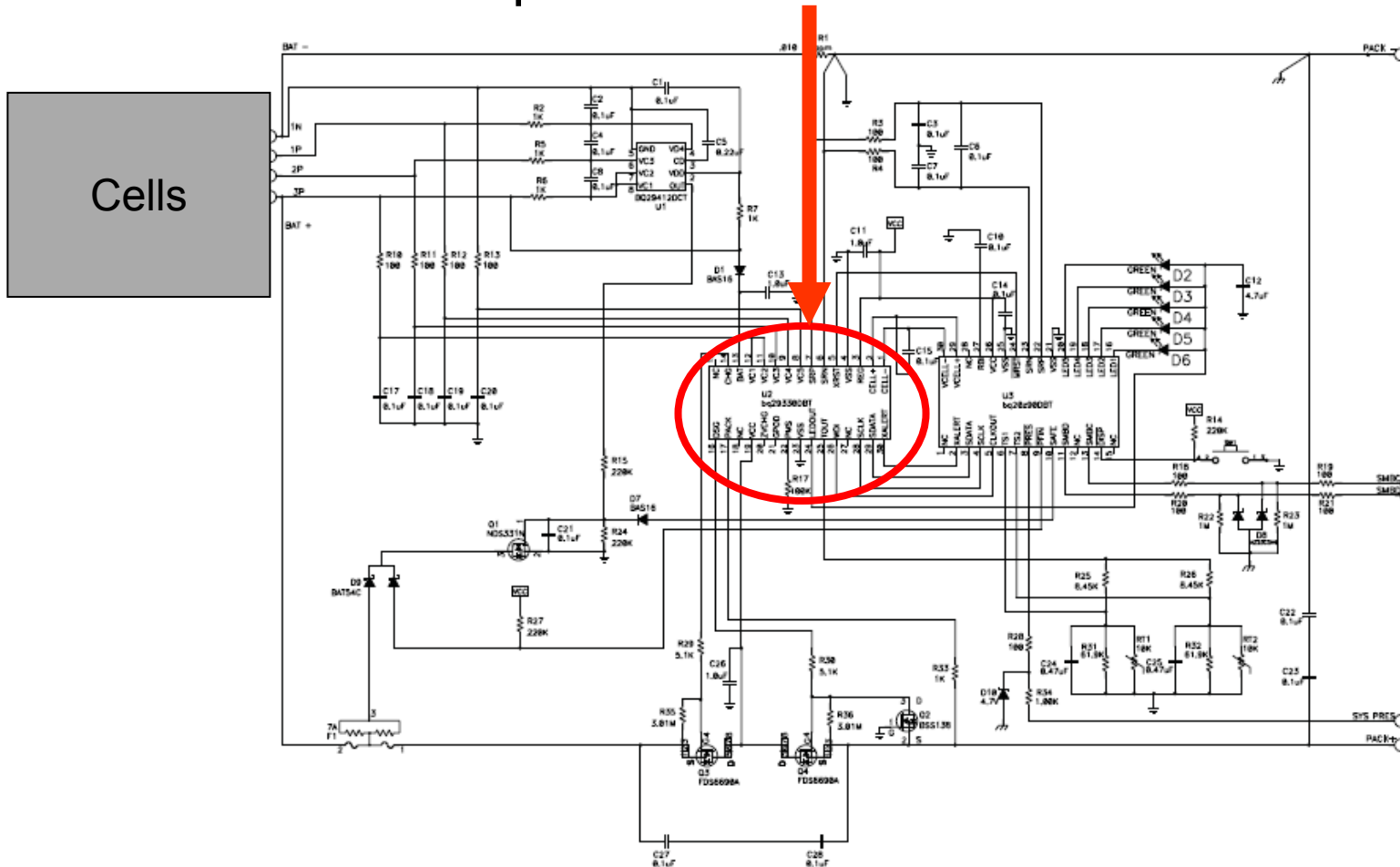




5-10 Cells Protector bq77PL900

- bq77PL900, formerly the bq29500
- “Product Preview” or “Preliminary” information
 - What is this part?
 - Where might this be used?
 - How does it work?
 - What are some design considerations?

- In relation to the z90 system discussed earlier, this is the AFE/protection function



