

# TI *Live!* BATTERY MANAGEMENT SYSTEMS SEMINAR

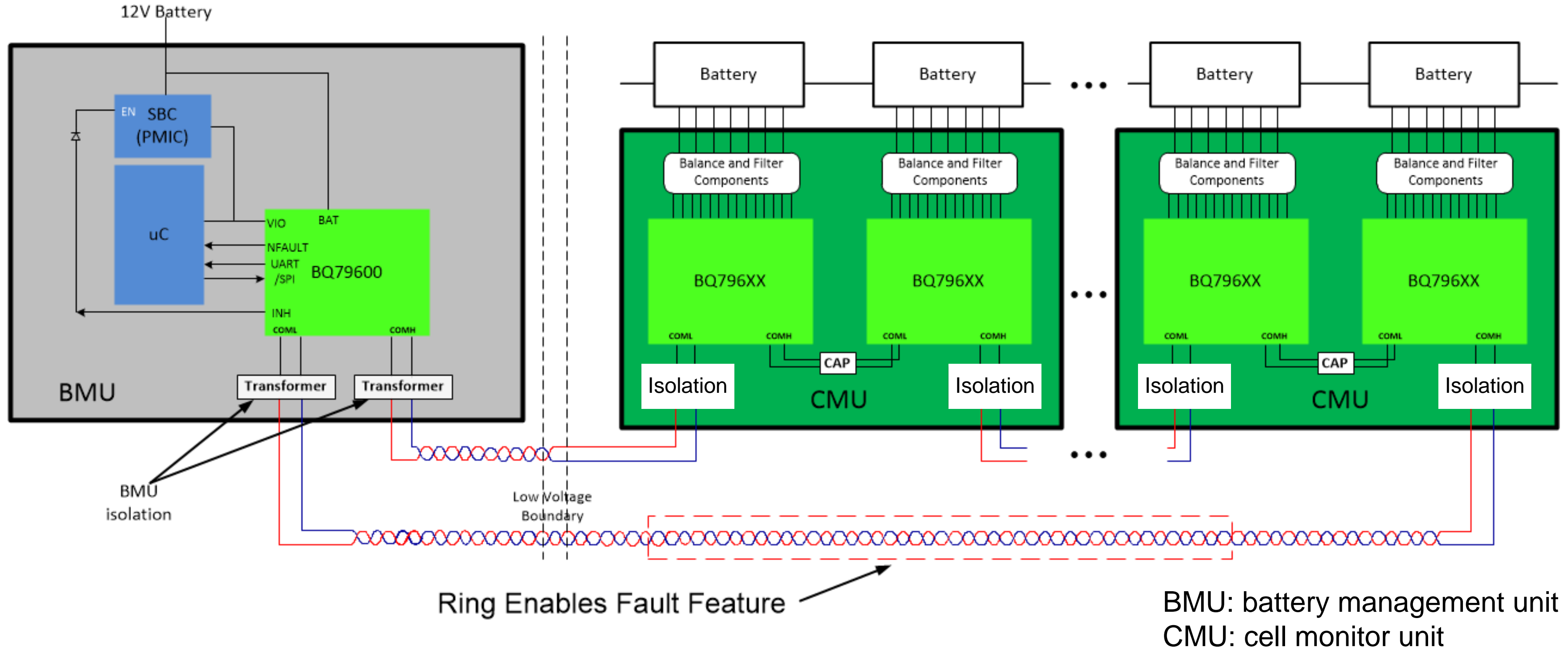
SPENCER HU

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



# 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).

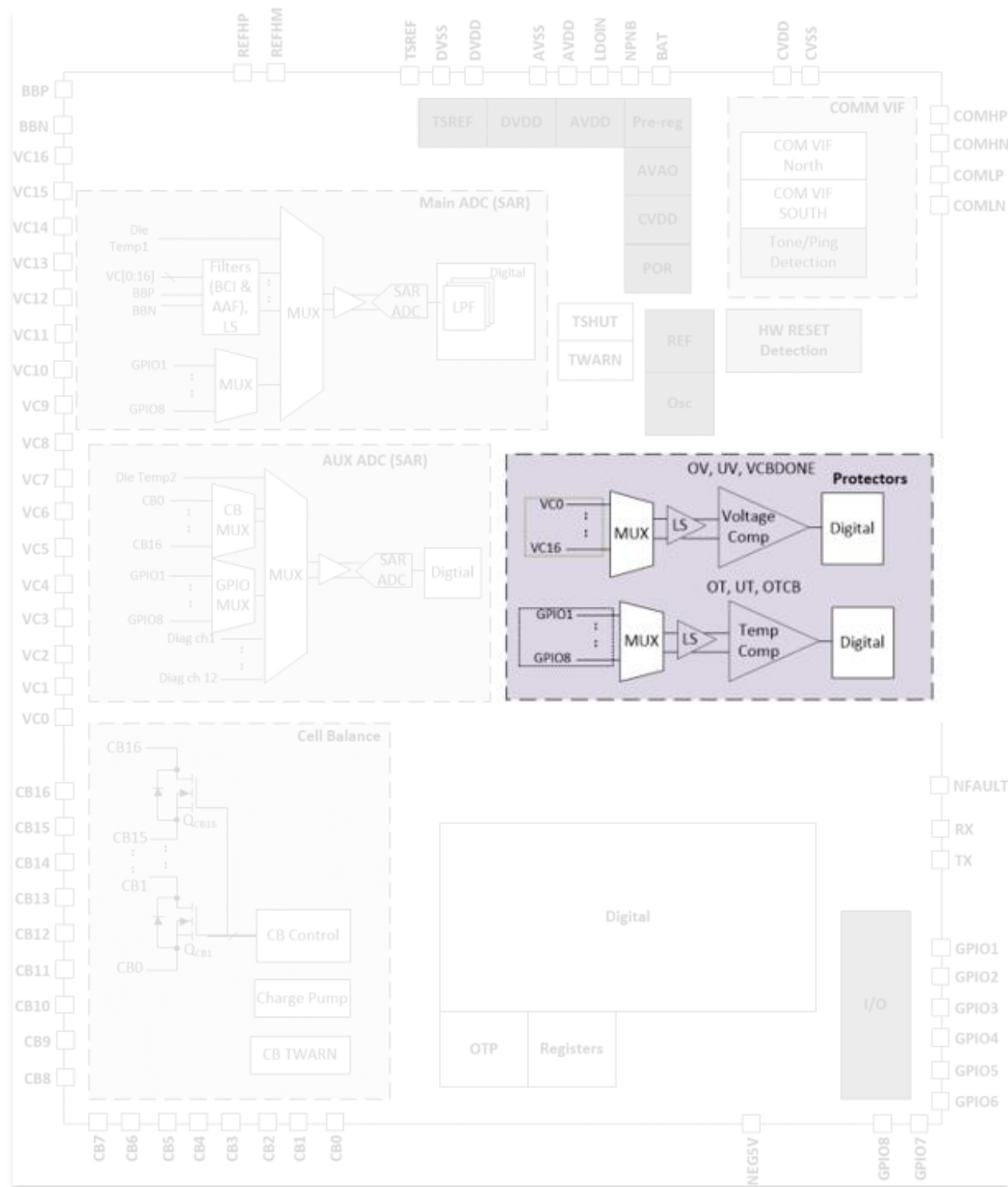
Standard call out: battery pack or system should send a thermal event alarm signal **5 minutes** before battery system catches fire or explodes caused by battery thermal runaway which endangers the cabin passengers.

