Texas Instruments

TI POWER

TI *Live!* BATTERY MANAGEMENT SYSTEMS SEMINAR

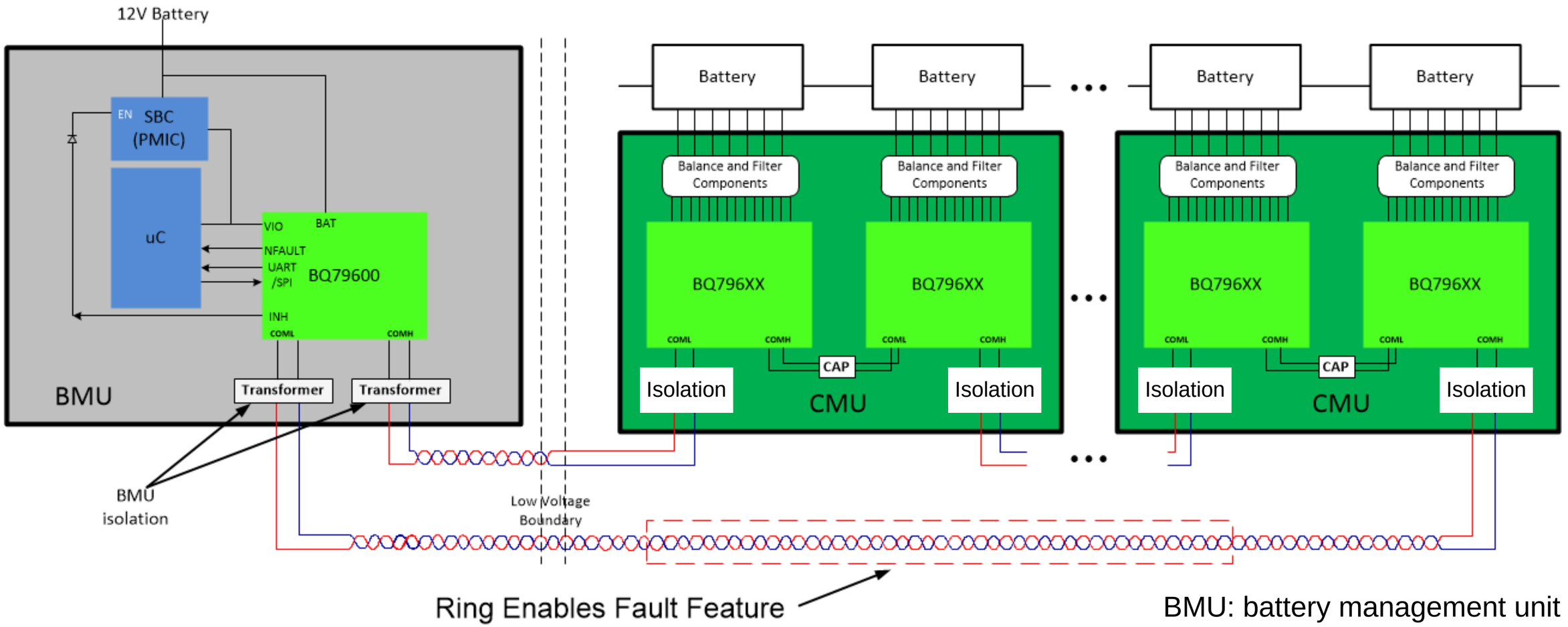
SPENCER HU

xEV BATTERY PACK AUTONOMOUS MANAGEMENT IN PARK MODE

Agenda

- System-level block diagram
- Why park mode monitoring?
- Park mode monitoring: traditional vs autonomous
  - Window comparator: OVUV/OTUT
  - Autonomous cell balancing
  - Reverse wake up
- TI electrical vehicle (EV) battery management systems (BMS) product
- BQ79616 introduction
- Demo and sample

BMS system-level block diagram



BMU: battery management unit
CMU: cell monitor unit

Why park mode monitoring?

- Driving mode: BMS microcontroller (MCU) takes control
- Enhanced battery safety requirements to avoid catastrophic events and to meet new and future governmental standards, e.g. GB38031-2020

New Chinese safety standard for batteries of electric vehicles - GB 38031-2020 standard

On May 12, 2020, the Chinese government has published a new safety standard for batteries of electric vehicles, the GB 38031-2020 standard. It will come into effect on January 1, 2021 and shall be used from that date on.

This Standard specifies safety requirements and test methods for power battery units, battery packs or systems used in electric vehicles (hereinafter referred to as batteries).