High power consumer

Power Tool



Medical



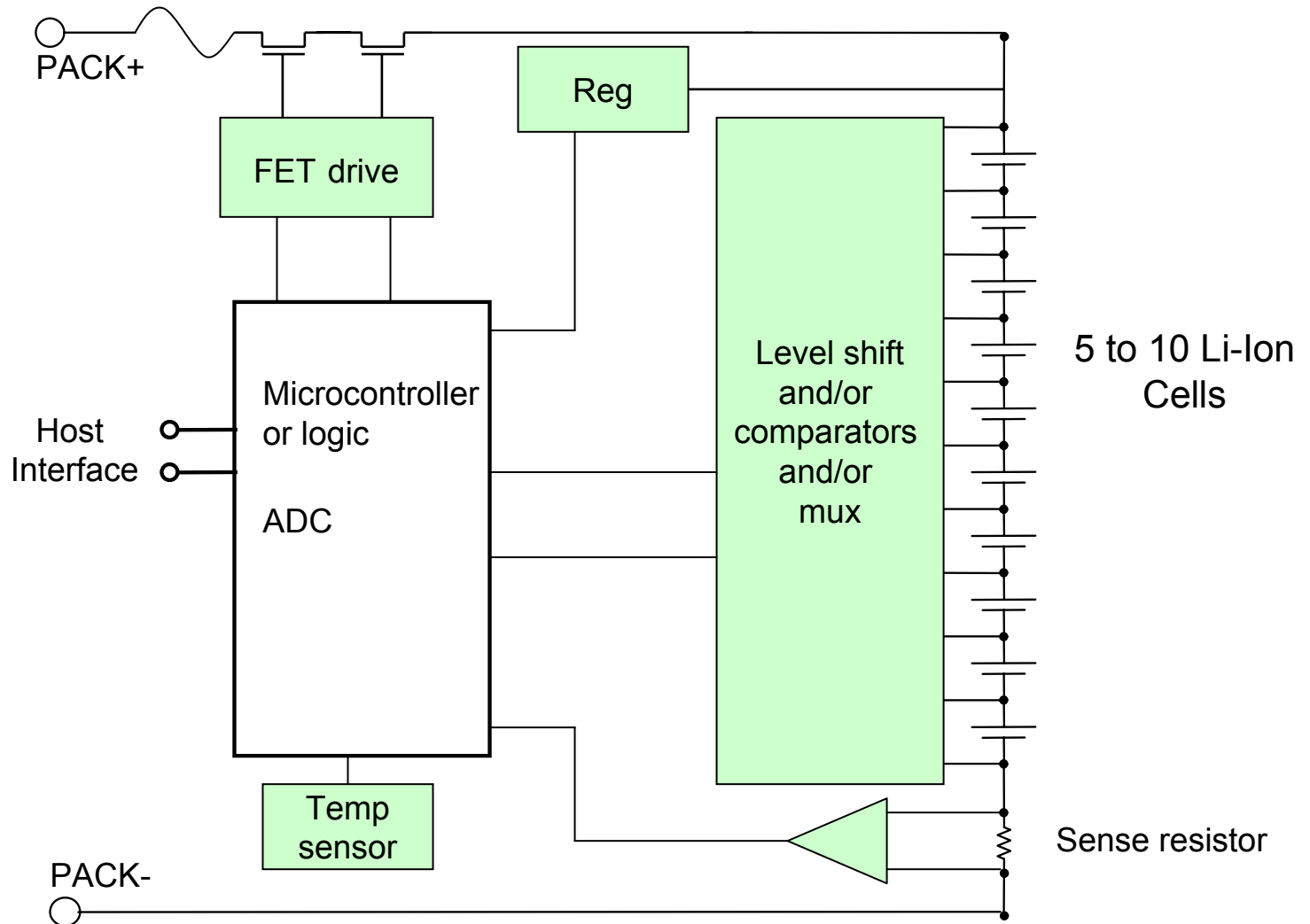
E-bike



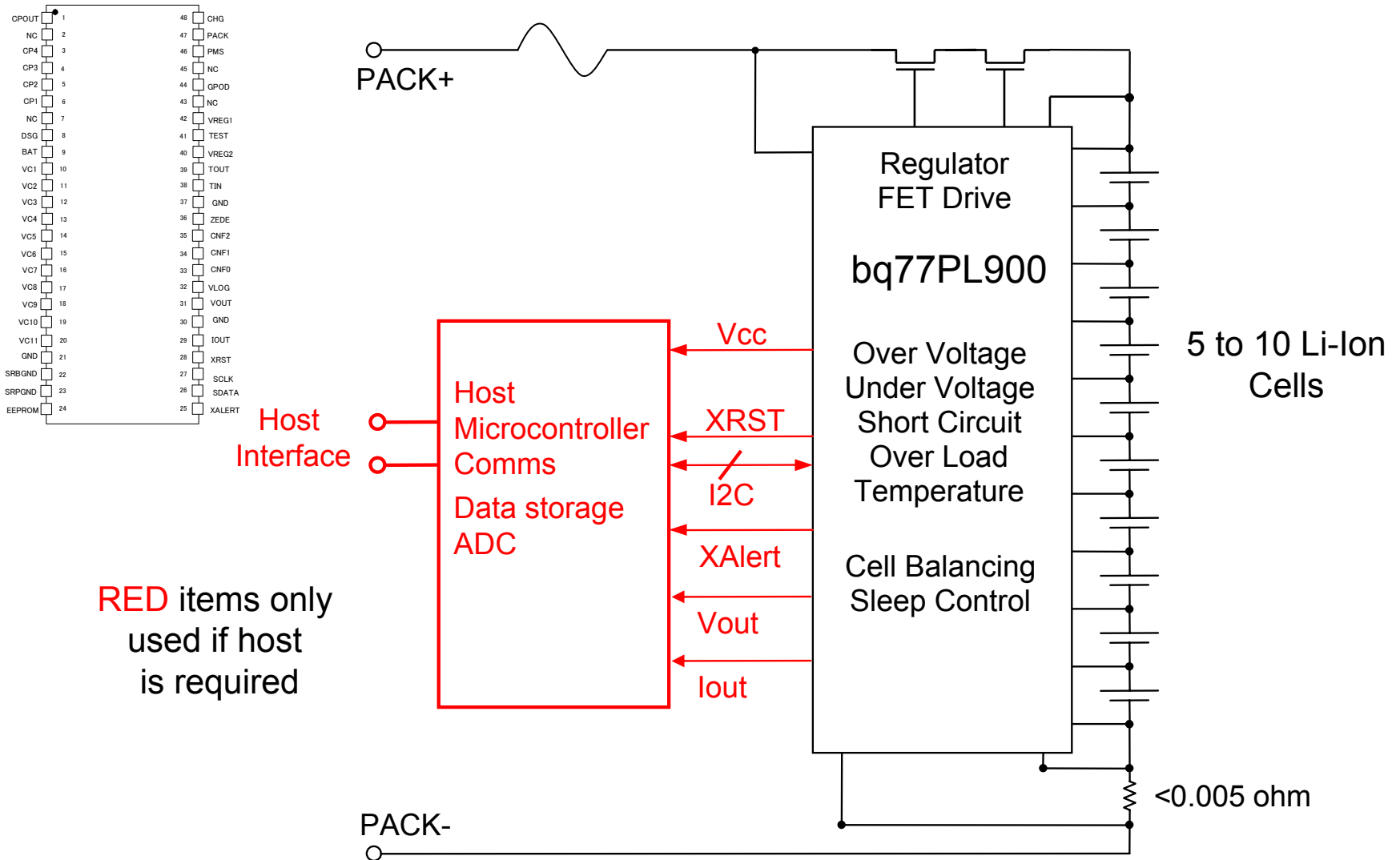
Military & Industrial



Solution without bq77PL900



Solution System Diagram



Device Key Features

- 5 to 10 Series Li-Ion Cell Protection
 - Current (discharge)
 - Voltage
 - Thermal shutdown
- Low Cost
 - Low Component Count
 - Optimized Integration
- Charge (CHG) and Discharge (DSG) protection P-ch FET Drive
- Low Power Shutdown State
- 0v Charging Capable (ZVCHG)
- Fully Integrated Cell Balancing

Protection Functions (stand-alone)

- Short Circuit (with 1mohm)
 - 60 to 135A for SC delay period -> DSG FET OFF
- Over Load (with 1mohm)
 - 10 to 85A for OL delay period -> DSG FET OFF
- Cell Over Voltage
 - 4.15 to 4.5V for COV delay period -> CHG and ZVCHG FET OFF
- Cell Under Voltage
 - 1.4 to 2.9V for CUV delay period -> DSG FET OFF ZVCHG FET ON, shutdown
- Over Temperature: FETs OFF
- Recovery:
 - Current: after charger connect or current falls to 0 + delay time
 - Voltage: when voltage changes above/below hysteresis threshold (and wake up)
 - Temperature: when temp drops below fixed threshold
 - Host mode recovery requires host action

Protection Summary

- Thresholds and Delays set by internal EEPROM memory

Function	DSG	CHG	ZVCHG ⁽¹⁾
SC	OFF	OFF	OFF
OL	OFF	OFF	OFF
COV	ON	OFF	OFF
CUV	OFF	OFF	ON
OT	OFF	OFF	OFF
Normal	ON	ON	OFF

Note 1: If ZVCHG is not used then CHG is ON when ZVCHG would be ON

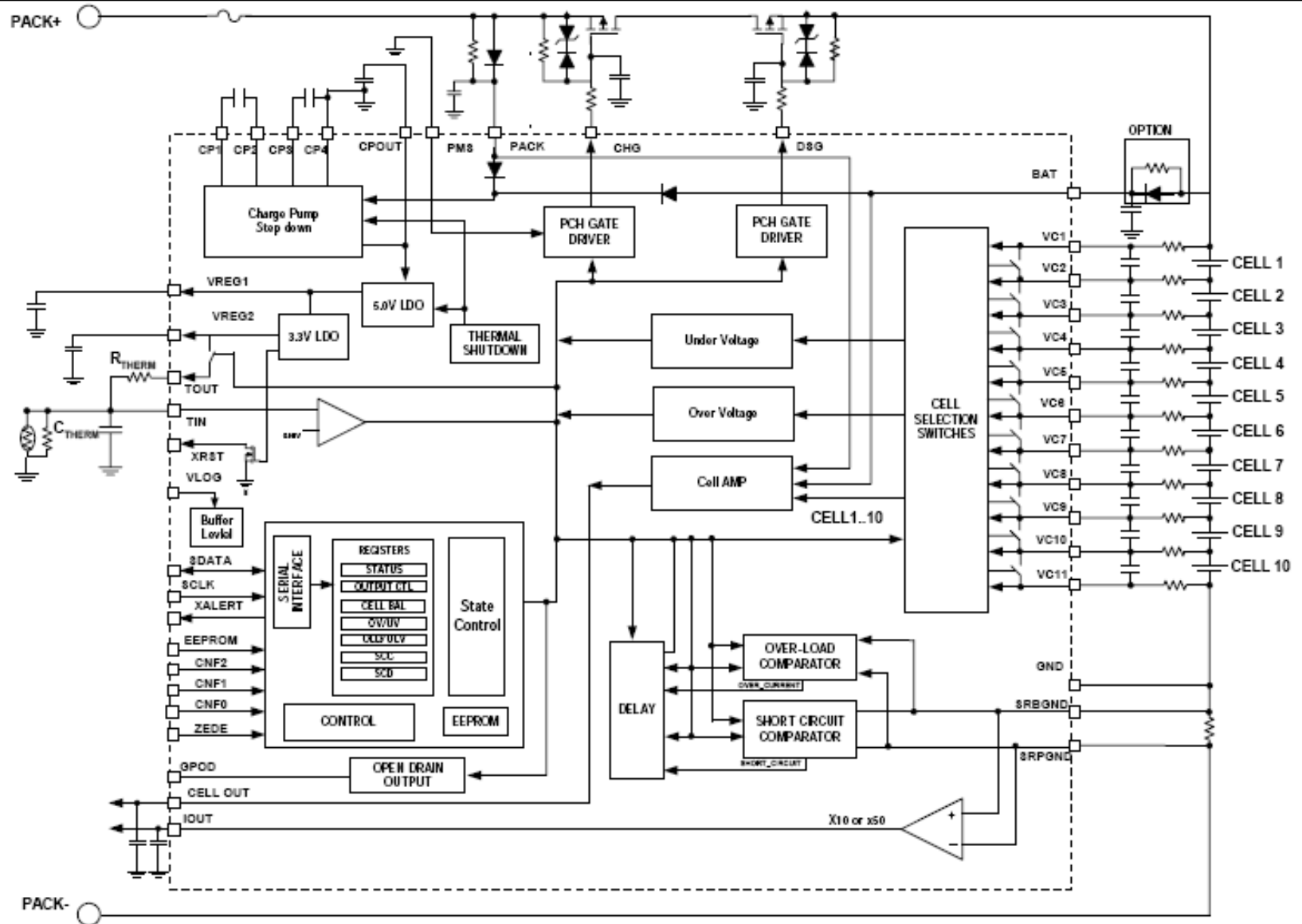
Power Modes

- Normal
 - When Battery is not under voltage, or
 - When charger voltage is applied
- Shutdown
 - When battery voltage is under voltage and no charger connected, or
 - When commanded from host & PACK voltage is 0V
 - Exit of shutdown happens when charger voltage is applied

Other Functions

- Integrated Cell Balancing Control
 - Integrated FETs
 - External FET drive would be needed for high current cell balancing
- Integrated Regulator for Internal Power
 - Device run from top of cell stack

bq77PL900 Block Diagram



Key Electrical Specifications

- Voltage
 - 60V Abs Max at Pack (LBC5x Process)
 - 7V Abs Max per cell input
 - 5V Recommended Max per cell input
 - Measurement performance specified in this range
- Current Measurement
 - Up to 150A with 1m Ω RSNS
- Current Consumption
 - Operating: ~1.25mA Max (over temperature)
 - Shutdown: ~1.0 μ A Max (over temperature)
- Temperature
 - Operating: -20 to +85°C
 - Functional: -40 to +100°C