# 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

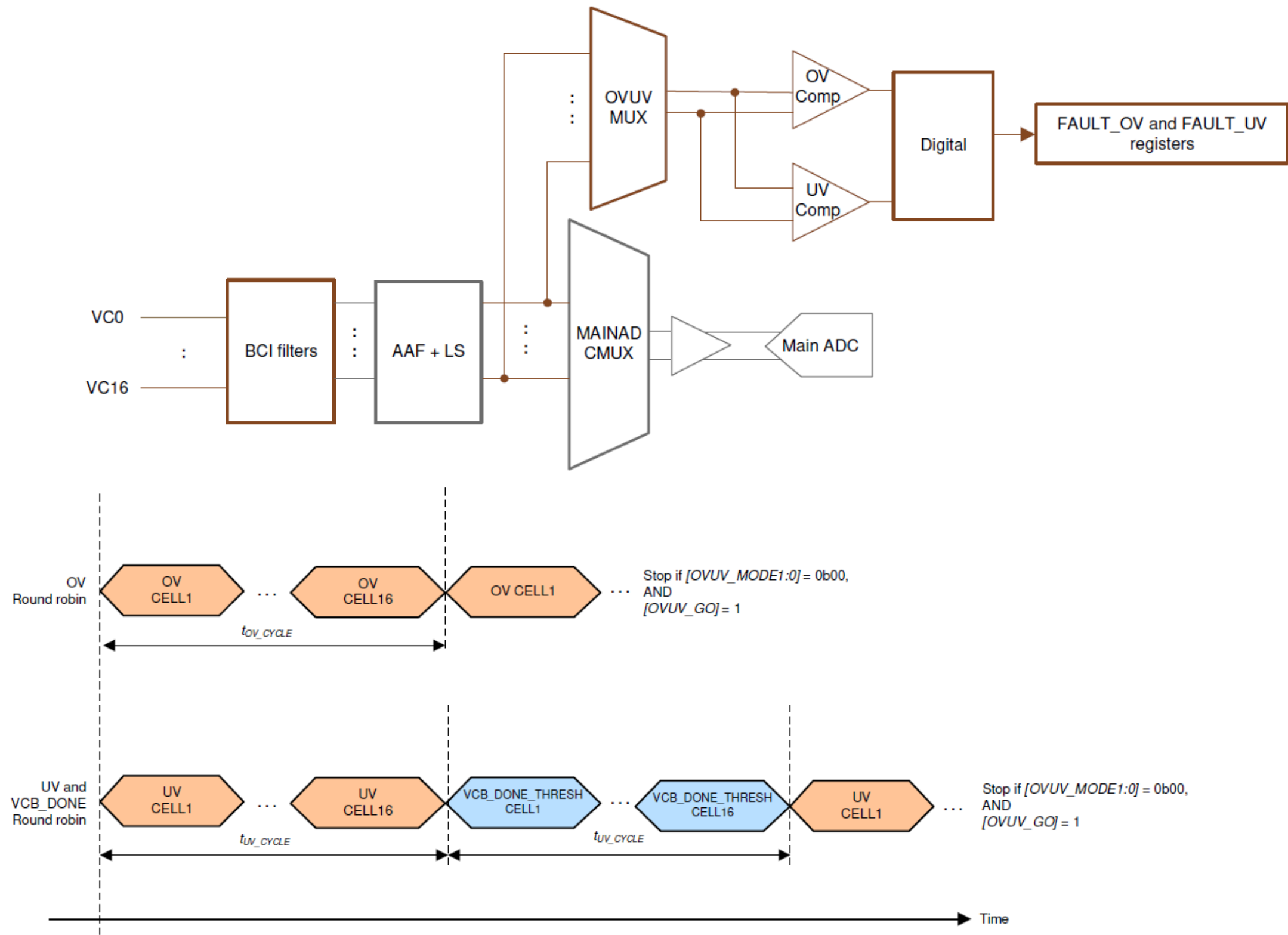
# Voltage/temperature window comparator

# 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  $I_q = 260 \mu A$

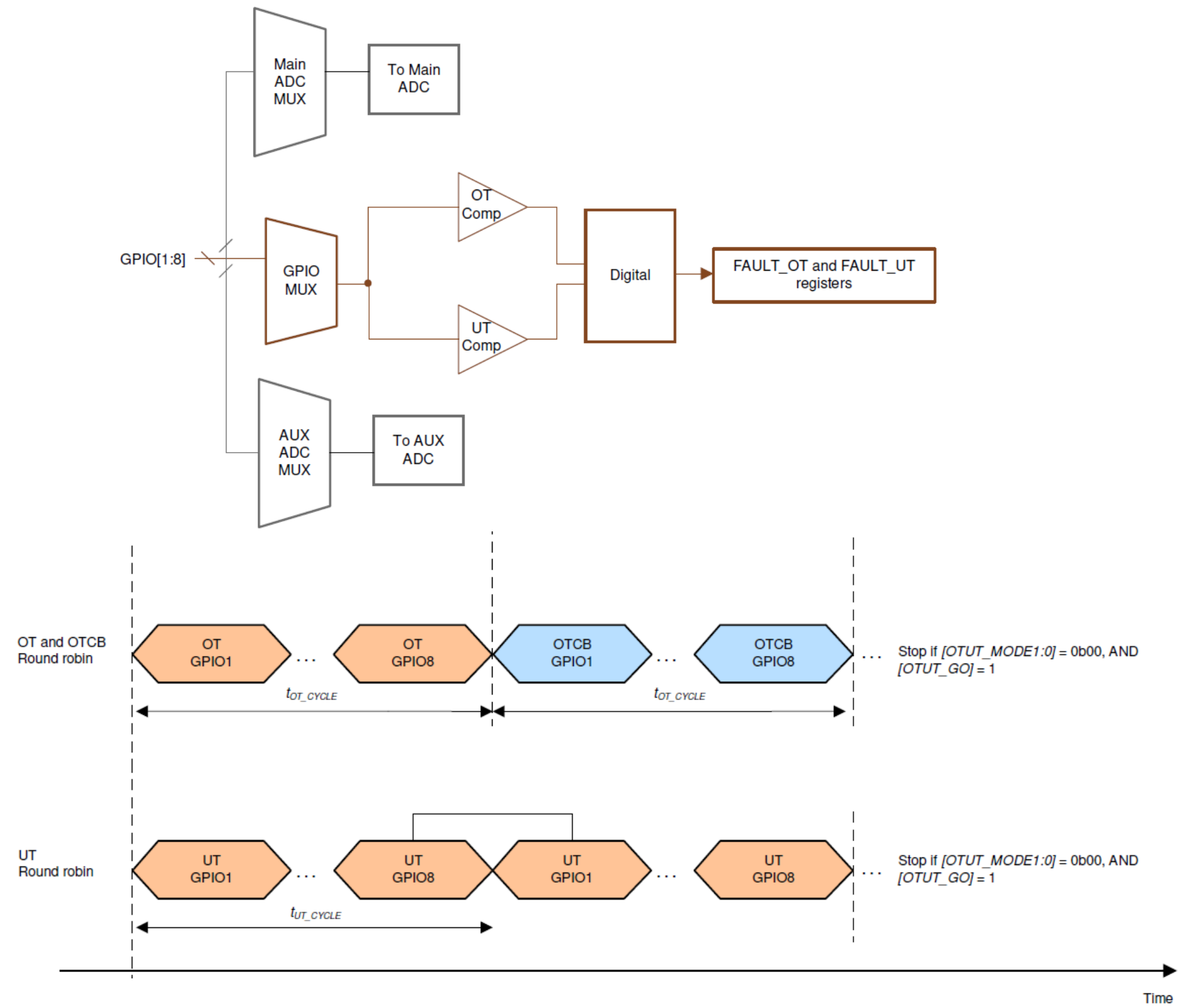
# OVUV architecture and scheduler



- 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