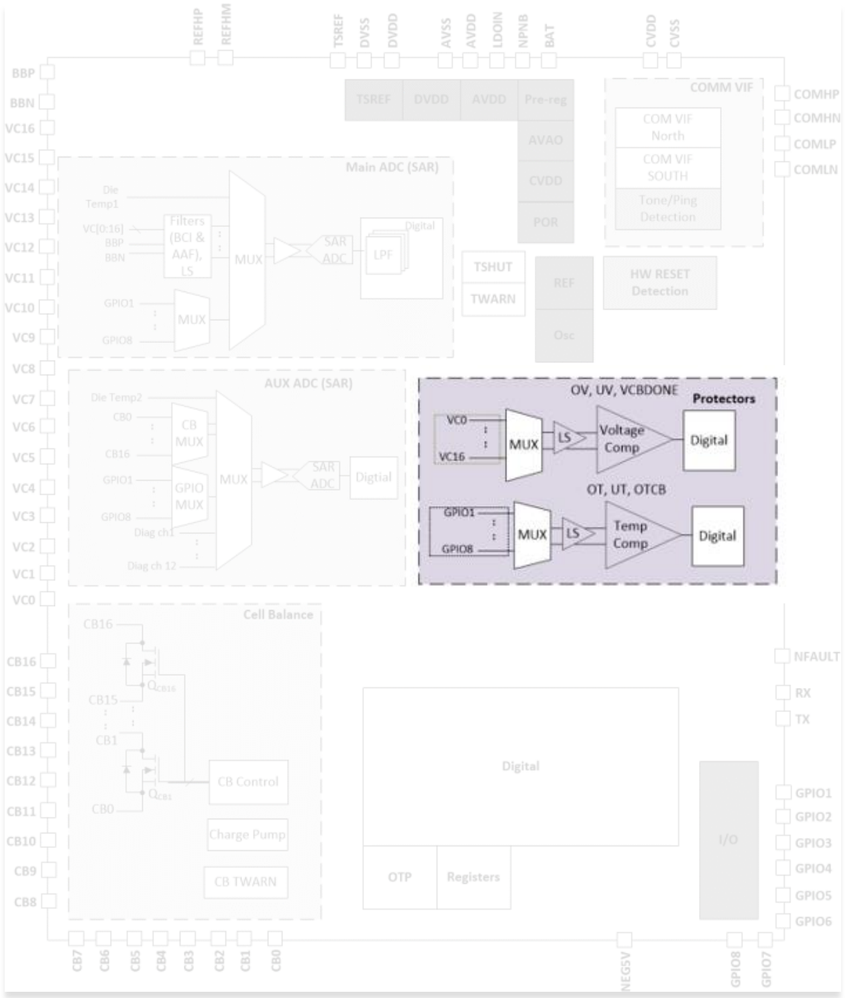
Standard call out: battery pack or system should send a thermal event alarm signal **5 minutes** before battery system catches fire or explodes caused by battery thermal runaway which endangers the cabin passengers.

Park mode monitoring | traditional vs. autonomous

- Traditional method disadvantage:
  - Over/under voltage/temperature (OVUV/ OTUT) spot check by host MCU
  - Needs MCU controls cell balancing
  - MCU often wakes up, depletes 12-V battery
  - Less safety coverage
- Autonomous method advantage:
  - Continuous OVUV OTUT coverage
  - Autonomous cell balancing with multiple protection
  - MCU offline, conserves 12-V battery energy
  - Reverse wakeup MCU upon battery pack fault
  - Higher diagnostic coverage