Logic level and Cell configuration

Logic level

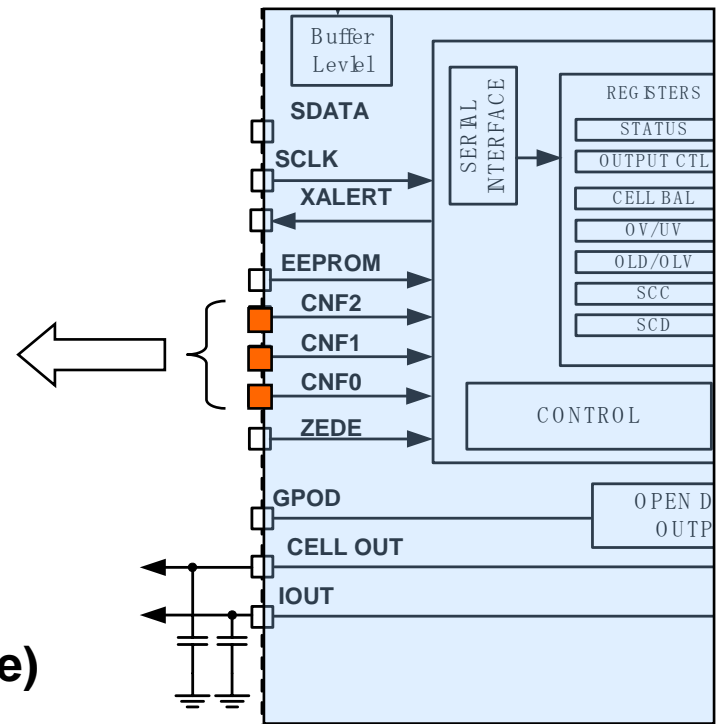
5V interface = Connect VLOG pin to VREG1(5V)

3.3V interface = Connect VLOG pin to VREG2(3.3V)

Cell configuration by pin selection

CNF2 PIN	CNF1 PIN	CNF0 PIN	CELL CONFIGURATION
0	0	0	10 cell
0	0	1	9 cell
0	1	0	8 cell
0	1	1	7 cell
1	0	0	6 cell
1	0	1	5 cell
All Other Combinations			10Cell

1= Connect VLOG (through 10k Ω resistance)
0= GND



Design considerations

bq77PL900

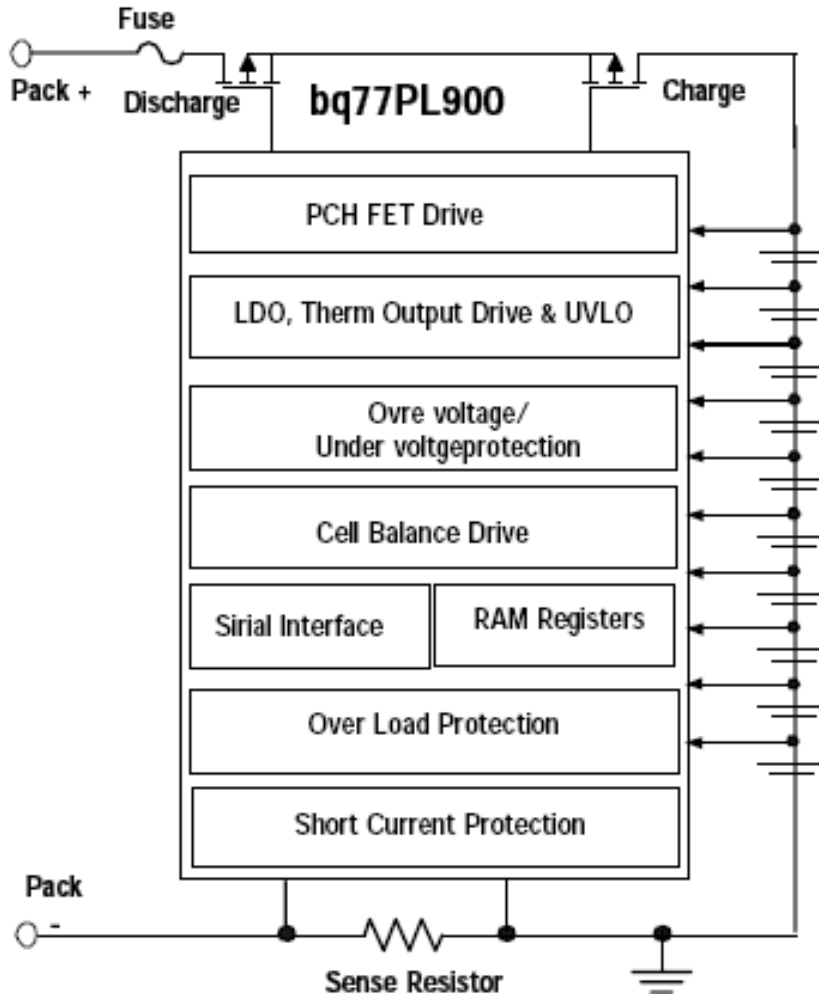
Standalone or Host mode?

- Standalone mode:
 - No host needed
 - Configure once
 - Device operates according to preset (fixed) configuration limits
 - May be suitable if device limits match system requirements & cell chemistry

Host mode:

- Host communicates with part via I2C
- Device is still configured via EEPROM
- Analog Voltage and Current Reporting Outputs
- Interrupt to host
- bq77PL900 Status (FETs, Protection, etc...)
- Host can take action before fixed limits
 - Can not override safety settings
 - Might implement more restrictive or other protections

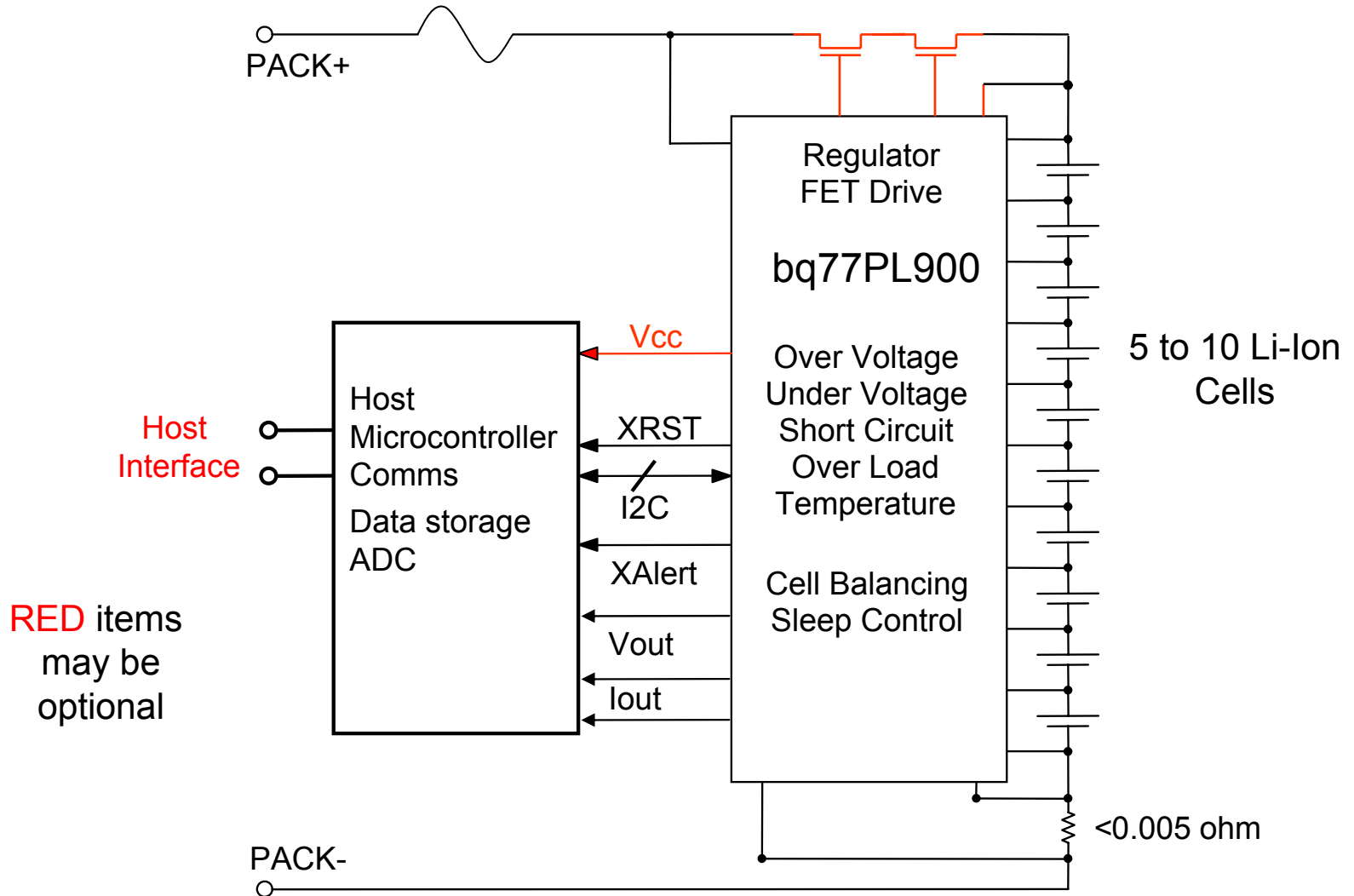
Stand alone Mode Operation



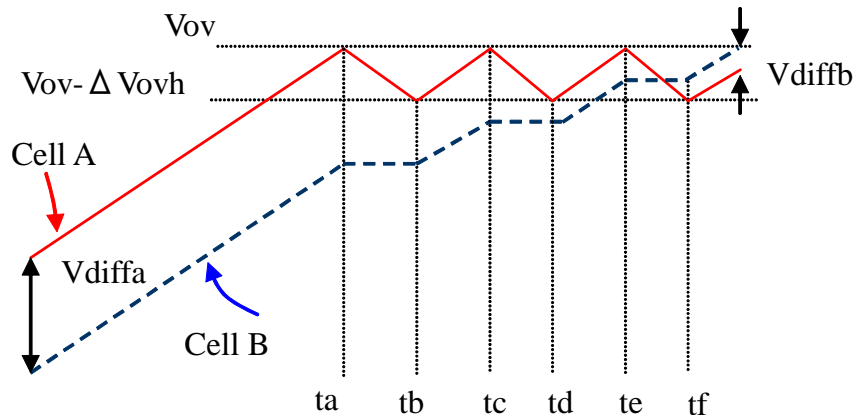
Protection

- SCD, OC
- Over temp
- Over voltage
- Under voltage
- Cell balance (optional)