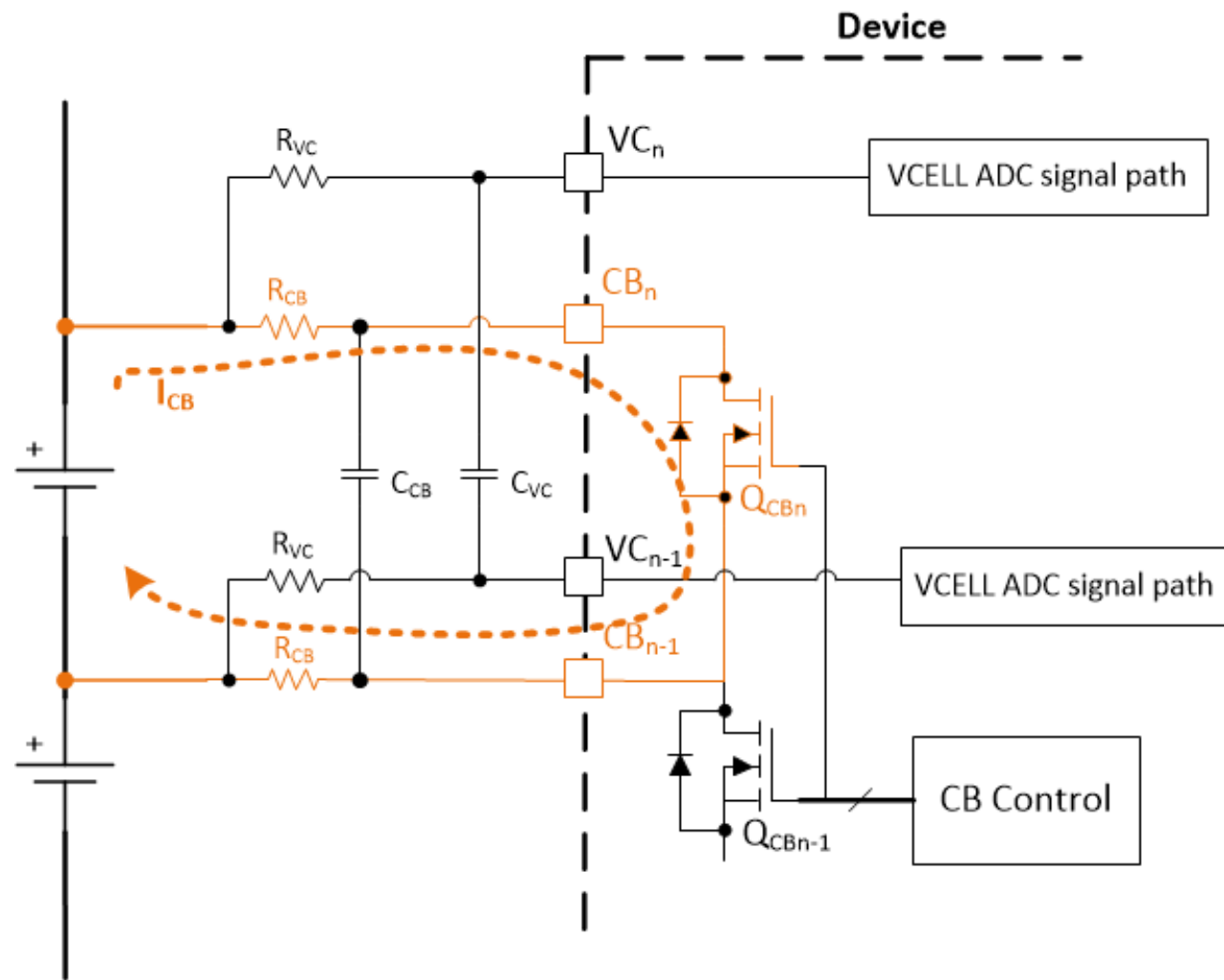
# OTUT architecture and scheduler



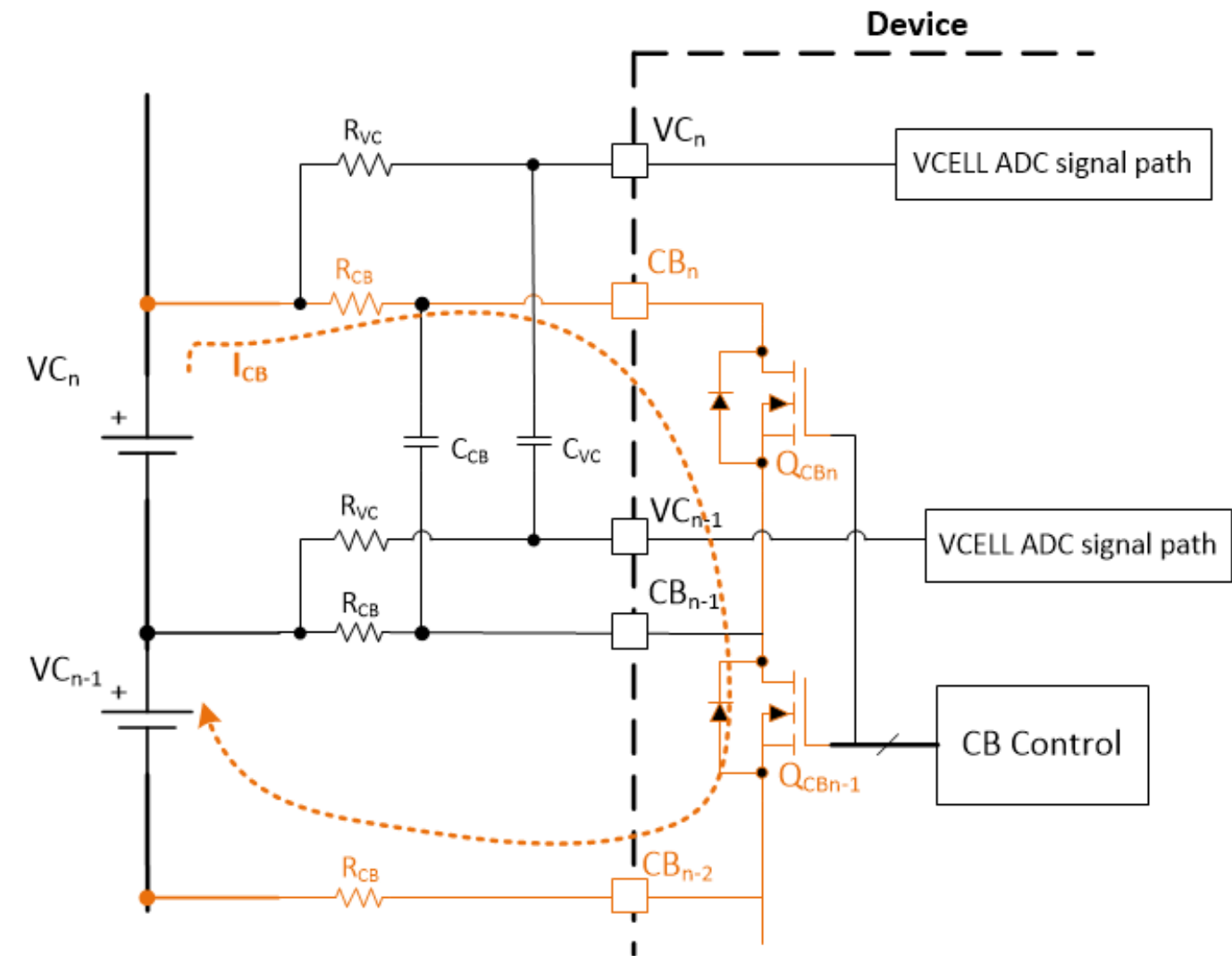
- OT and UT are checked in parallel by two separated comparators
- Support round-robin run mode
- OT also offers balancing pause feature
