Smart Charger Implementation Examples & Architectures

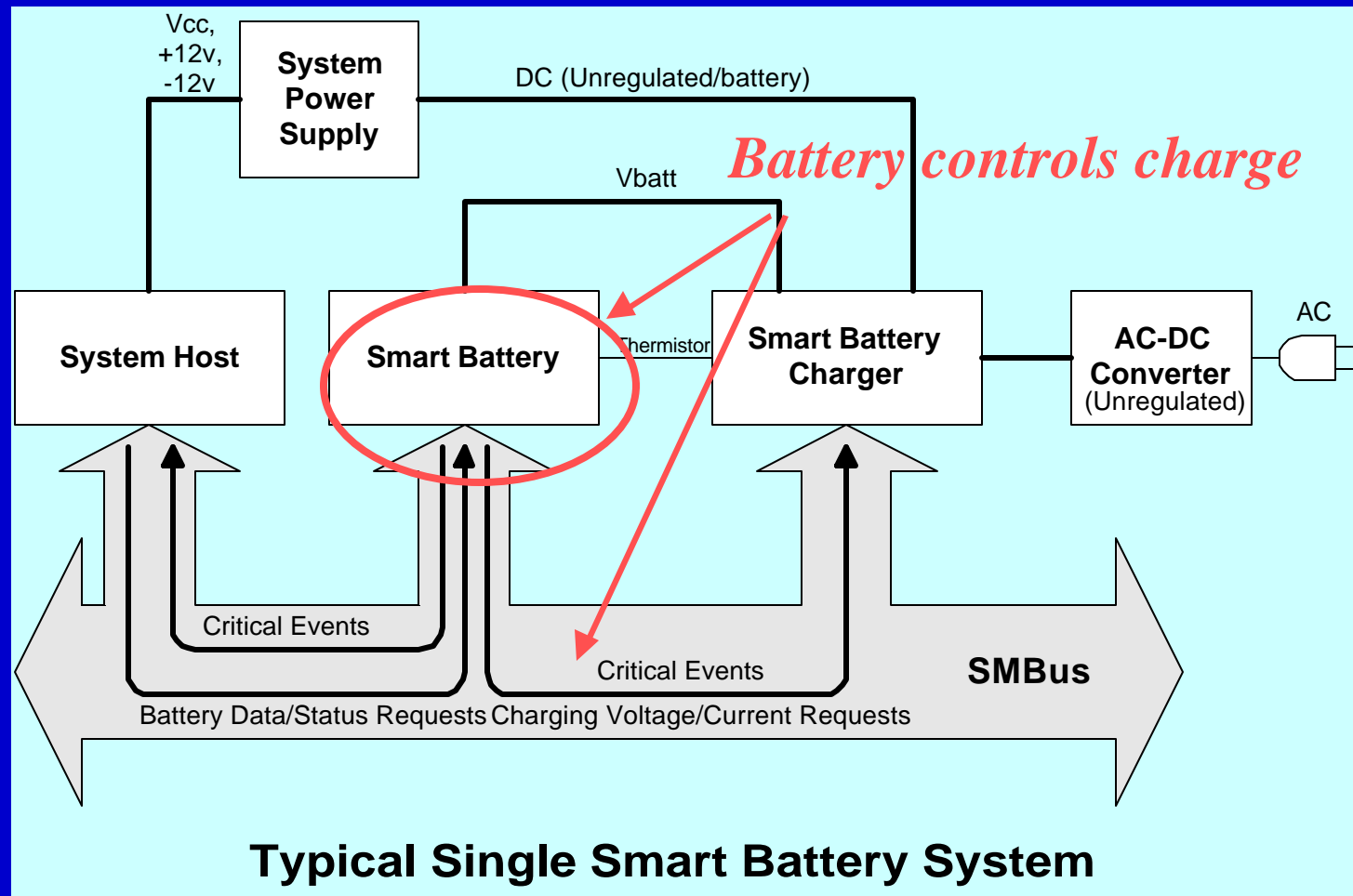## Dale Stolitzka, National Semiconductor Corporation

Topics

- Typical Battery-controlled Charging
- Review Smart Charger Characteristics
- A litmus test for Battery-controlled SBC's
- Non-compliant architectures
- Host-controlled Charging (a.k.a., Level 3)
- Multiple-battery systems
- Thermistor pin Examples