Host mode operation

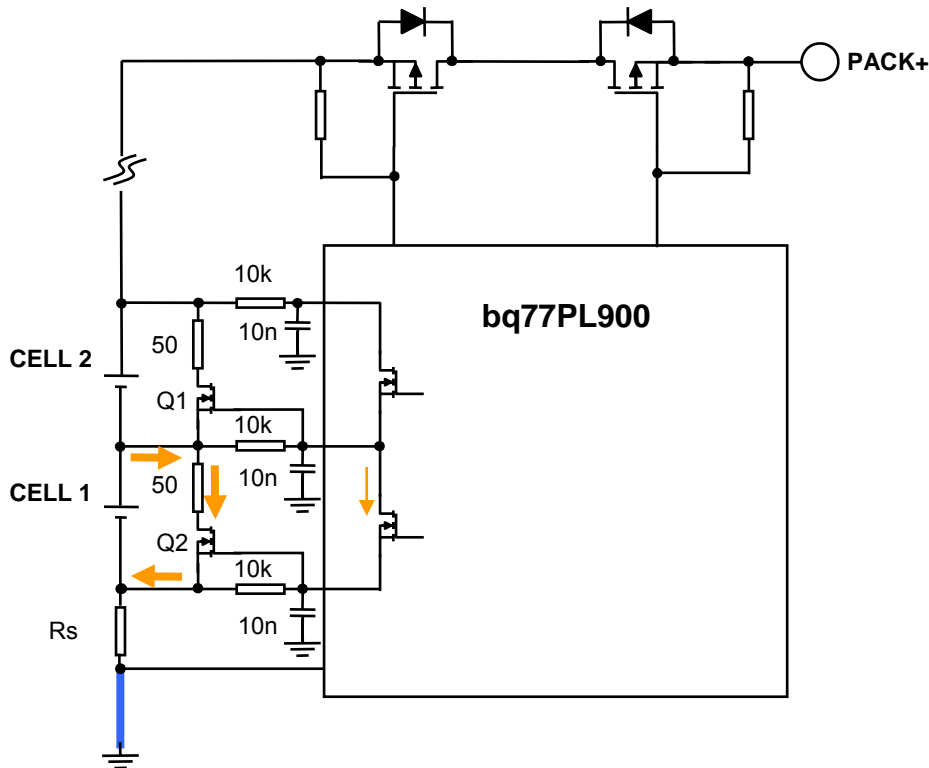


Standalone Cell Balancing



- Once one Cell hit COV, charging stops, and cell will be discharged until it hits lower threshold and charging continues
- Cell Balancing Stops once COV condition is met
- Algorithm protects cell inputs

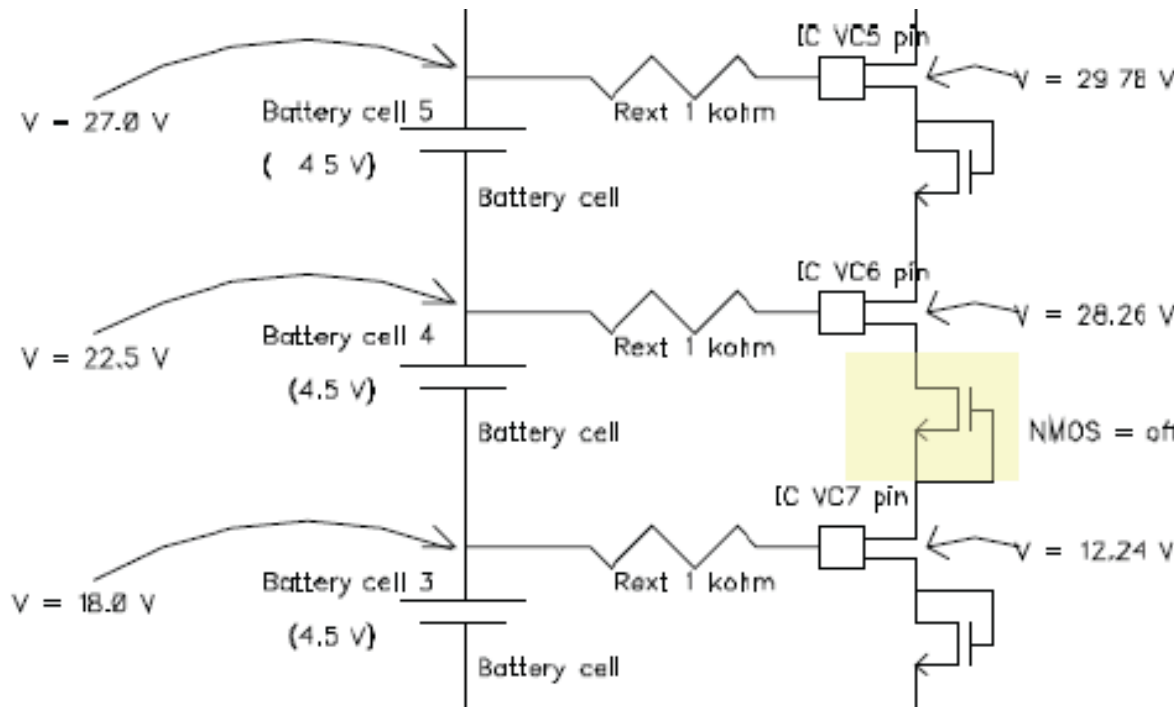
Fast External Cell Balancing



- External MOSFET can be controlled by the state of the integrated FET
- Higher bypassing current is achieved due to low R_{dson} of the external FETs

Cell balancing voltage at the IC

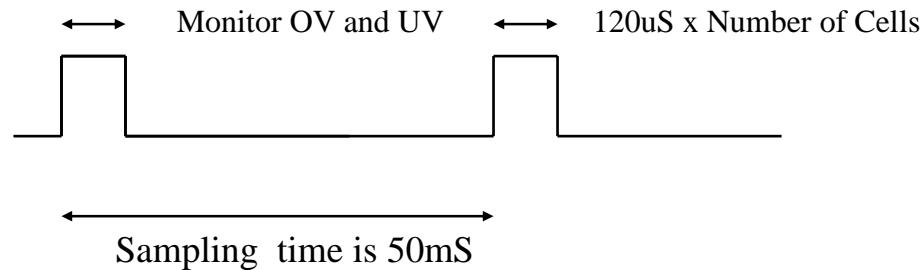
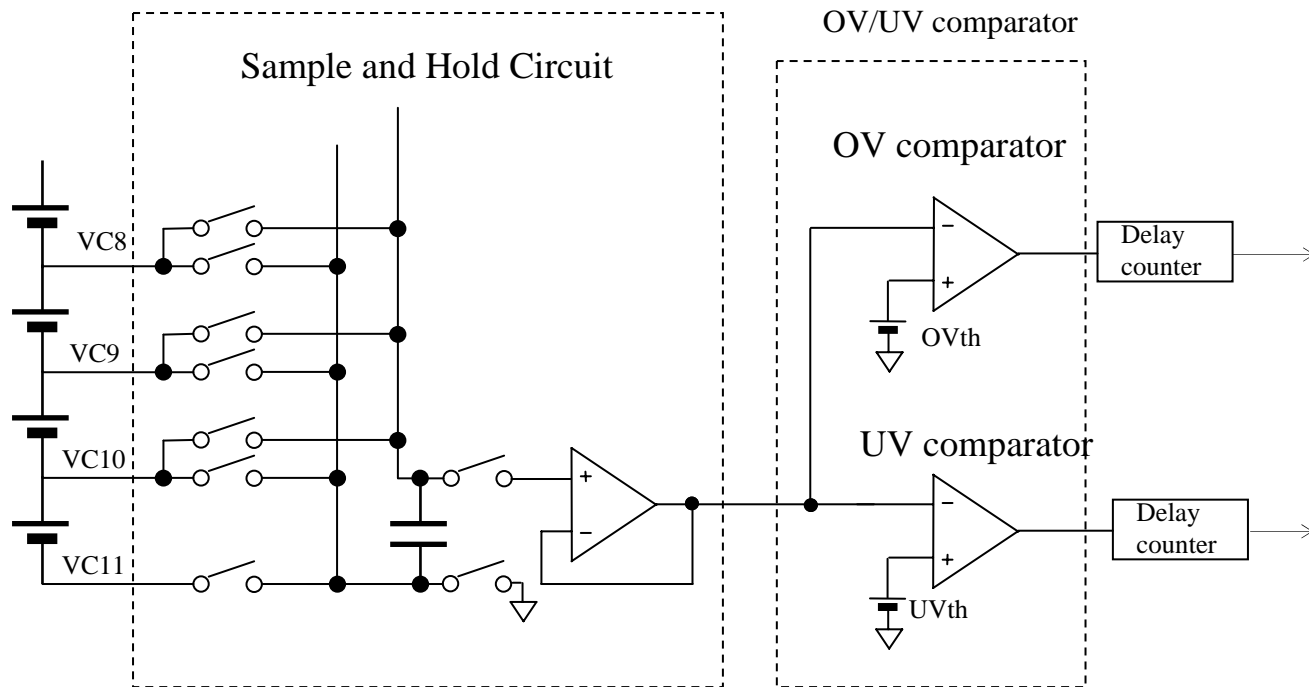
- In host mode, the microprocessor is in control of the balancing & will need an algorithm to avoid damaging voltages at cell inputs
 - No adjacent cell balancing
 - No every other cell balancing
- Watch the voltage at the IC