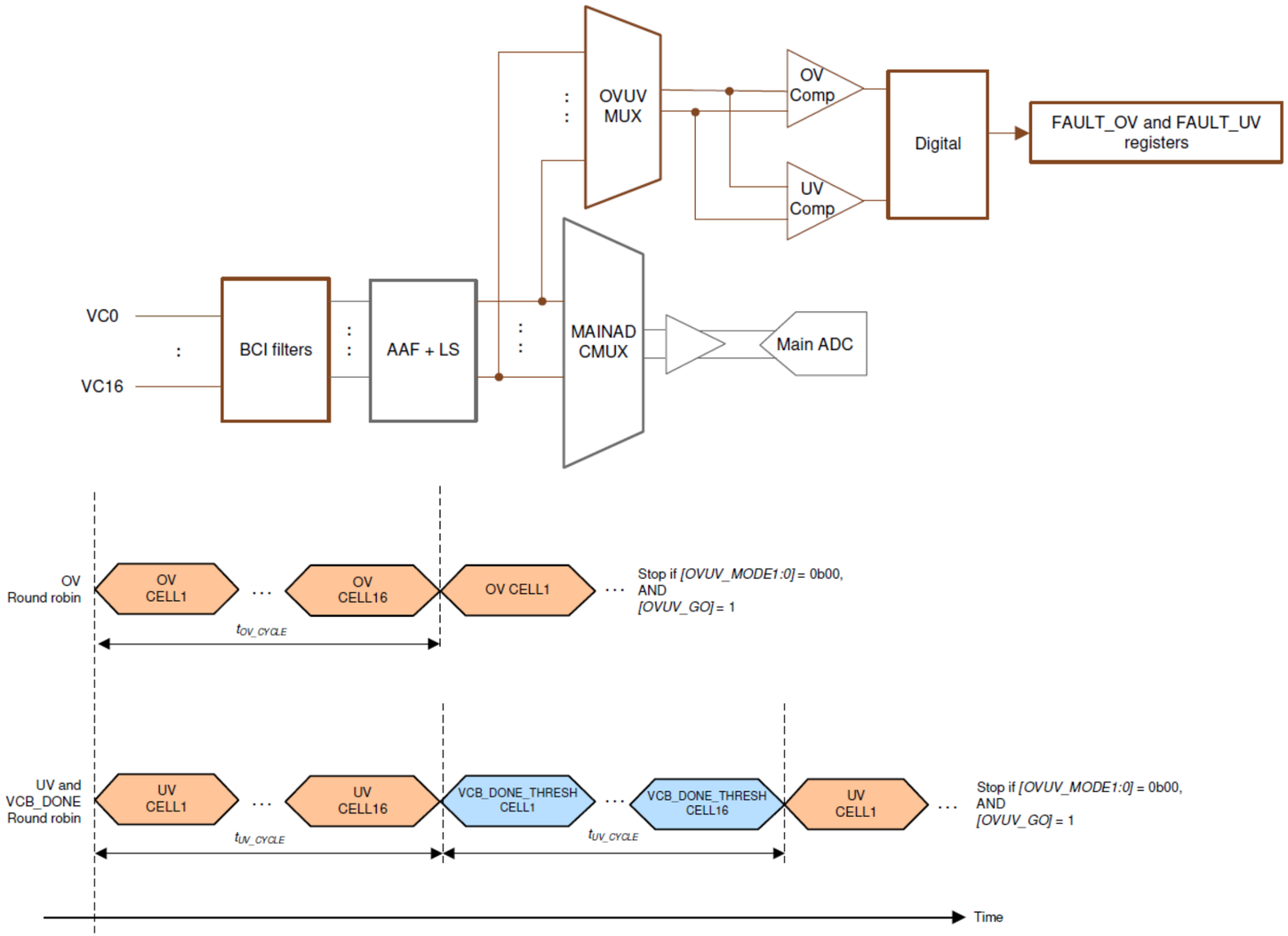
Voltage/temperature window comparator

Window comparator



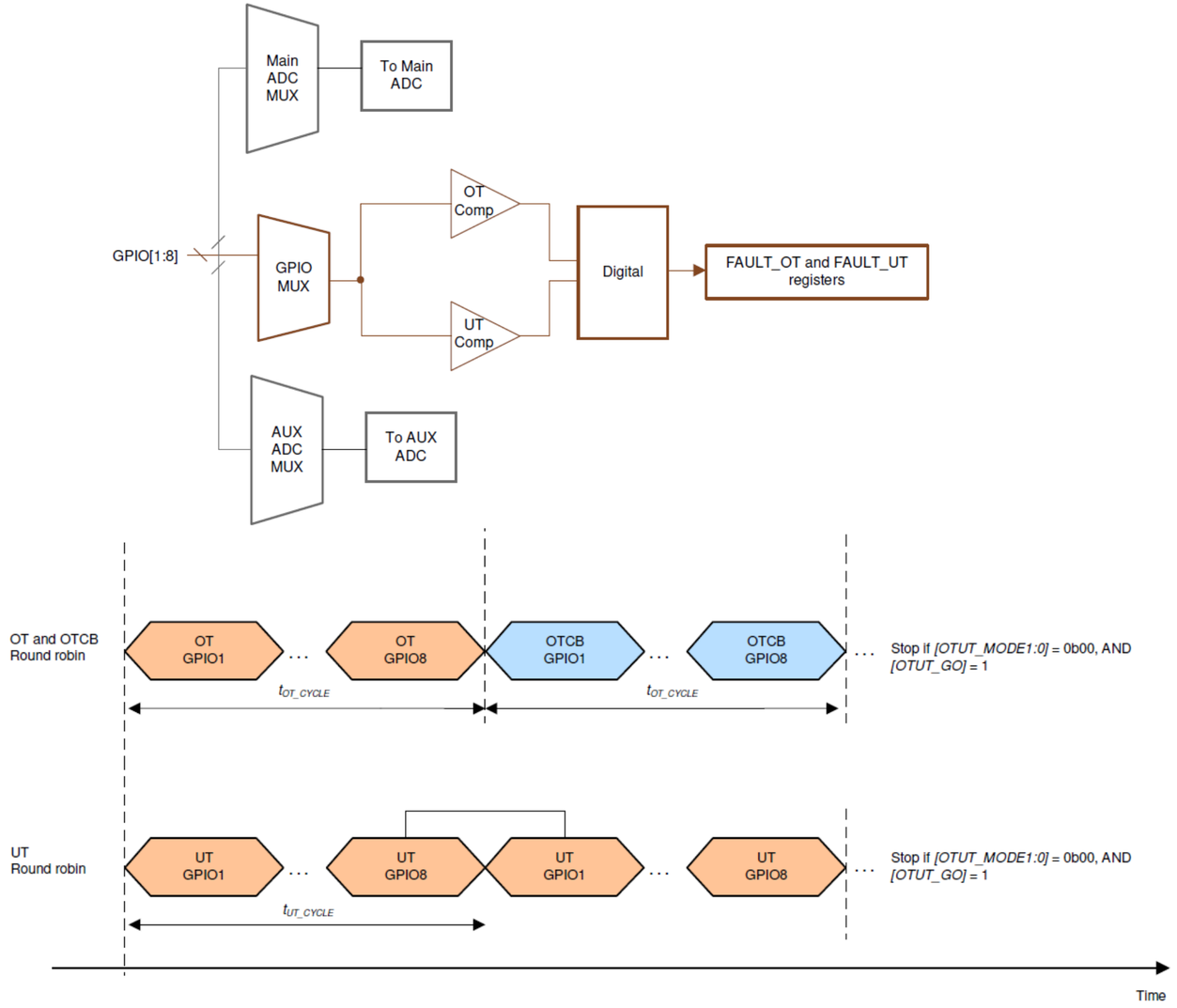
- Low-power comparators are continuously running while the device is in sleep mode:
  - Provide UV/OV monitoring on cell voltage
  - Provide OT/UT monitoring on GPIO NTC
- Threshold is programmable for different applications and chemistries
- Independent from main analog-to-digital converter (ADC)
- Sleep mode Iq = 260 uA

OVUV architecture and scheduler



- OV and UV are checked in parallel by two separated comparators
- Support round-robin run mode
- Under voltage detection can stop the over balancing
- Detected fault could trigger the device to send fault tone which wakes up the BMS MCU