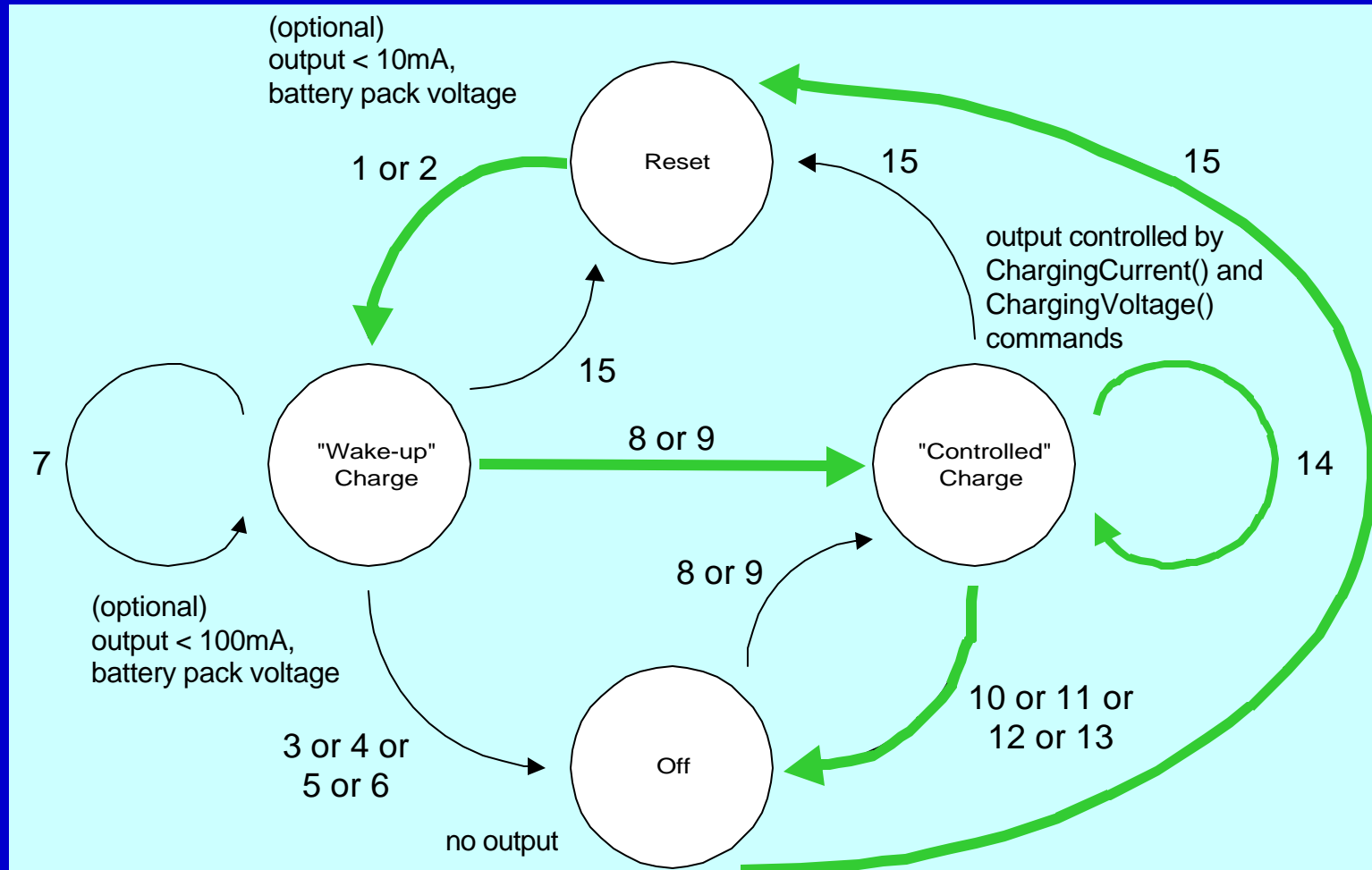*"Smart Charger Implementation Examples..." by National Semiconductor*

Cautionary Note

- This presentation highlights some compliant and non-compliant charging architectures.

- Even if the architecture is compliant to the SBS specifications, this does not warrant or make any recommendations about the applicability of a specifc charging method to a particular battery or cell chemistry.

- The SBS specifications are intended to give the implementor freedom to implement specific architectures of choice.

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Typical Single Battery System

Vcc, +12v, -12v

System Power Supply

DC (Unregulated/battery)

Vbatt

Battery controls charge

System Host

Smart Battery

Thermistor

Smart Battery Charger

AC-DC Converter (Unregulated)