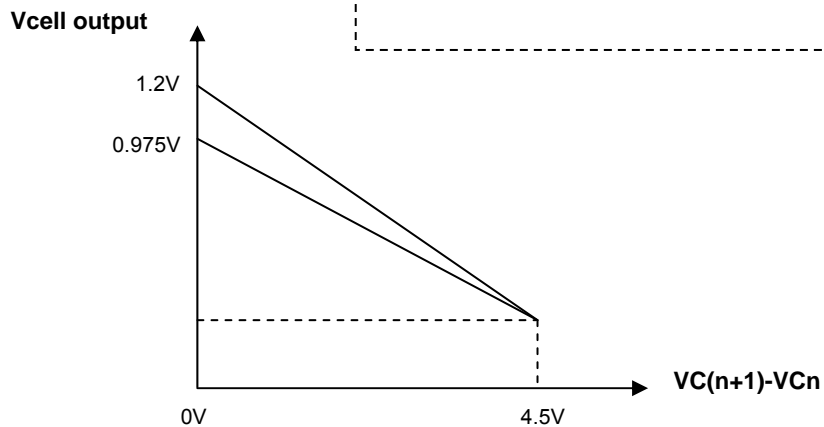
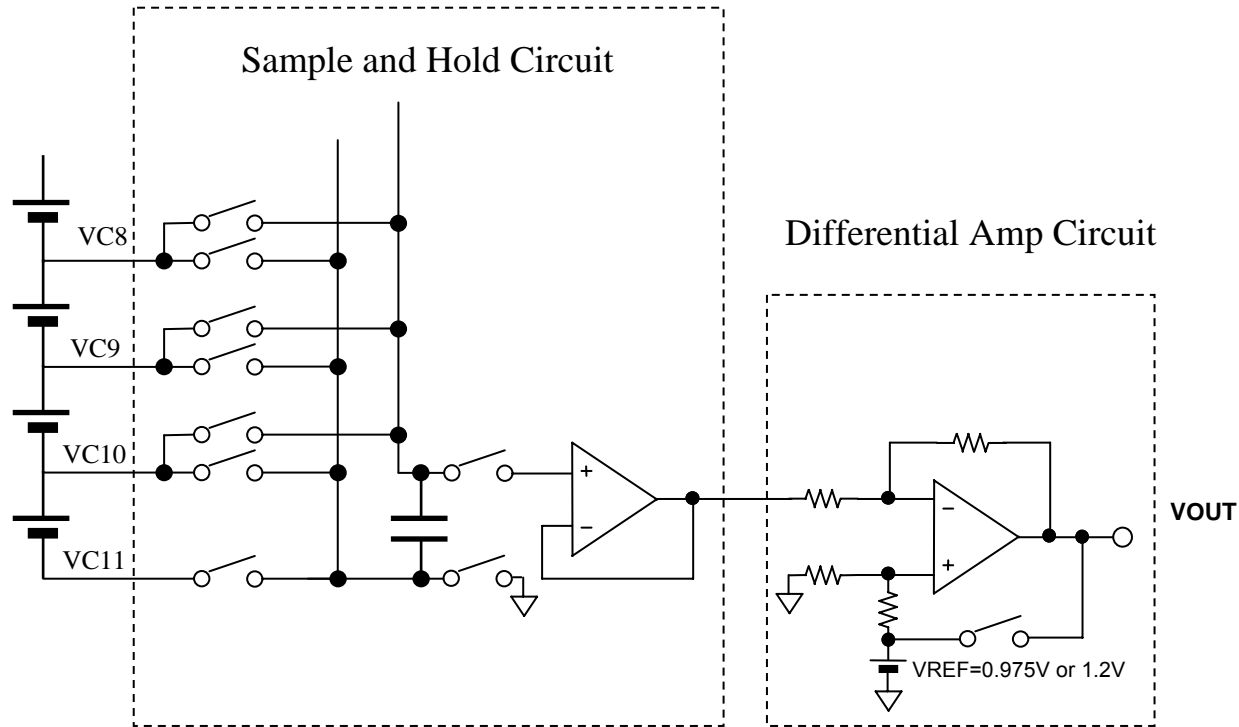
Balancing on both sides of a cell imposes a damaging voltage on the cell pins, in this example, multiple cells

>16V

OV/UV comparator



VCell amp



$$V_{OUT} = 0.975 - \{ (\text{Cell Voltage}) \times 0.15 \} \quad \text{when } (V_{GAIN} = 0)$$

or

$$V_{OUT} = 1.200 - \{ (\text{Cell Voltage}) \times 0.20 \} \quad \text{when } (V_{GAIN} = 1)$$

Calibration process in datasheet

ICell AMP

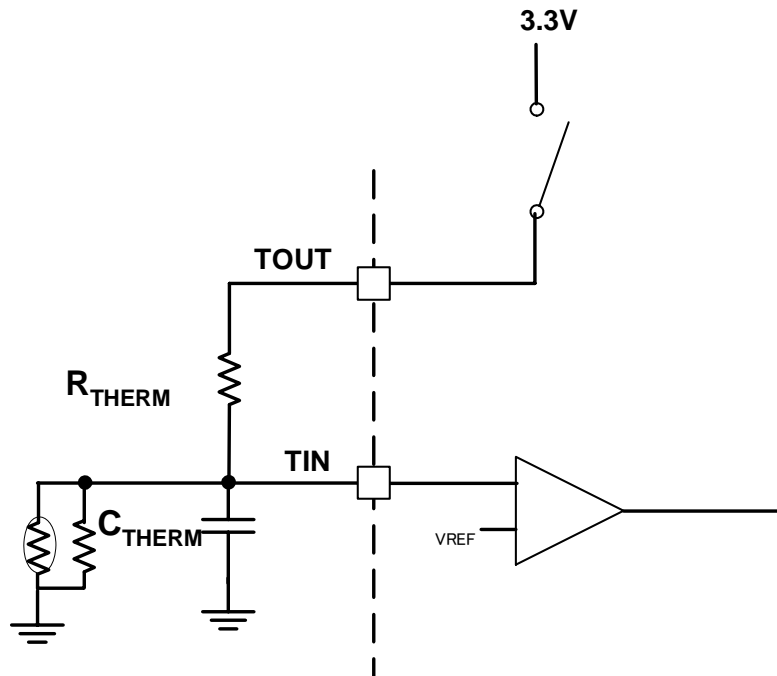
$$V_{\text{CURR}} = 1.20 + (I_{\text{PACK}} \times R_{\text{SENSE}}) \times (10 \text{ or } 50)$$

Enable pin = *FUNCTION_CONTROL* [IACAL, IAEN]

IACAL	IAEN	CONDITION
0	1	NORMAL
1	1	OFFSET
X	0	OFF

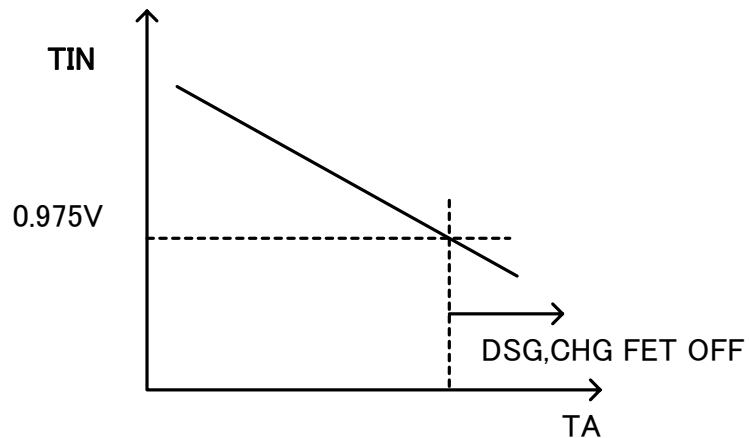
IACAL and IAEN Configuration

Thermistor (Stand alone)



Stand alone mode
Periodically enable TOUT

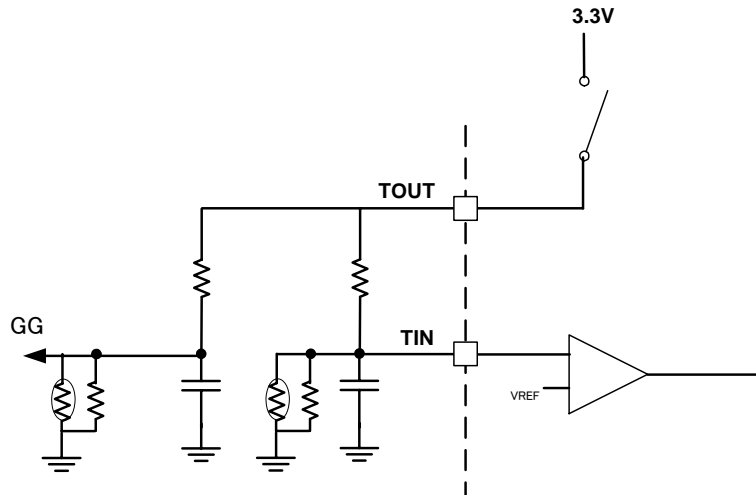
Interval = 1sec



Thermistor (Host Control Mode)