- Detected fault could trigger the device to send fault tone, which wakes up the system

# Autonomous cell balancing

# Cell-balancing circuit



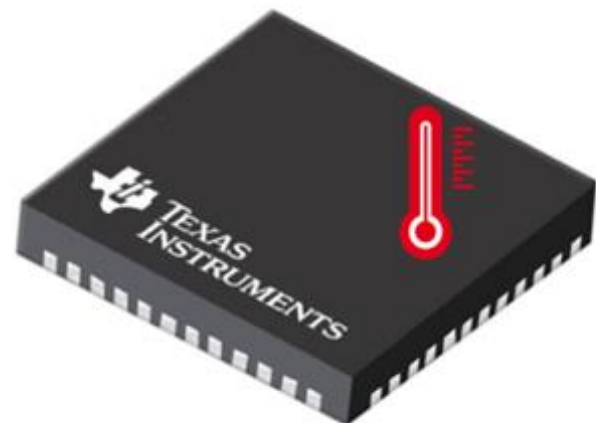
$$I_{CB} = \frac{V_{Cell}}{(2 \times R_{CB}) + R_{dson_{Q_{CB}}}}$$



$$I_{CB} = \frac{\text{Sum of two } V_{CELL}}{(2 \times R_{CB}) + R_{dson_{Q_{CBn}}} + R_{dson_{Q_{CBn-1}}}}$$