AC

Critical Events

Critical Events

SMBus

Battery Data/Status Requests Charging Voltage/Current Requests

Typical Single Smart Battery System

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SBC Characteristics

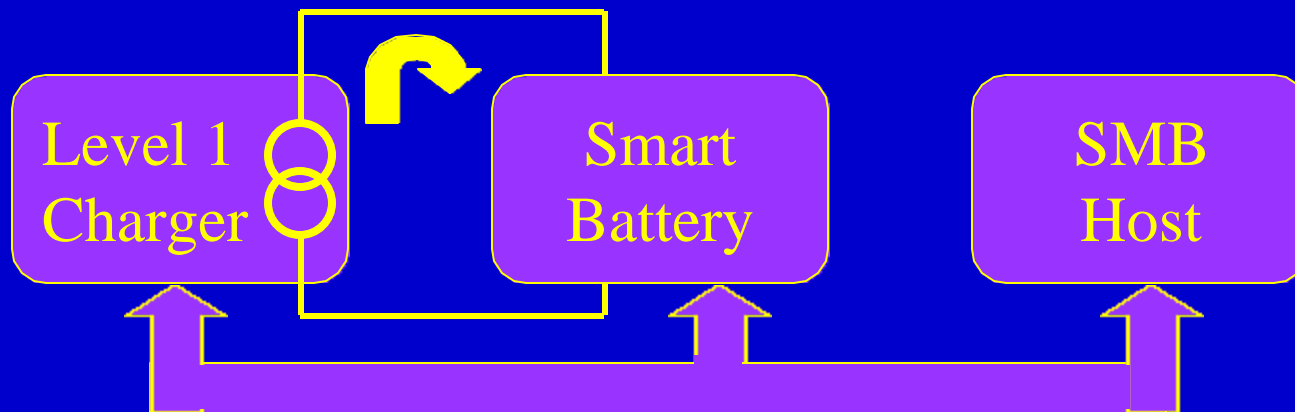
(optional)
output < 10mA,
battery pack voltage

Reset

1 or 2

15

15

output controlled by
ChargingCurrent() and
ChargingVoltage()
commands

15

7

"Wake-up" Charge

8 or 9

"Controlled" Charge

14

(optional)
output < 100mA,
battery pack voltage

8 or 9

3 or 4 or
5 or 6

Off

10 or 11 or
12 or 13

no output

Battery-controlled Charging Litmus Test

- Requires *ChargingCurrent* and *Charging-Voltage* be refreshed periodically, else stop?
- Stop if current or voltage request is 0?
- Stop if battery's Therm pin is out-of-range?
- Stop if any *AlarmWarning* bits[15:12] are True?
- Stop if wake-up charge time limit is exceeded?
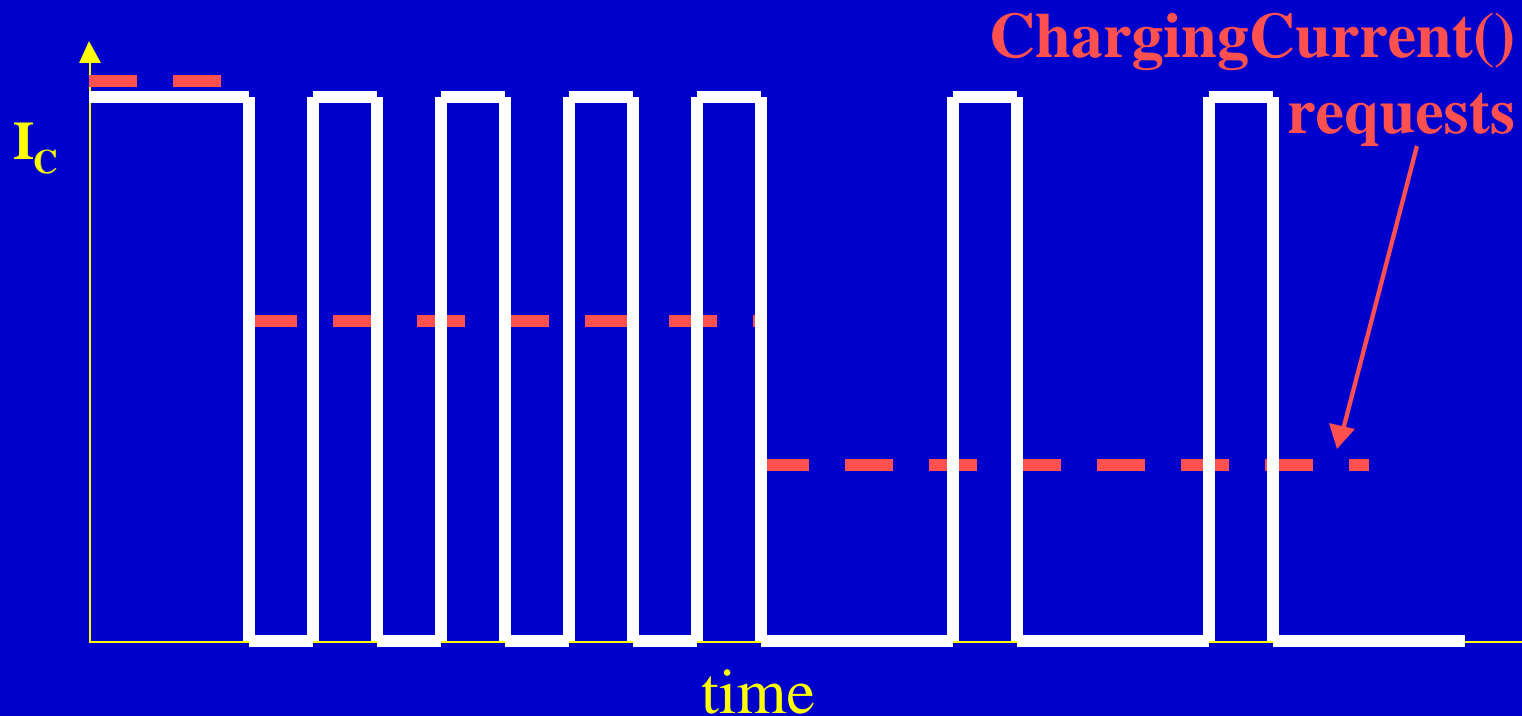- Does not load the bus nor battery when off or inactive?