Monitor temp by μP and AFE

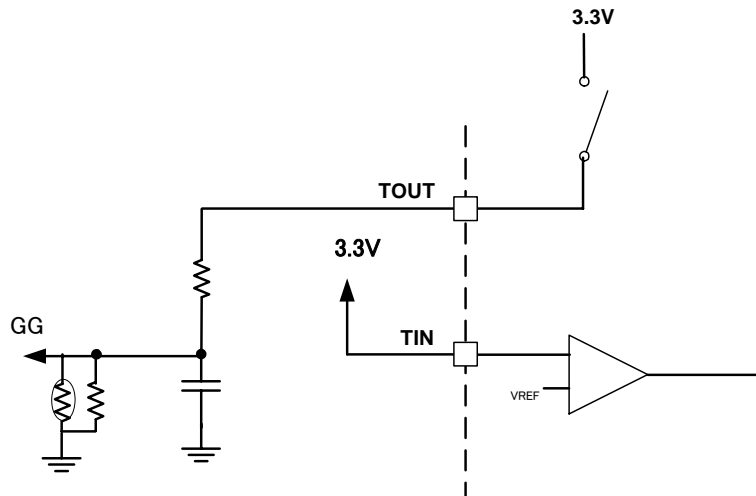
μP needs to turn on TOUT by I2C



Monitor temp by μP

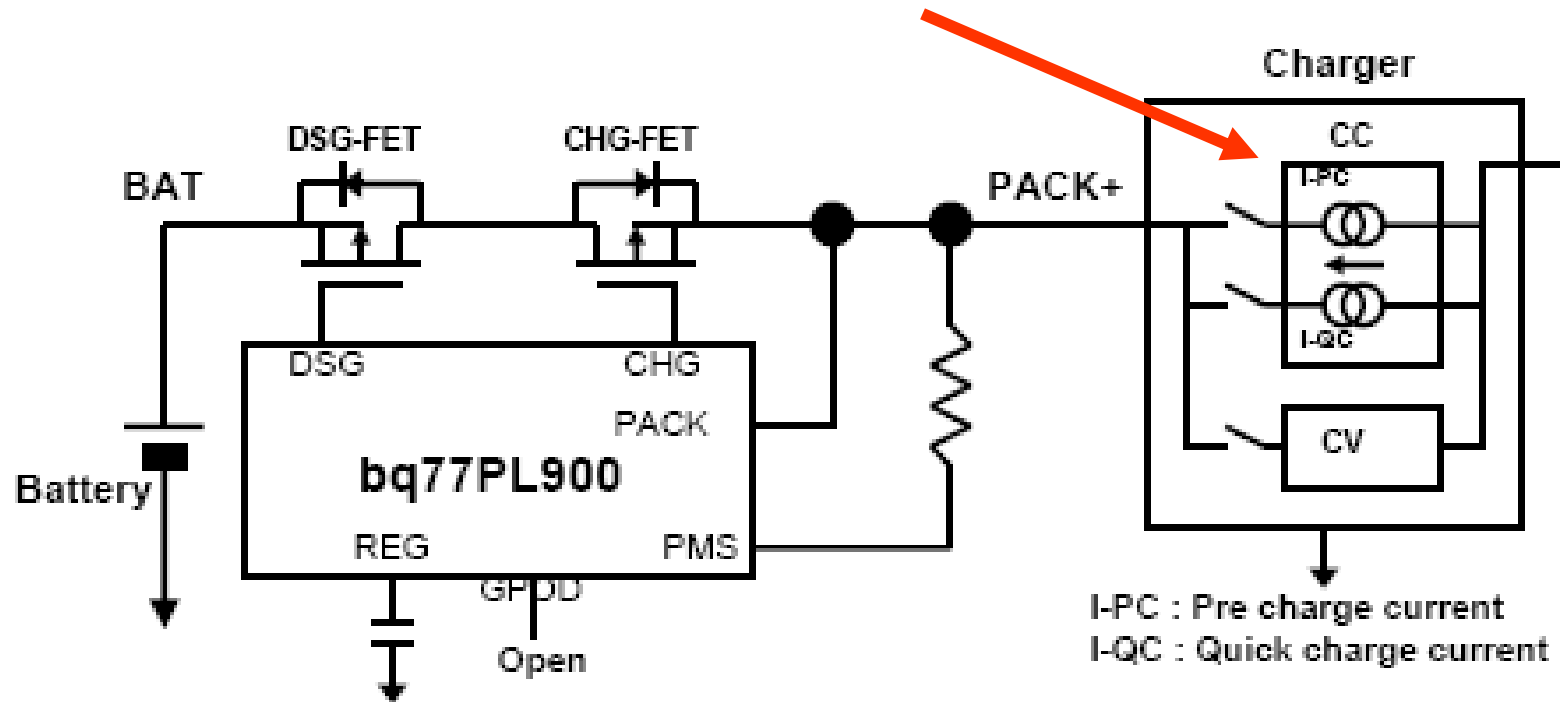
μP needs to turn on TOUT by I2C

AFE never detects overtemp



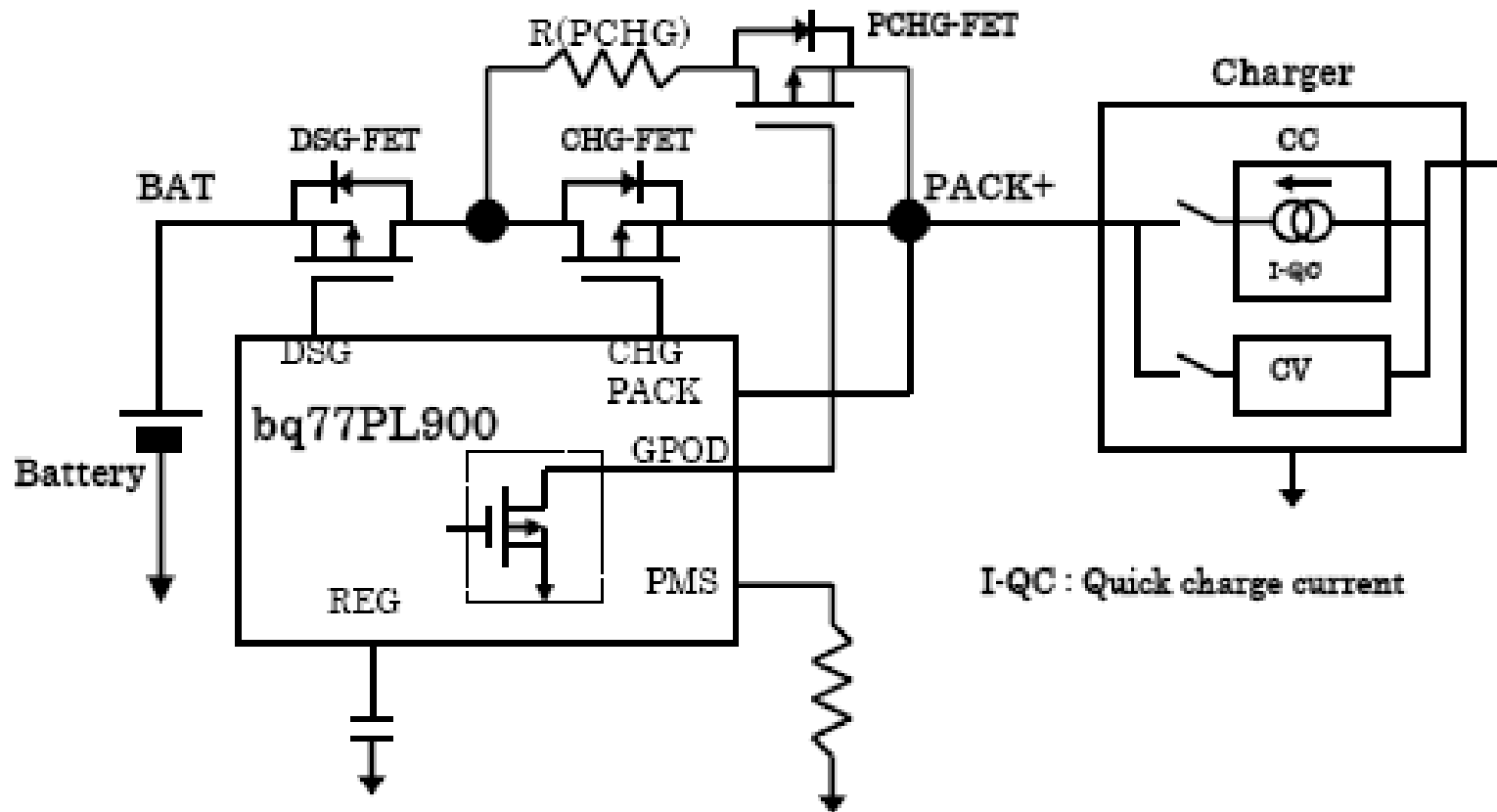
Common FET

(Stand Alone Mode and Host Control Mode)



0V/Pre-charge FET circuit

(Stand Alone Mode and Host Control Mode)