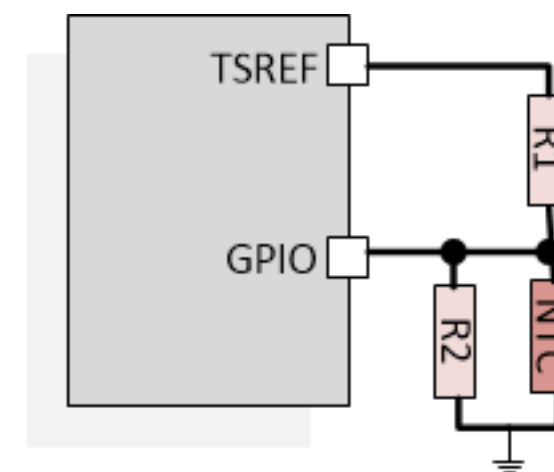
# Cell-balancing thermal pause

## Die temp warning



- Monitor through internal die sensor
- Pause balancing if die temp  $> 105\text{ }^{\circ}\text{C}$
- Recover with  $10\text{ }^{\circ}\text{C}$  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
<b>Control</b>	Always duty cycle between odd and even	Only turn on the channels that are enabled
<b>Stop conditions</b>	Timers (up to 10 hours), AND Cell voltage threshold	Timers (up to 10 hours), AND Cell voltage threshold
<b>Thermal pause</b>	Yes	Yes

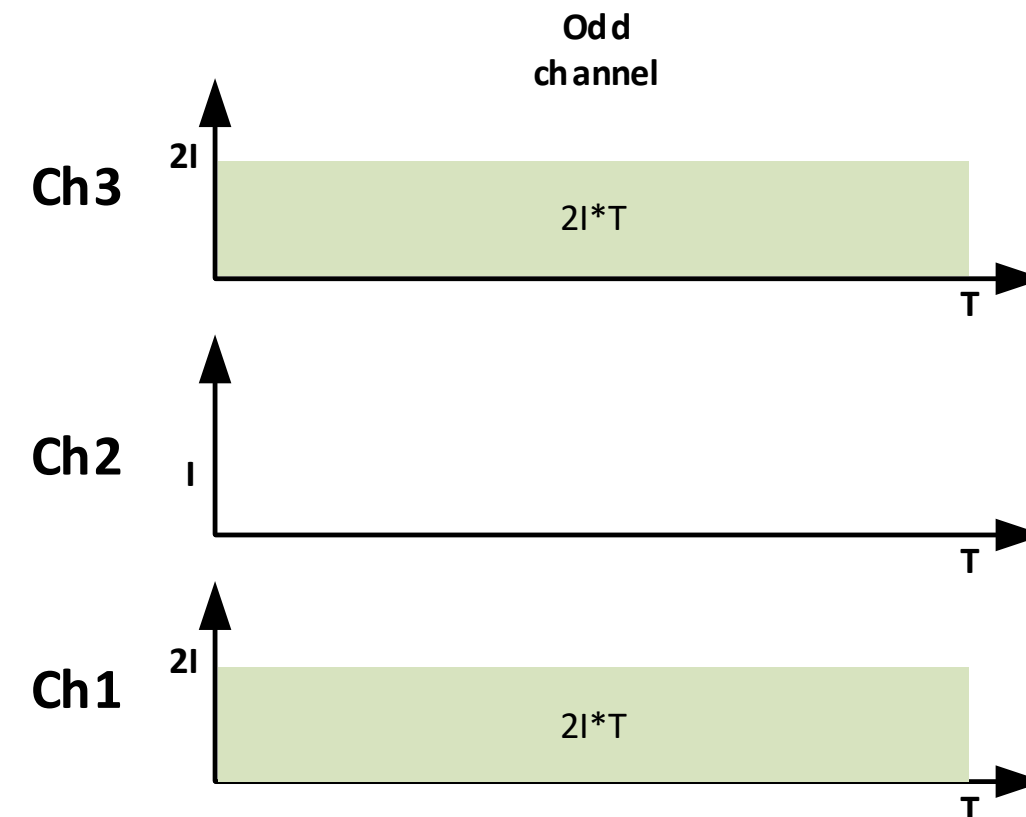
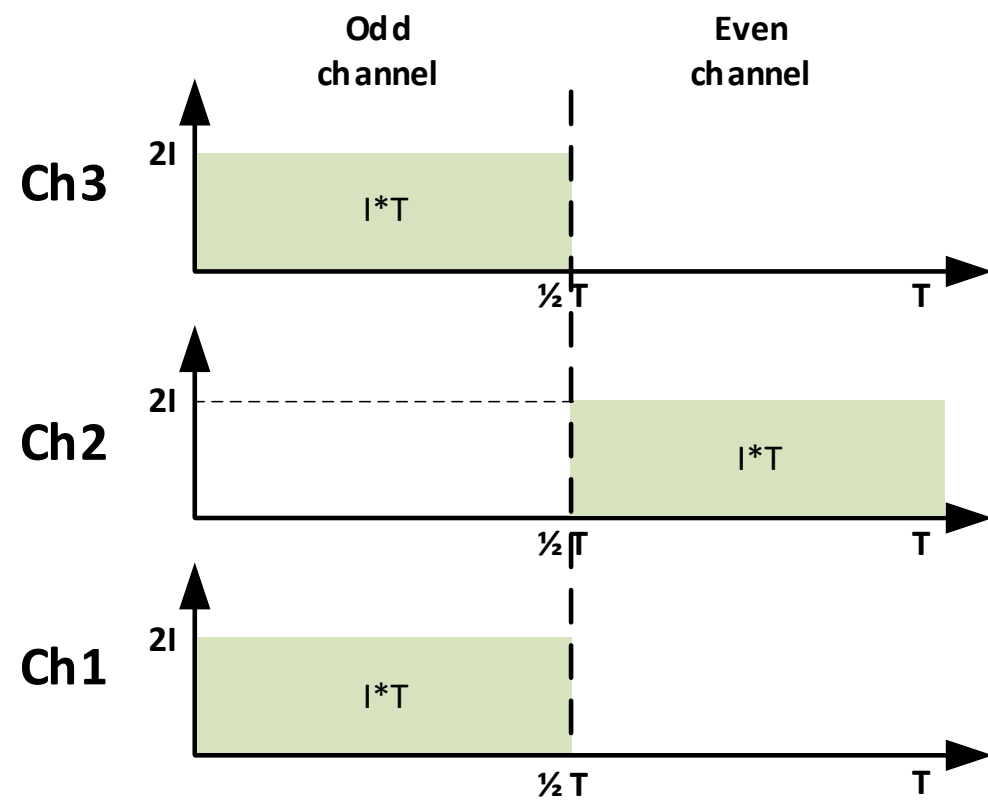
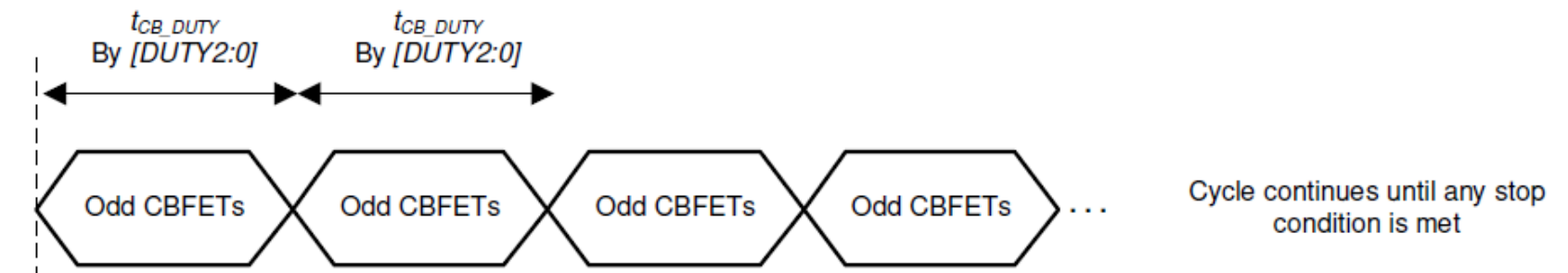
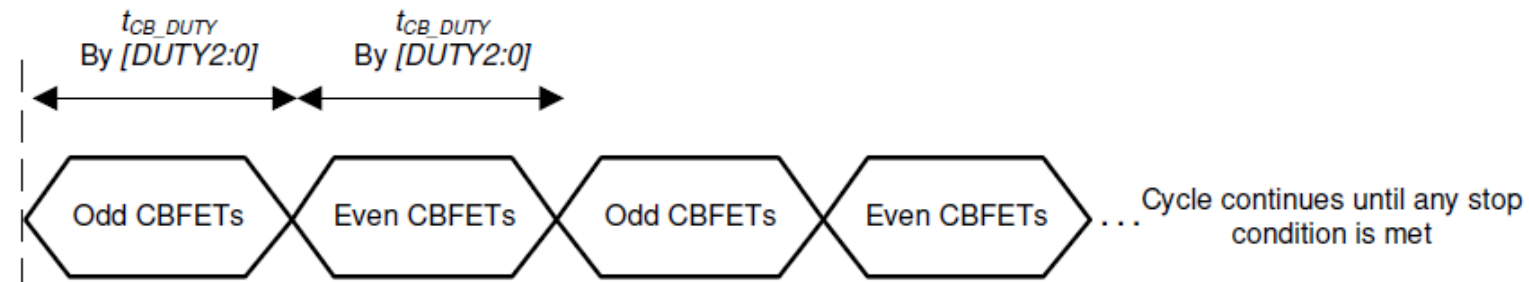
C B 1	C B 2	C B 3	C B 4	C B 5	C B 6	C B 7	C B 8	C B 9	C B 10	C B 11	C B 12	C B 13	C B 14	C B 15	C B 16	Valid or invalid setting	Manual CB control
Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Invalid setting	Total enabled channels >, OR > 2 consecutive channels are enabled
Green	Green	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Valid	Ok, device turns on the enabled channels
Green	Grey	Grey	Grey	Grey	Green	Grey	Grey	Green	Grey	Grey	Green	Grey	Grey	Green	Grey		