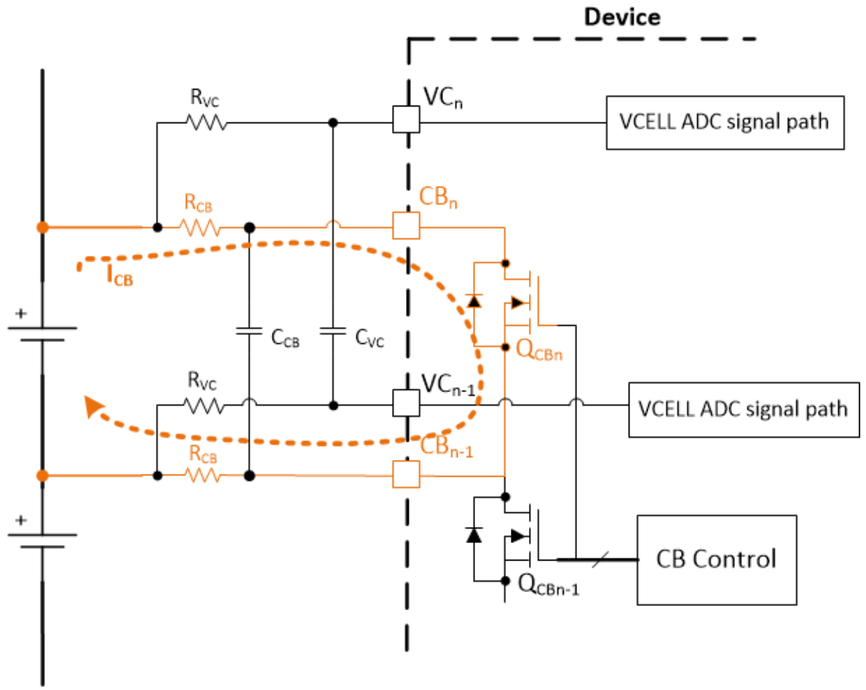
OTUT architecture and scheduler



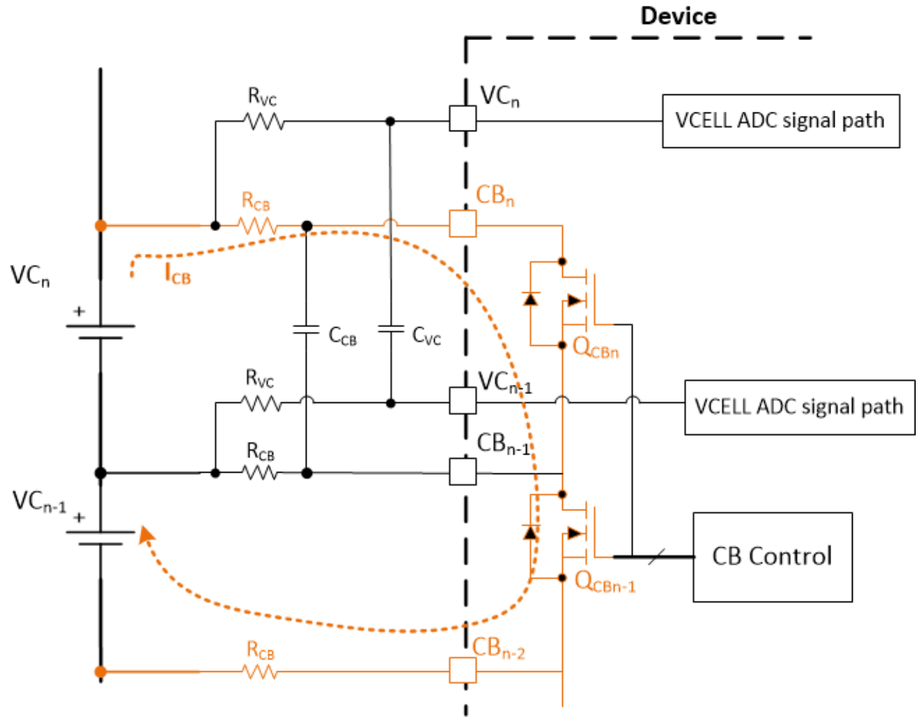
- OT and UT are checked in parallel by two separated comparators
- Support round-robin run mode
- OT also offers balancing pause feature
- Detected fault could trigger the device to send fault tone, which wakes up the system

Autonomous cell balancing

Cell-balancing circuit



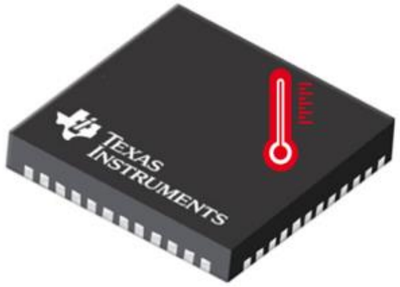
$$ICB = \frac{VCell}{(2 \times RCB) + Rdson_{QCB}}$$



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

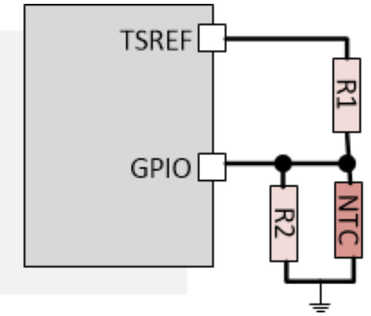
Cell-balancing thermal pause

Die temp warning



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

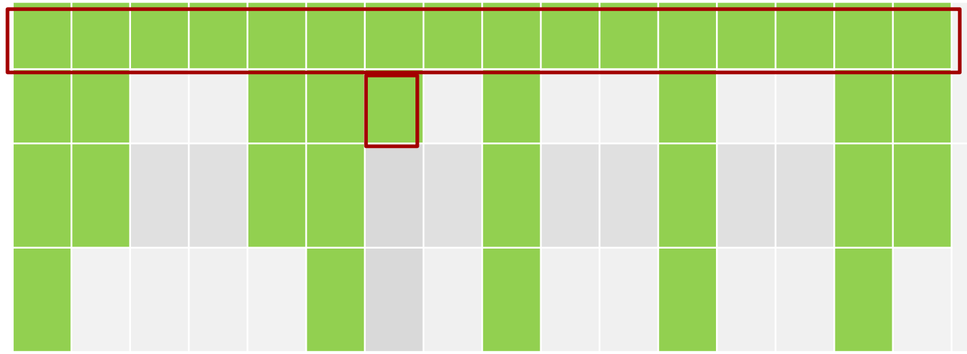
Thermistor monitoring



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

Cell-balancing control scheme

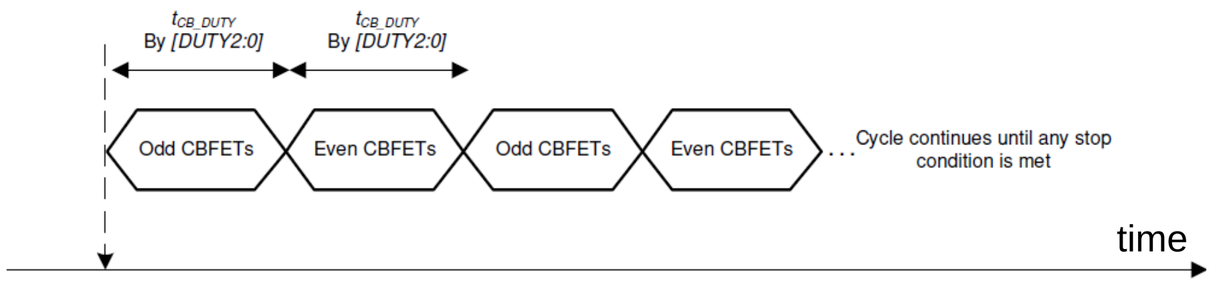
	Auto control	Manual control
Control	Always duty cycle between odd and even	Only turn on the channels that are enabled
Stop conditions	Timers (up to 10 hours), AND Cell voltage threshold	Timers (up to 10 hours), AND Cell voltage threshold
Thermal pause	Yes	Yes