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Pulsing Battery-controlled Charger

- The SBC may not pulse the battery

# Pulsing Battery-controlled Charger

- This architecture is non-compliant
  - Duty-cycled current pulses exceed the safe current limit set by ChargingCurrent()
  - Safe operation relies on specific and chemistry-dependent factors
  - Does not meet 5% *ChargingCurrent* and *ChargingVoltage* accuracy over finite intervals

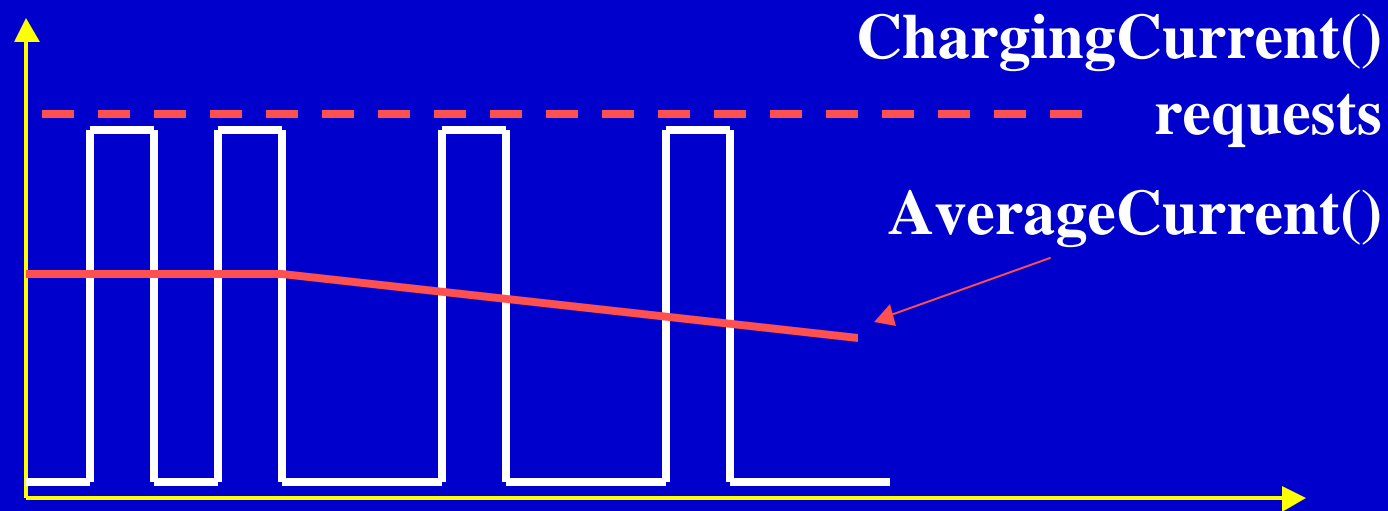*"Smart Charger Implementation Examples..." by National Semiconductor*