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

# Cell-balancing control scheme (auto mode)

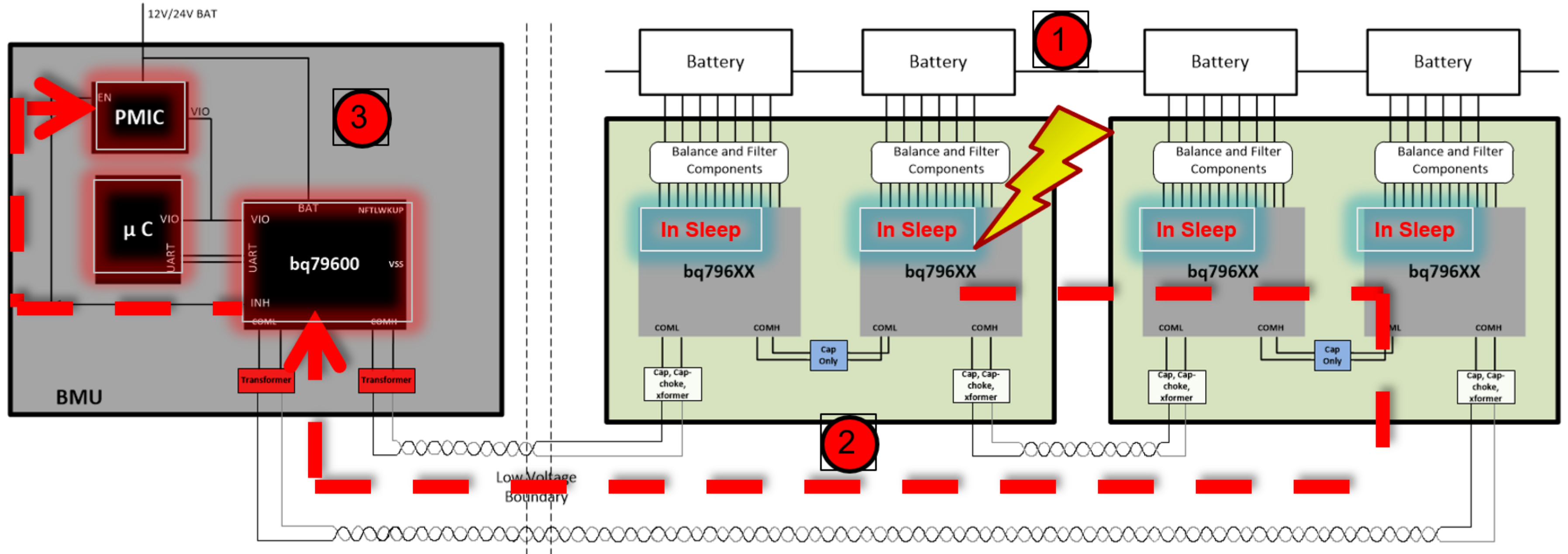
- Autonomous balancing supports up to 10 hours
- Odd/even