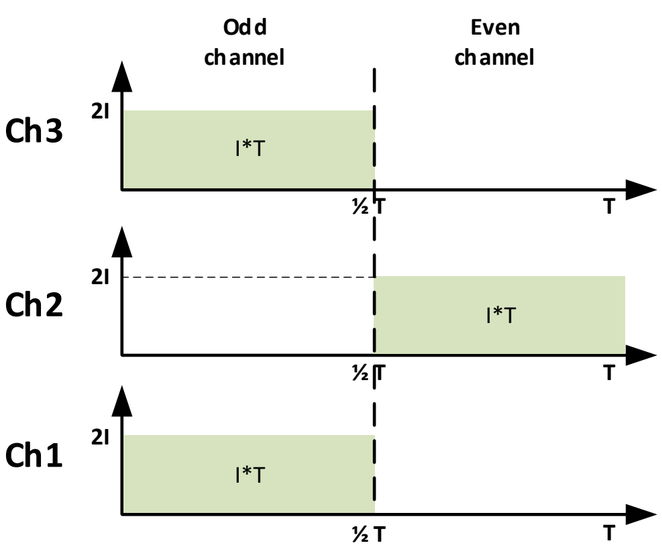
CB1	CB2	CB3	CB4	CB5	CB6	CB7	CB8	CB9	CB10	CB11	CB12	CB13	CB14	CB15	CB16	**Valid or invalid setting**	**Manual CB control**
																Invalid setting	Total enabled channels >, OR > 2 consecutive channels are enabled
																Valid	Ok, device turns on the enabled channels

- **Auto Cell-balancing control** can support all the configuration list above

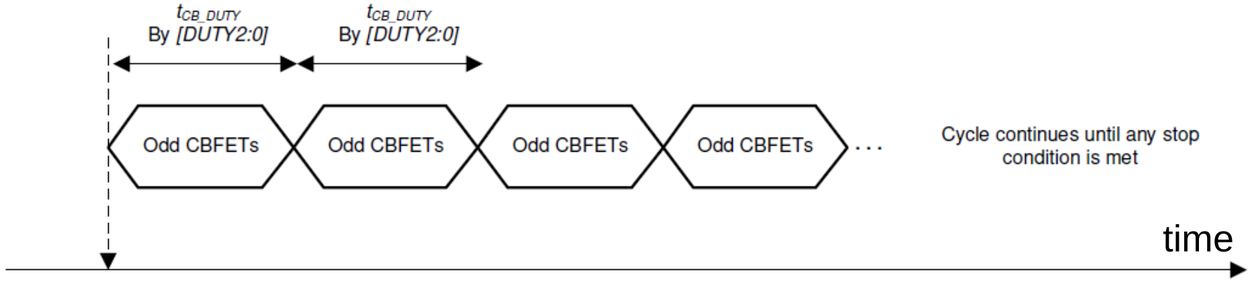
Cell-balancing control scheme (auto mode)

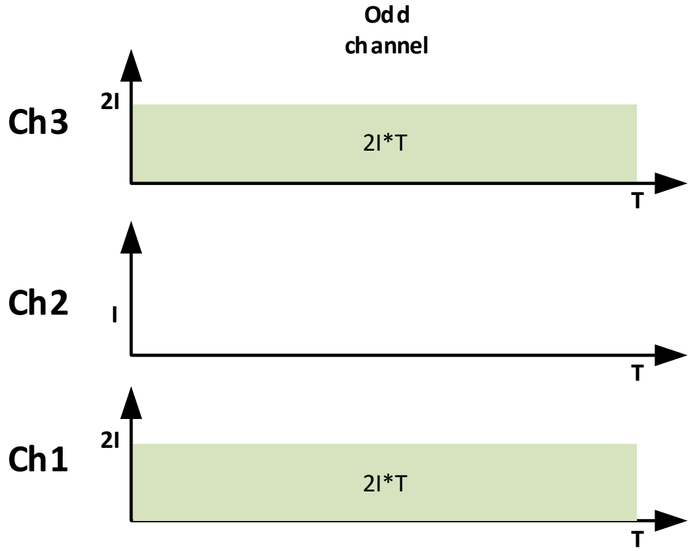
- Autonomous balancing supports up to 10 hours
- Odd/even