Battery Internally Controls Charging

- CHARGE_CONTROLLER_ENABLED = 1
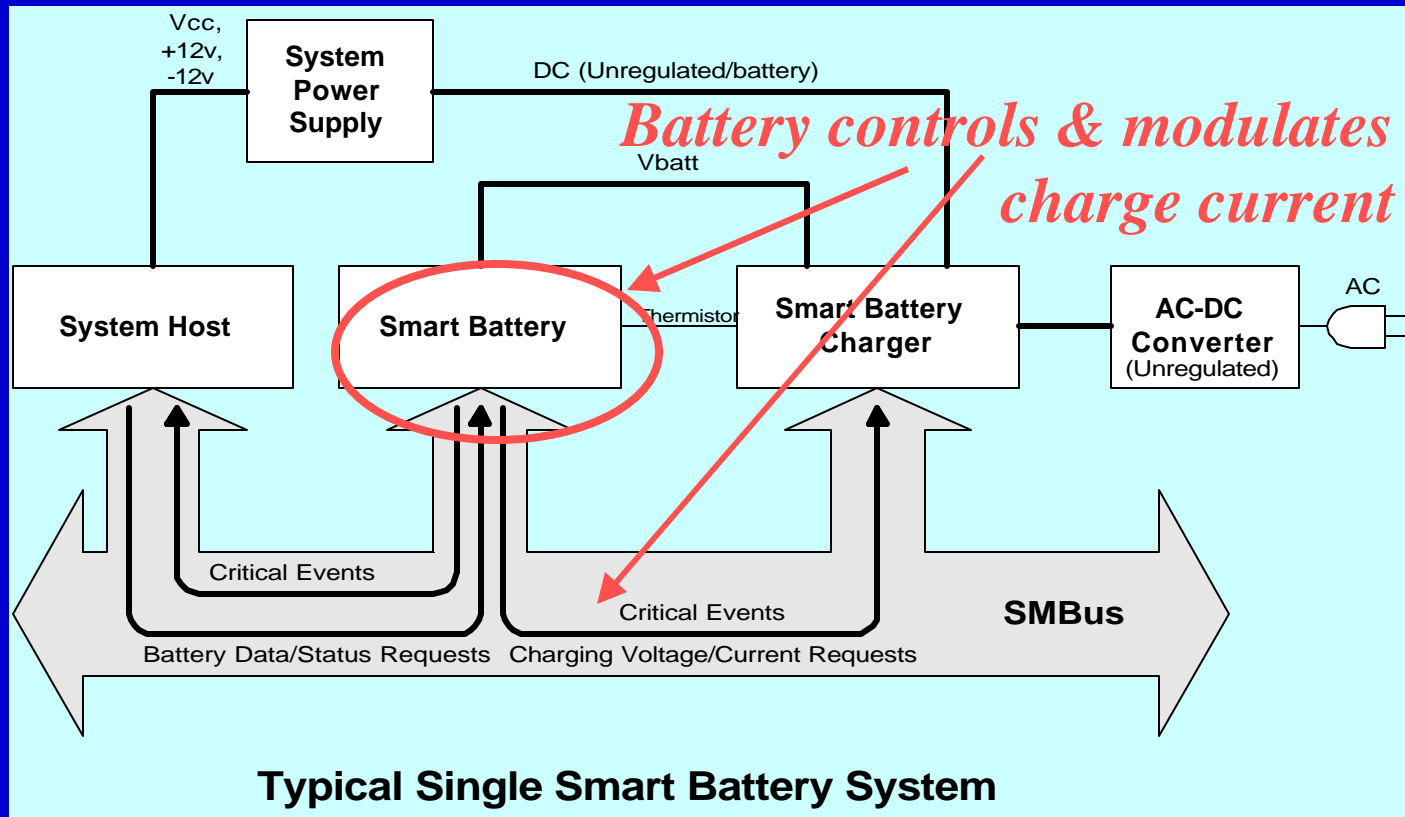
Typical Single Smart Battery System

"Smart Charger Implementation Examples..." by National Semiconductor

Battery Internally Controls Charging

- ## This architecture is compliant
  - ### The battery maintains periodic Charging-Current and ChargingVoltage messages
  - ### Battery modulates current, internally

ChargingCurrent()
requests

AverageCurrent()

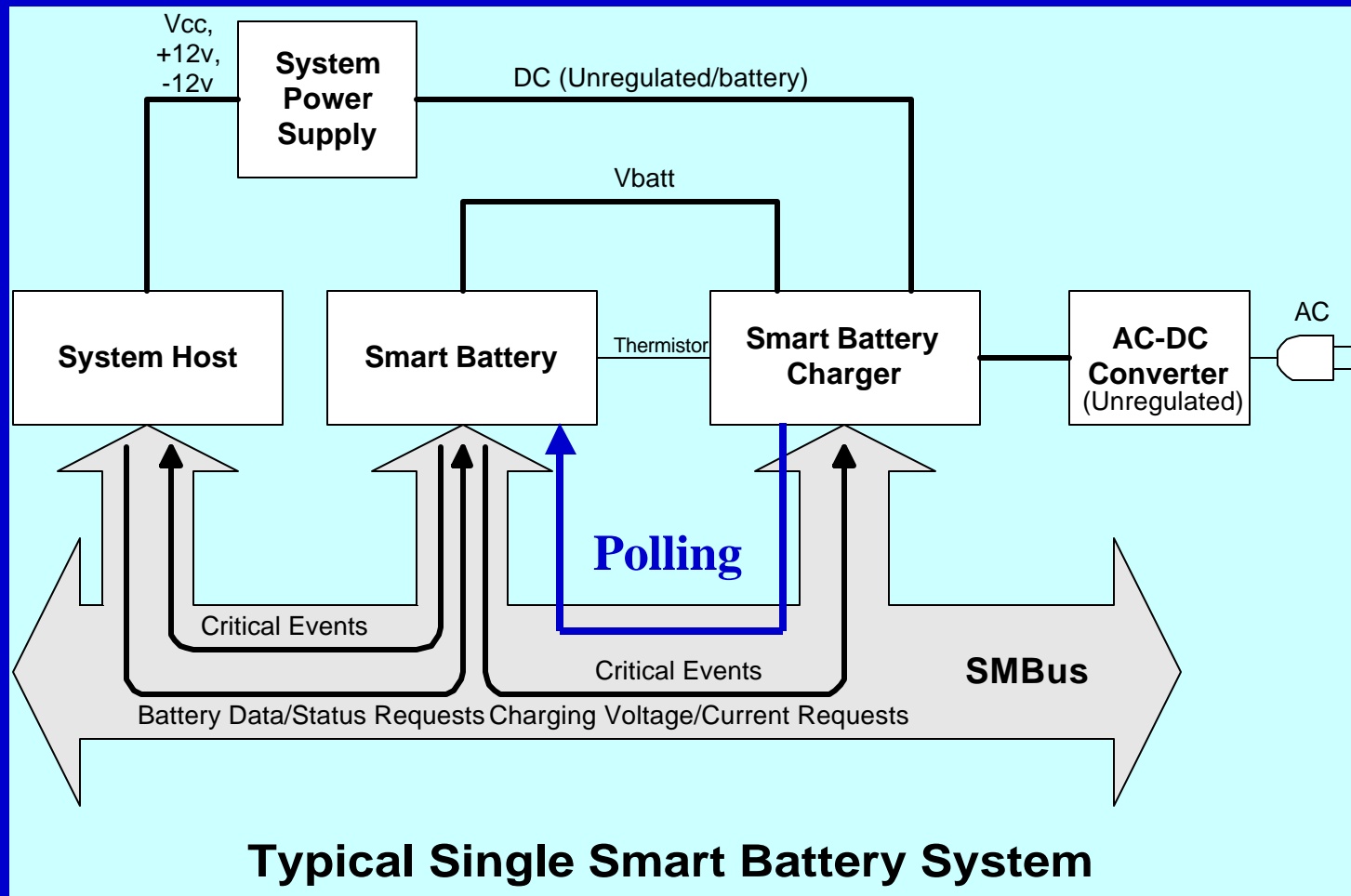*"Smart Charger Implementation Examples..." by National Semiconductor*