I-QC : Quick charge current

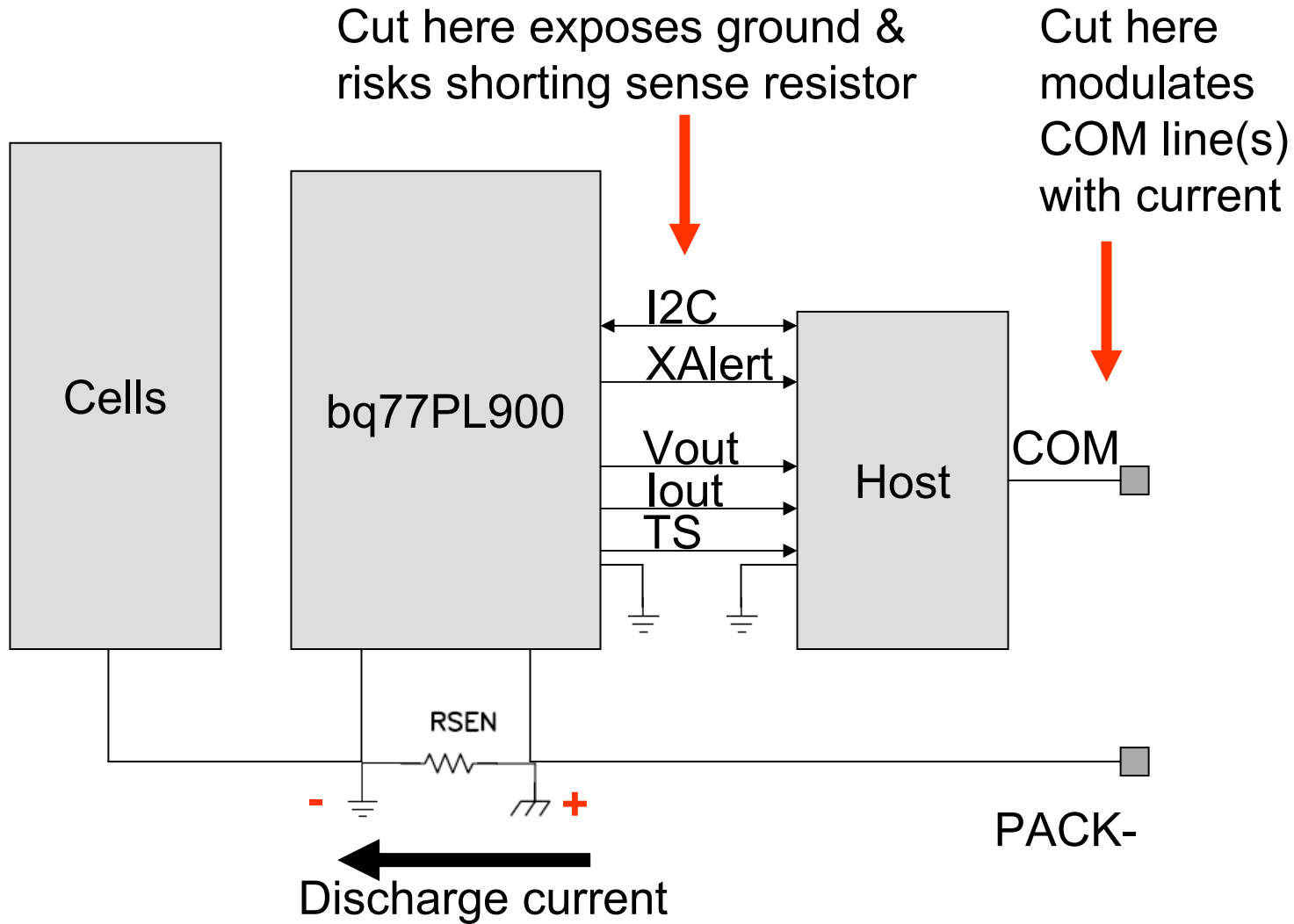
Configuration

- EEPROM holds configuration settings
 - Protection Limits
 - Intended as one time configuration
- I2C programmable
 - 12 registers (8 bit)
 - 5 are EEPROM
- Not for re-writable parameter storage

Grounding

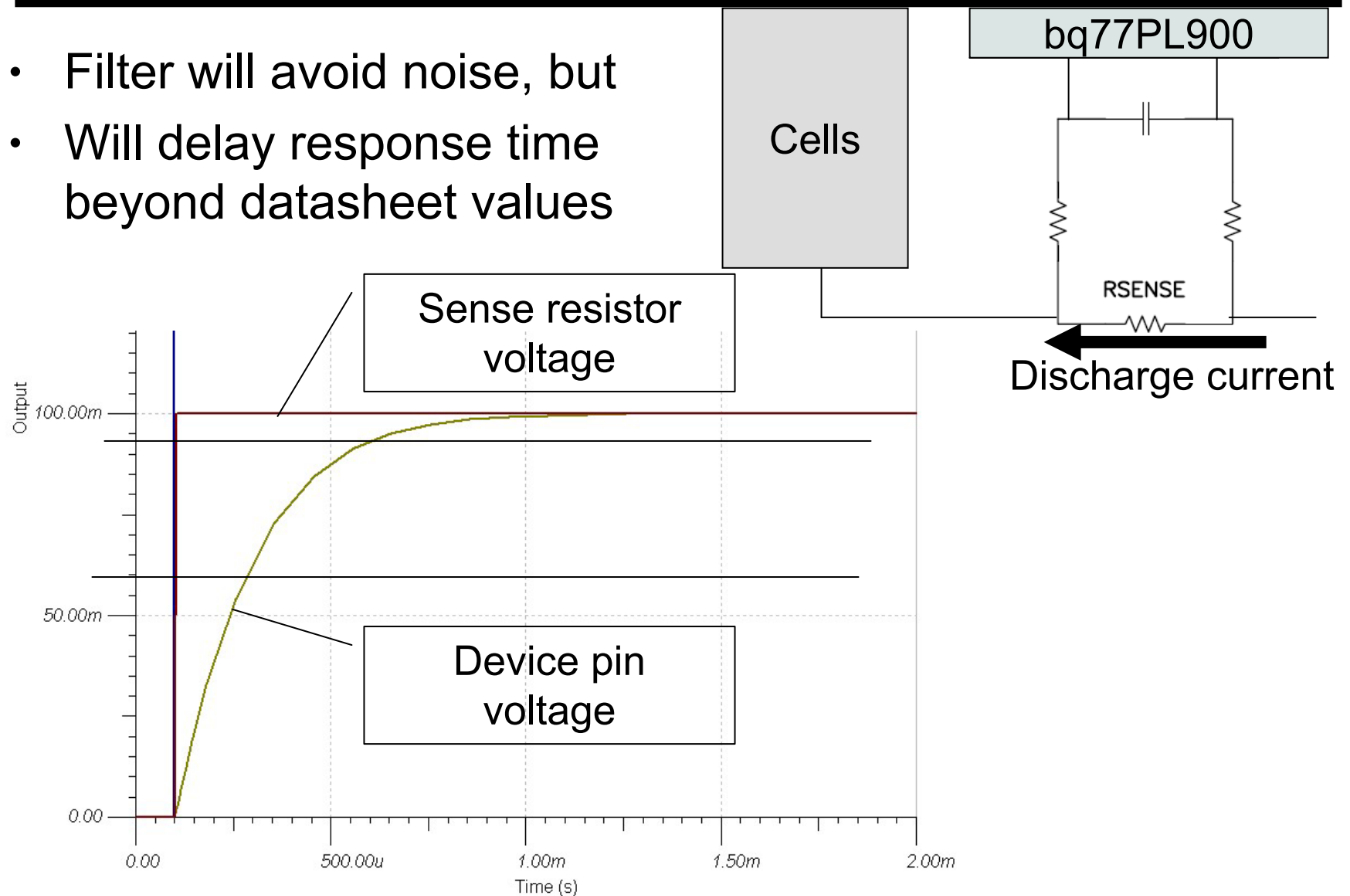
- Due to potential high current applications, device ground is recommended on the battery side of sense resistor.
- If ground is brought out to an external host, both sides of the sense resistor are exposed and current monitoring could be impacted by improper system connection.

Grounding



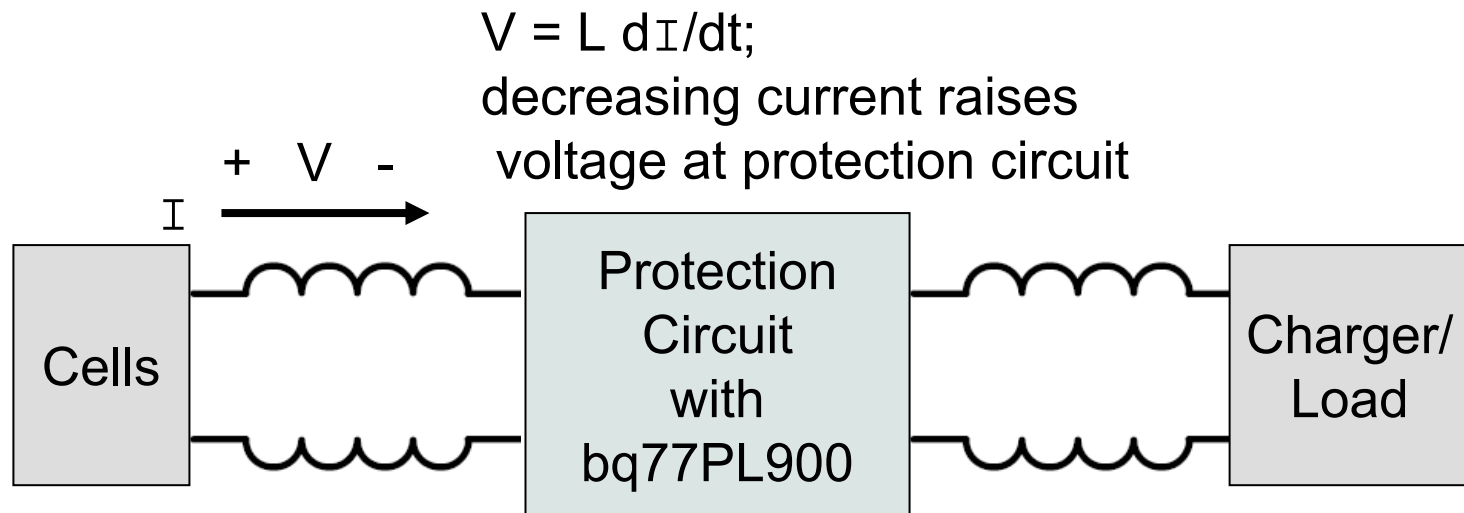
Current monitoring & limits

- Filter will avoid noise, but
- Will delay response time beyond datasheet values