- Odd only



# Reverse wakeup

# BQ79600 + BQ79616: Auto wake-up system at fault

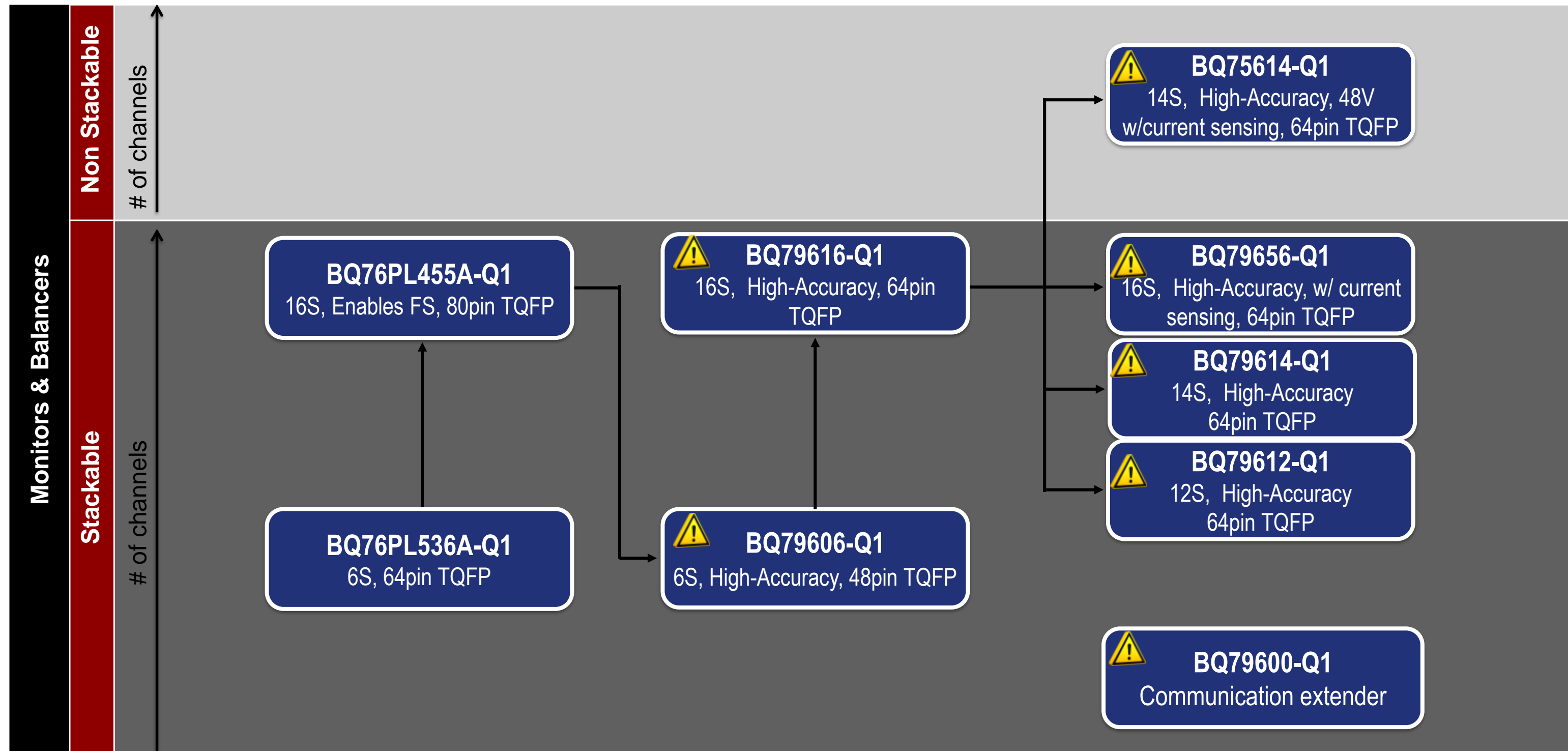


- 1) Detect fault while BQ79616 is sleep mode (low Iq)
- 2) Fault tone transfers through communication line to the BQ79600
- 3) BQ79600 wakes up, and then wakes up PMIC (Power management IC) and uC (MCU)