Host-controlled Charging (Level 3)

- Host-controlled charging generically refers to any Host that controls the battery charging. Hosts may be:
  - Smart Battery Charger (Level 3)
  - System Host with a built-in charger
  - System Host that manages the bus traffic by communicating directly to a slave SBC
  - ...

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Host-controlled Charging Rules

- The Host must periodically poll the battery for charging current and voltage
  - Time period is not specified but periodic
- Battery still broadcasts AlarmWarning()
- The battery may still modulate current
- All other Litmus test rules apply
  - Thermistor ranges, etc.

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SBC Contains the Host-controller

Typical Single Smart Battery System

System Host Manages Bus Traffic

Typical Single Smart Battery System
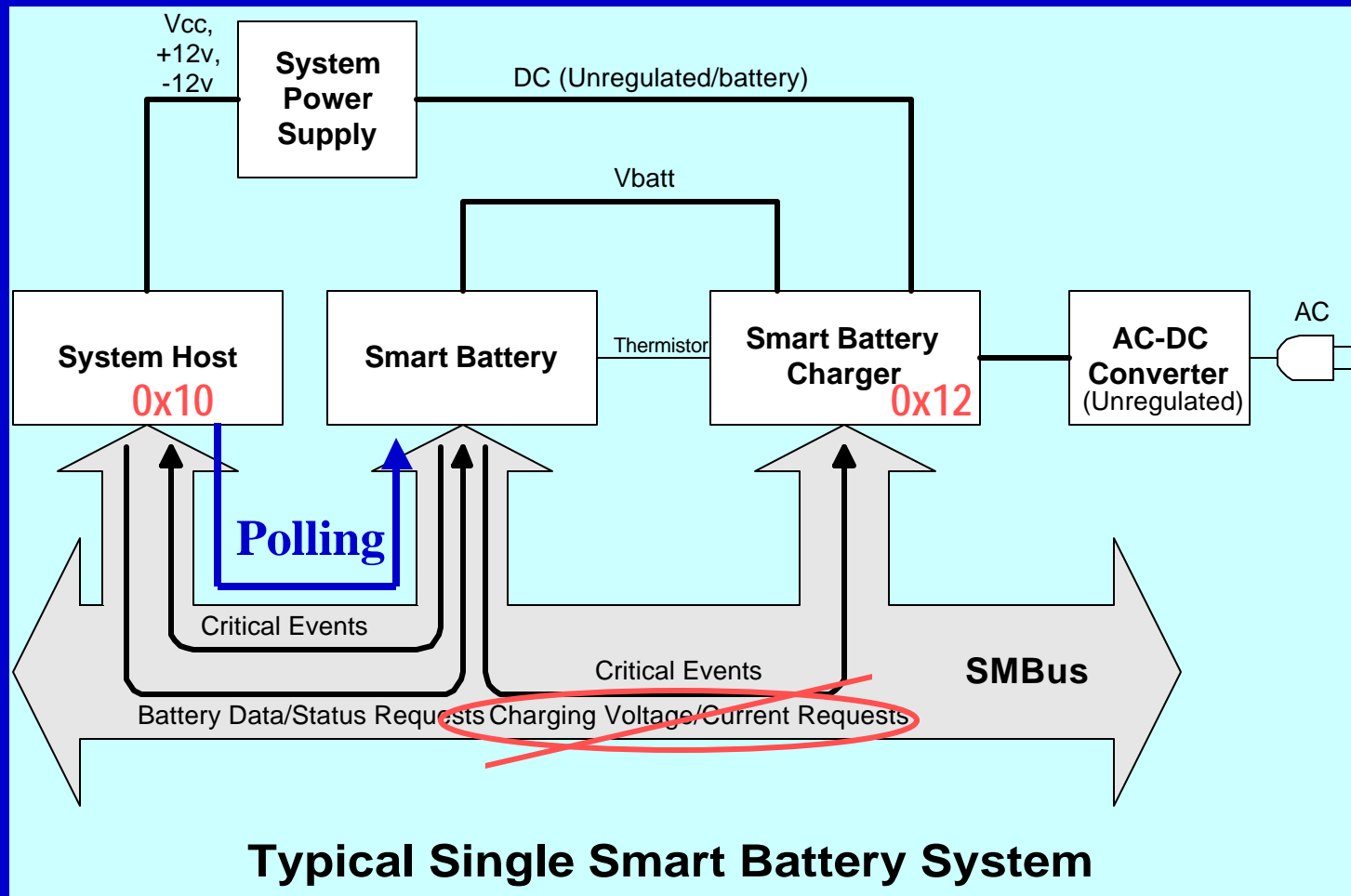
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System Host Contains the SBC