Maximum voltage

- Device voltage is 60V max
 - Confirm charge voltage
 - Open circuit or max current
 - Confirm system transients don't exceed this
 - Feedback from reactive load
 - Inductance in cell leads

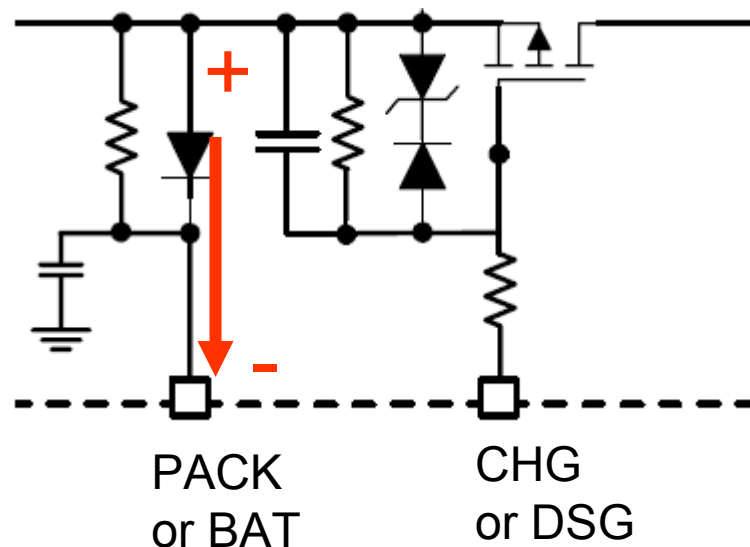
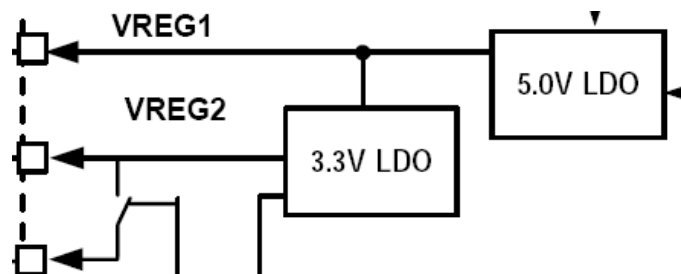


Fault Protection

- Short circuit operation
 - Keep part alive for protection
 - Watch safe operating area of FETs
- Reverse voltage (charger) protection
 - Protect the IC from negative voltage
 - Protect the FET
 - Reverse diode recommended at PACK outputs to clamp charger, reduce voltage to FETs, catch inductive spike
- Typical application circuit provides these with diode to power pins.

Regulator

- Regulators are in series, 25mA max combined, not both
- FET drive affected by current
 - BAT/PACK are both supply and FET source sense pins
 - $I \cdot R$ drop to BAT/PACK will show up as V_{gs} when FET OFF
- Regulator goes off when part shuts down
 - If you want to shut off bq77PL900, need external regulator for host

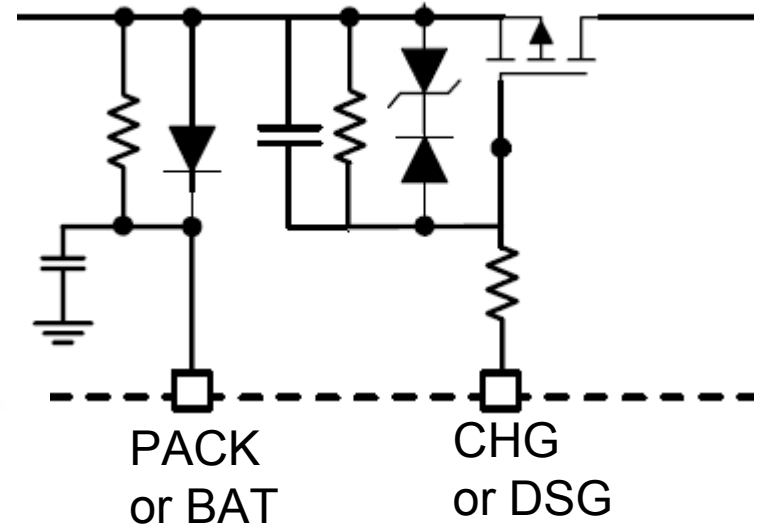
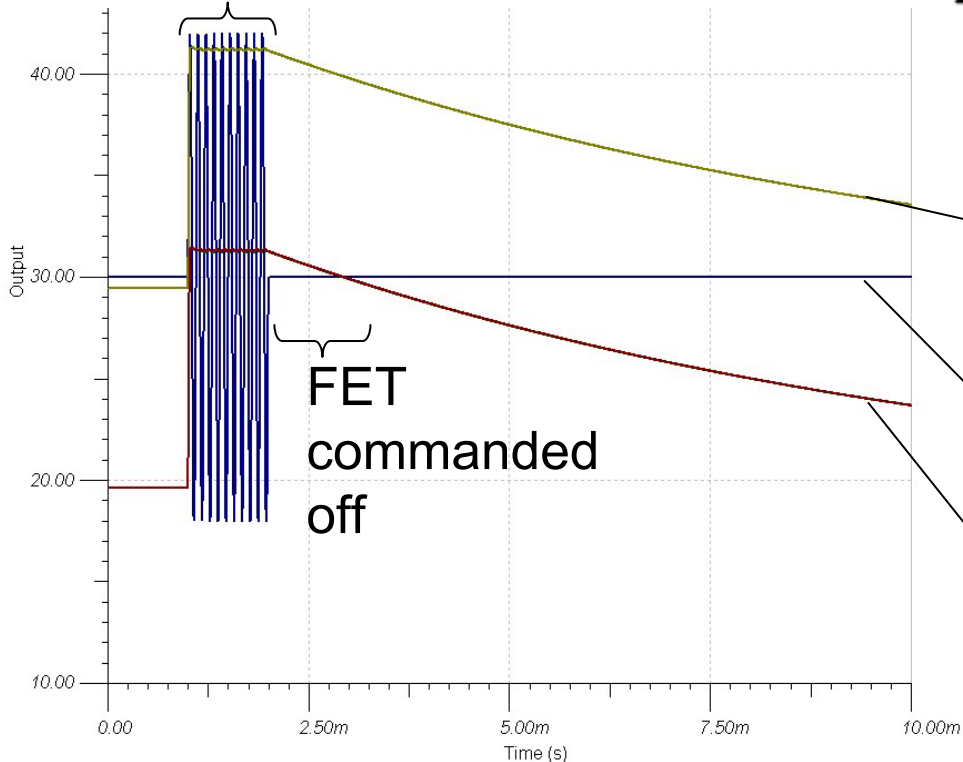


Device maintains 0V when FET off

Peak detection

- Peak may be damaging
- Peak detection of large transients will turn off FET

FET held on by gate capacitance



PACK or BAT
or BAT

CHG or DSG
or DSG

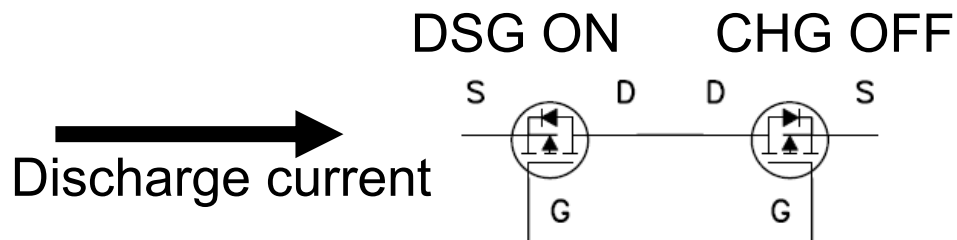
PACK or BAT pin -
decays due to resistor and
device load

Battery or Pack voltage,
FET source

CHG or DSG, driving
FET gate

FETs

- Do you want both, DSG only or none?
- P channel FETs
- Current & power limit
 - Parallel FETs for high current
 - Gate capacitance may be large, switching slow
 - Heat sink if necessary
- Protect CHG FET during OV (standalone & host)
 - DSG current flows in CHG FET diode until recovery threshold (and host action)
 - Depending on load & robustness of FET, you may not want to leave the charger with this condition



Summary

- bq77PL900 provides a 5-10 cell protection solution component for standalone operation or host control
- Features include
 - Over voltage & under voltage protection
 - Over current & short circuit current; discharge protection
 - Over temperature protection
 - Cell balancing
- Be aware of system conditions & requirements in designing with the device