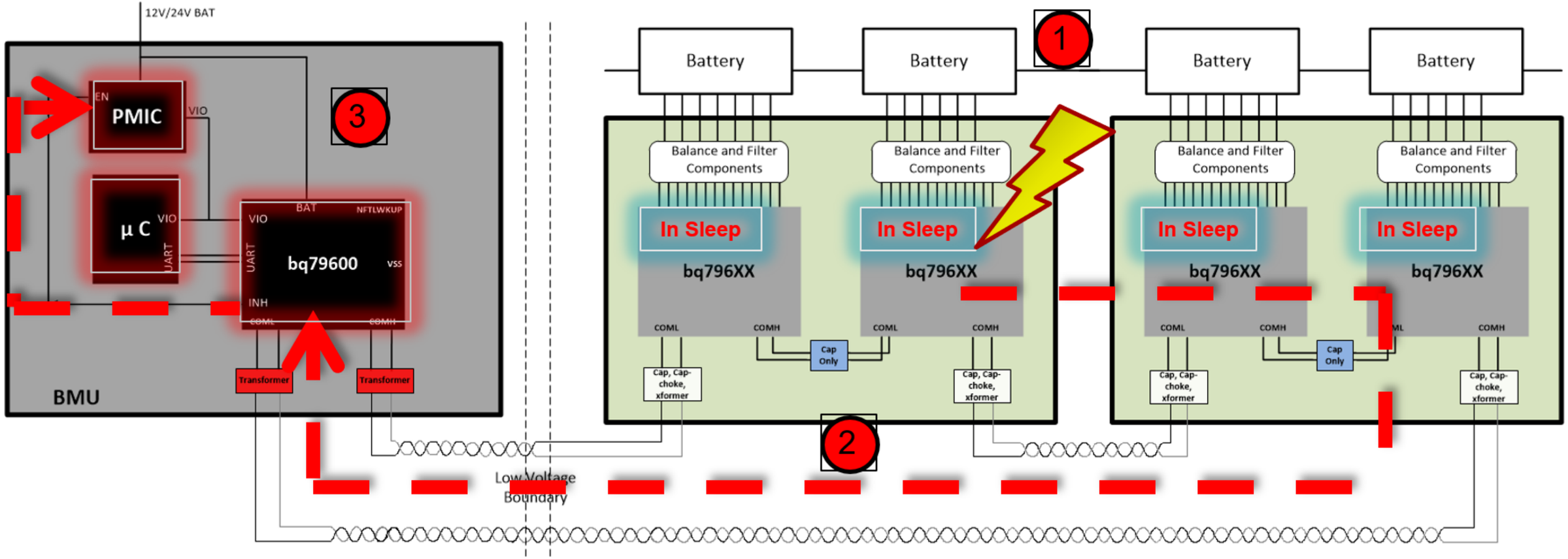
- Odd only





Reverse wakeup

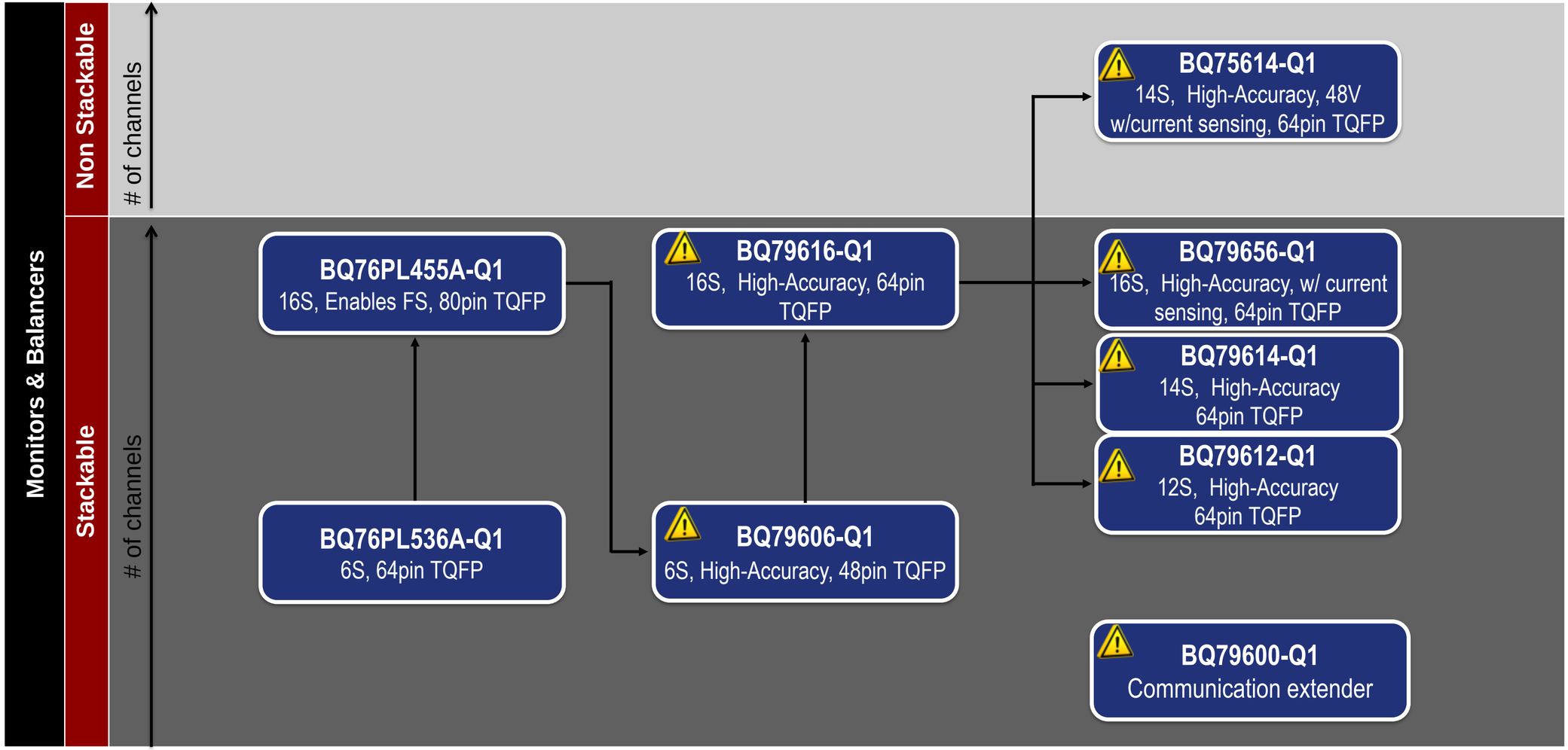
BQ79600 + BQ79616: Auto wake-up system at fault



1) Detect fault while BQ79616 is sleep mode (low Iq)
2) Fault tone transfers through communication line to the BQ79600
3) BQ79600 wakes up, and then wakes up PMIC (Power management IC) and uC (MCU)