Typical Single Smart Battery System

- Vcc, +12v, -12v
- System Power Supply
- DC (Unregulated/battery)
- Vbatt
- System Host **0x10 & 0x12**
- Smart Battery
- Thermistor
- Smart Battery Charger
- AC-DC Converter (Unregulated)
- AC
- Critical Events
- Critical Events
- SMBus
- Battery Data/Status Requests
- Charging Voltage/Current Requests
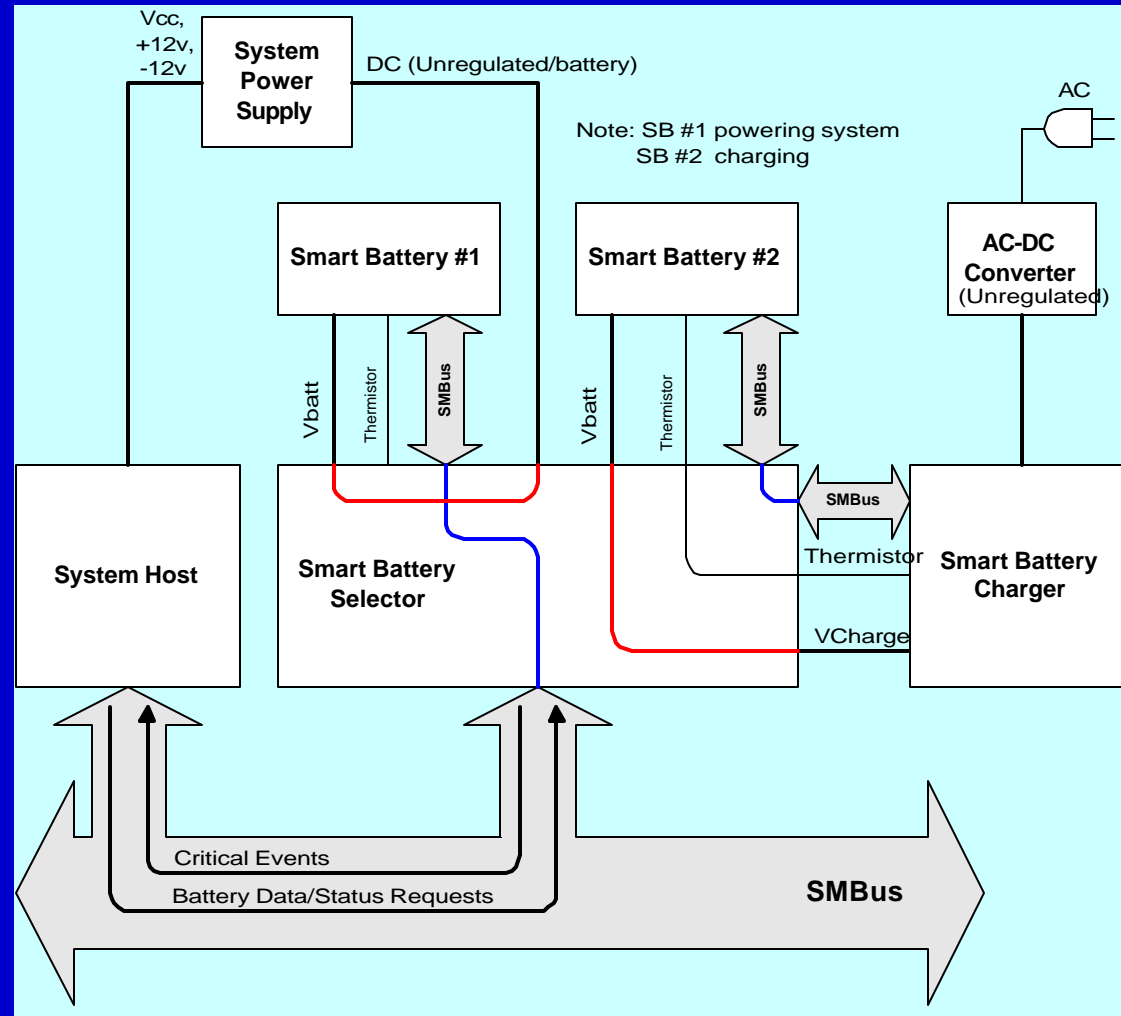- **ChargingVoltage and ChargingCurrent requests**
