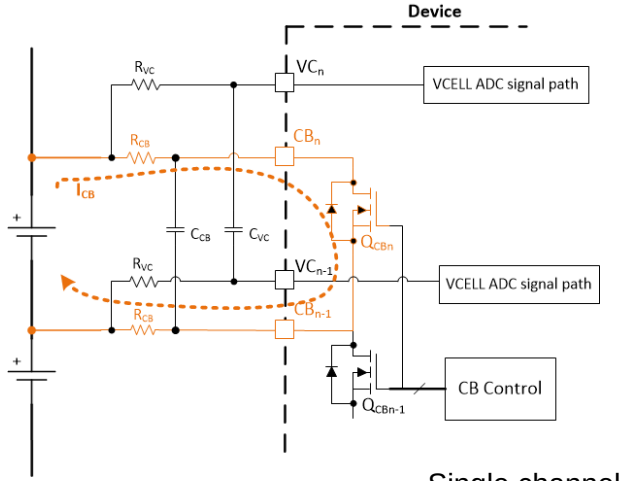
T_V/I sync = 1ms

back

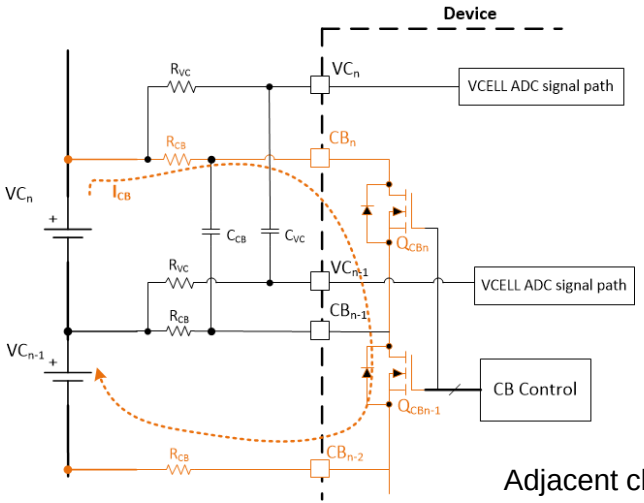
CELL BALANCING & THERMAL MANAGEMENT

Cell balancing current

Max cell balancing current
300mA with Ta = 60C
240mA with Ta = 80C



Single channel



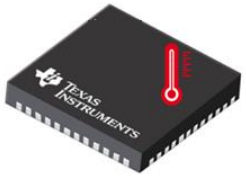
Adjacent channels

$$ICB = \frac{VCell}{(2 \times RCB) + Rdson_{QCB}}$$

$$ICB = \frac{Sum\ of\ two\ VCELL}{(2 \times RCB) + Rdson_{QCBn} + Rdson_{QCBn-1}}$$

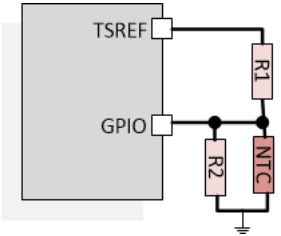
CB thermal pause

- CB TWARN



- Monitor through internal die temperature
- Pause CB if die temp > 105^{o}C
- Recover with 10^{o}C hysteresis
- Always on

- Thermistor OTCB

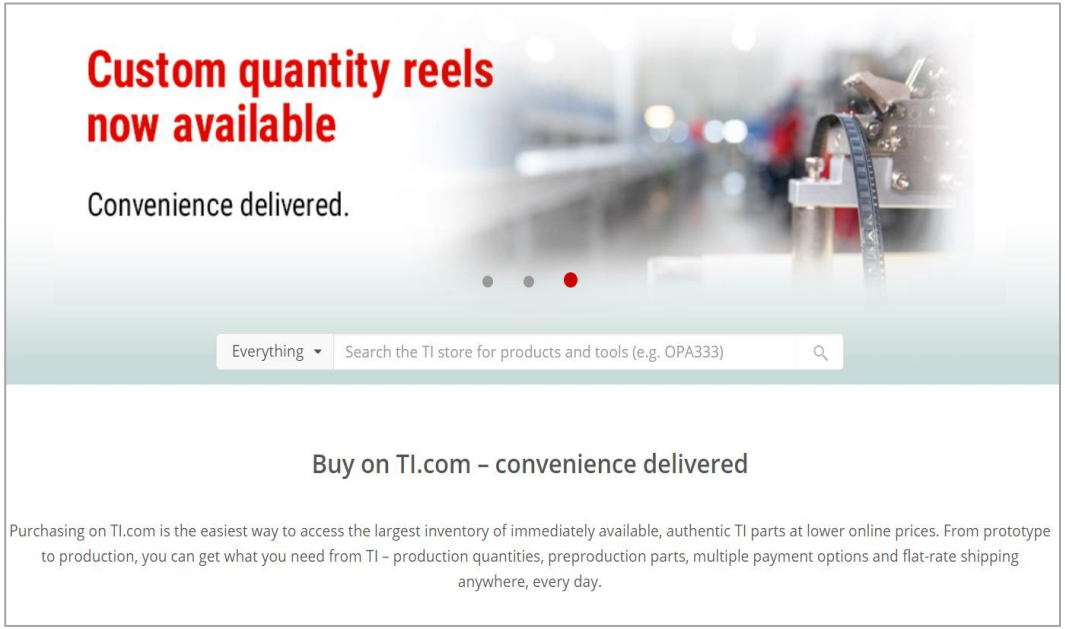


- Monitor through external thermistor
- Pause CB if thermistor measurement > OTCB threshold (programmable)
- Resume CB with COOLOFF hysteresis (programmable)
- Register bit enable

back

Aiming to provide you with convenience

Buying on TI.com: from concept to production, inventory when you need it.



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