TI EV BMS product portfolio

Functional Safety
ASIL D

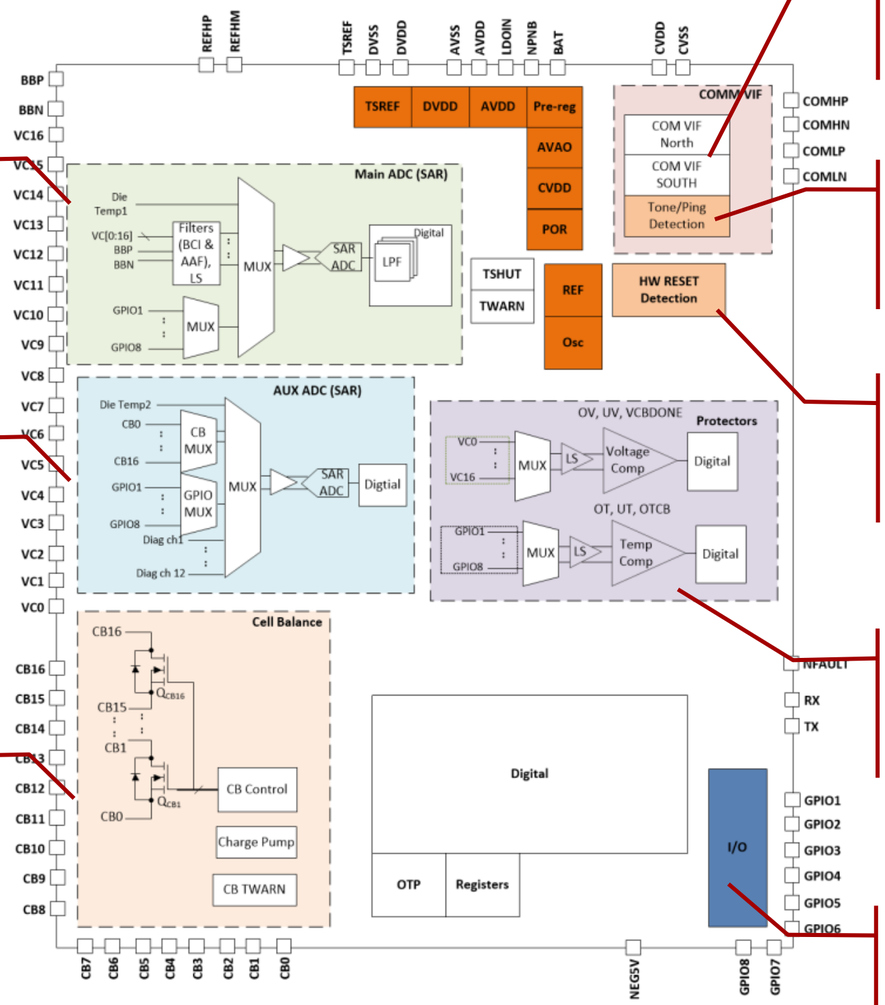


What is the BQ79616?

Main ADC
Measure VCELL, busbar (if used) and temperatures.

Aux ADC
Redundancy for Main measurement. Mainly use for diagnostic. Also measure VBAT.

Cell balancing
Internal CB w/ typ 2.5Ω Rdson.
Support Icb 240 mA w/ thermal management.



Vertical interface
Bi-directional daisy chain communication requires 1 twisted-cable pair. Also support ring communication.

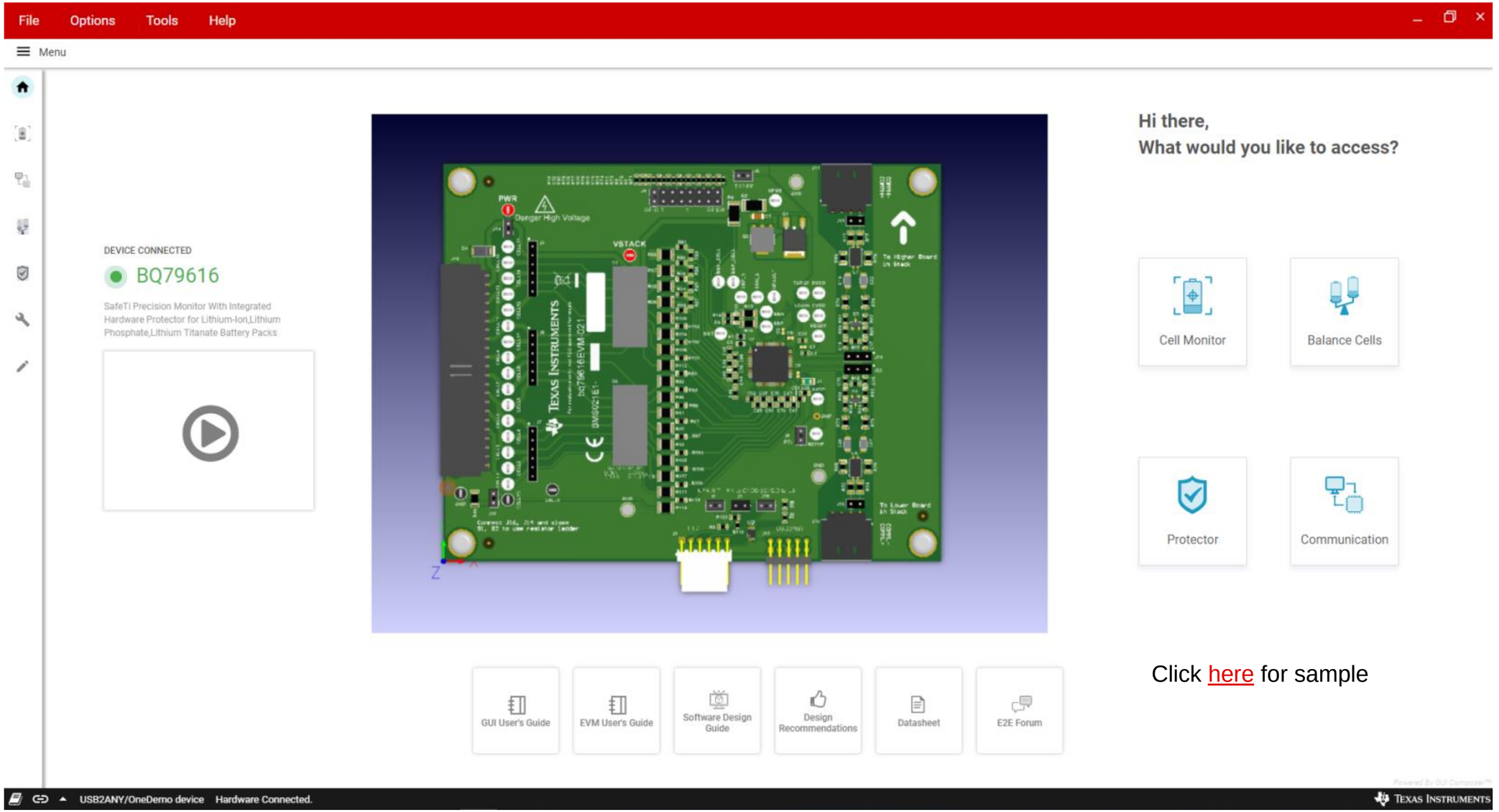
Tone/ping detection
Handle critical power transition signal (e.g. WAKE, SHUTDOWN etc).