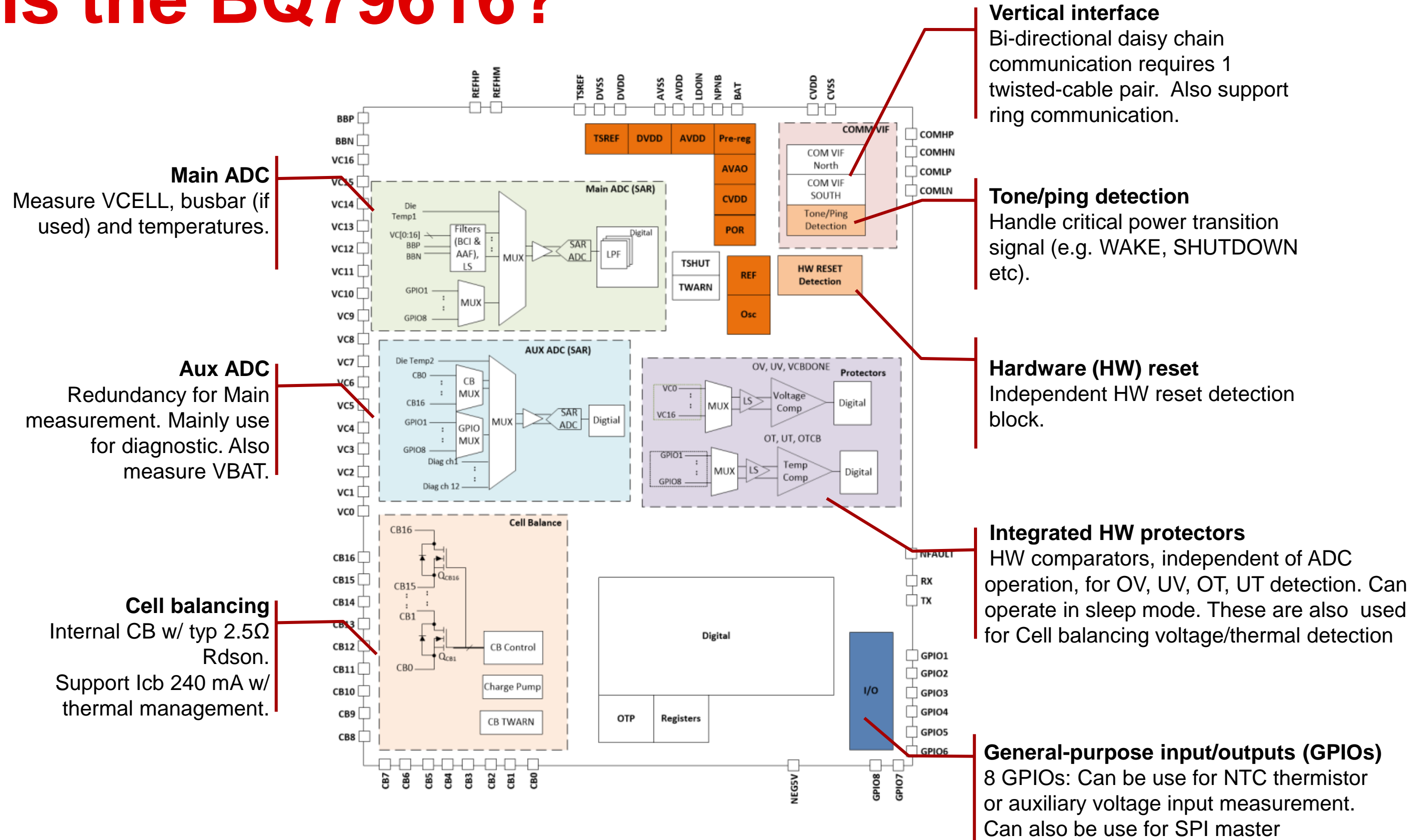


# TI EV BMS product portfolio

 Functional Safety  
ASIL D



# What is the BQ79616?



# BQ79616 evaluation module and user interface

The screenshot displays the BQ79616 user interface software. At the top, there is a red header bar with menu items: File, Options, Tools, and Help. Below this is a grey navigation bar with a 'Menu' icon. The main interface is divided into several sections:

- Left Sidebar:** A vertical toolbar with icons for home, device connection, settings, and other functions.
- Device Status:** A section on the left indicating 'DEVICE CONNECTED' with a green dot and the model number 'BQ79616'. Below this, it reads 'SafeTI Precision Monitor With Integrated Hardware Protector for Lithium-Ion, Lithium Phosphate, Lithium Titanate Battery Packs'. A large play button icon is positioned below the text.
- Central Image:** A photograph of the BQ79616 evaluation module (EM) PCB. The board is green and features various components, including a large black chip, capacitors, and connectors. Labels on the board include 'PWR', 'Danger High Voltage', 'VSTACK', 'TEXAS INSTRUMENTS', and 'BQ79616EVM-021'. There are also arrows pointing to 'To Higher Board in Stack' and 'To Lower Board in Stack'.
- Right Panel:** A section titled 'Hi there, What would you like to access?' containing four large, light-blue buttons: 'Cell Monitor', 'Balance Cells', 'Protector', and 'Communication'.
- Bottom Row:** A row of six smaller, light-blue buttons: 'GUI User's Guide', 'EVM User's Guide', 'Software Design Guide', 'Design Recommendations', 'Datasheet', and 'E2E Forum'.
- Bottom Bar:** A black status bar at the very bottom showing 'USB2ANY/OneDemo device Hardware Connected.' and the Texas Instruments logo.

Click [here](#) for sample

# BQ79616 user interface: Cell monitor board details

The screenshot displays the BQ79616 user interface for monitoring a cell board. The main area shows 16 individual cell monitors, each with a battery icon and a voltage reading. A 'Stop Polling' button is visible above the grid. Below the grid is a plot area showing the voltage of the selected cell (CELL 1) over time. The plot shows a voltage of approximately 2.043V that dips slightly around 10 seconds and then returns to the baseline. The right-hand side of the interface contains a status panel with various system indicators and a cell fault status section for the selected cell.

Cell	Voltage (V)
CELL 1	2.043 V
CELL 2	2.044 V
CELL 3	2.037 V
CELL 4	2.042 V
CELL 5	2.043 V
CELL 6	2.046 V
CELL 7	2.041 V
CELL 8	2.046 V
CELL 9	2.048 V
CELL 10	2.051 V
CELL 11	2.054 V
CELL 12	2.047 V
CELL 13	2.052 V
CELL 14	2.054 V
CELL 15	2.053 V
CELL 16	2.060 V

Status - 0x02	
Polling	●
CTS	●
MAIN RUN	●
OVUV RUN	●
CB RUN	●
CTL	●
AUX RUN	●
OTUT RUN	●
CB DONE	●

Fault Summary - 0x02	
Power Rail	●
OV UV	●
Communication	●
ADC Comparison	●
System	●
OT UT	●
OTP	●
Protector	●

Cell Fault Status - CELL 1	
UV	●
OV	●



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