Hardware (HW) reset
Independent HW reset detection block.

Integrated HW protectors
HW comparators, independent of ADC operation, for OV, UV, OT, UT detection. Can operate in sleep mode. These are also used for Cell balancing voltage/thermal detection

General-purpose input/outputs (GPIOs)
8 GPIOs: Can be use for NTC thermistor or auxiliary voltage input measurement. Can also be use for SPI master

BQ79616 evaluation module and user interface



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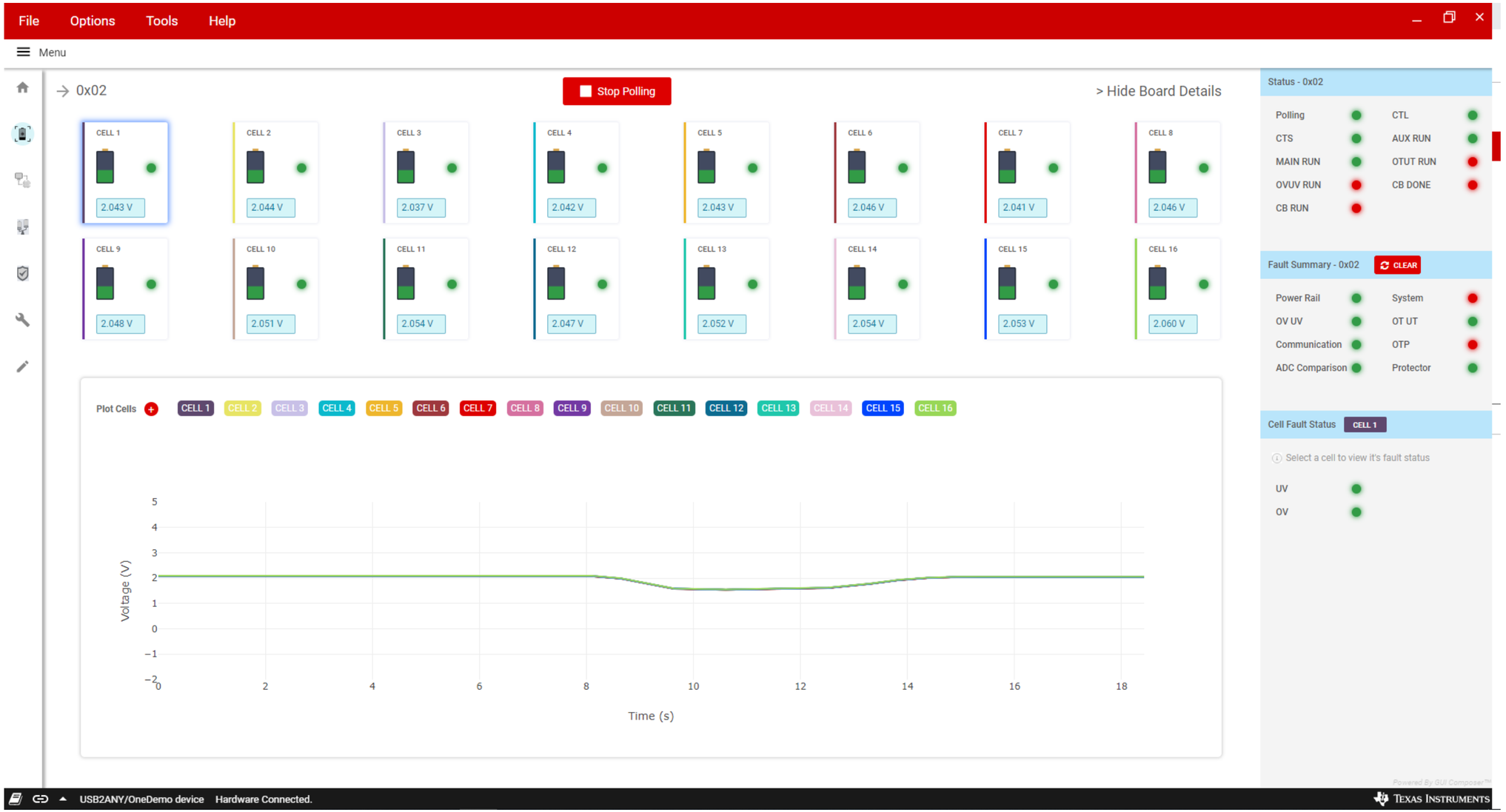
BQ79616 user interface: Cell monitor board details



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