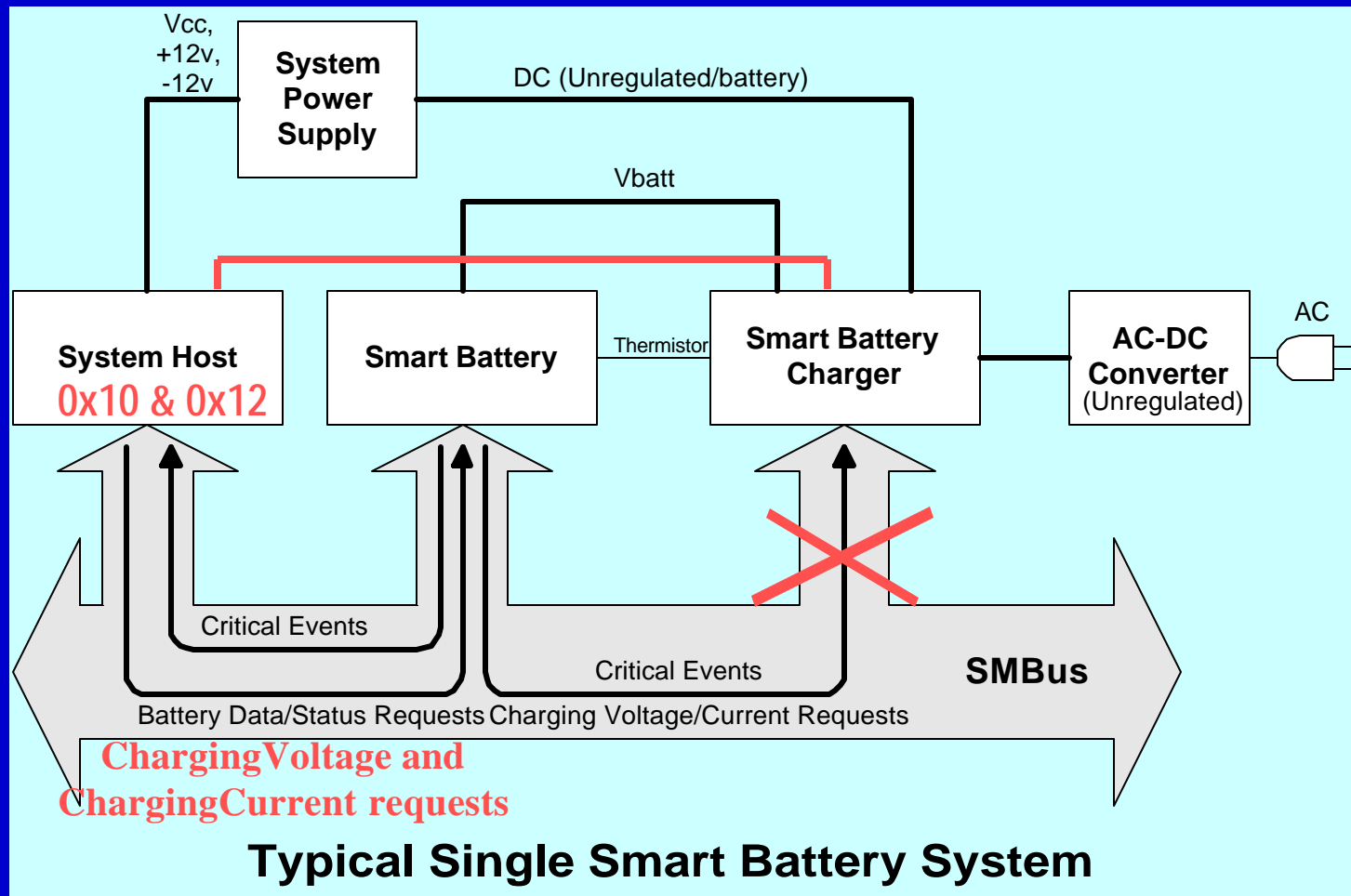
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Multiple Battery Systems

- Systems can contain up to 4 batteries
  - Battery Selector system can use 4
- Options may include, and not limited to:
  - One battery idle, one battery charges
  - One battery discharges, one charges
- May not charge two batteries simultaneously
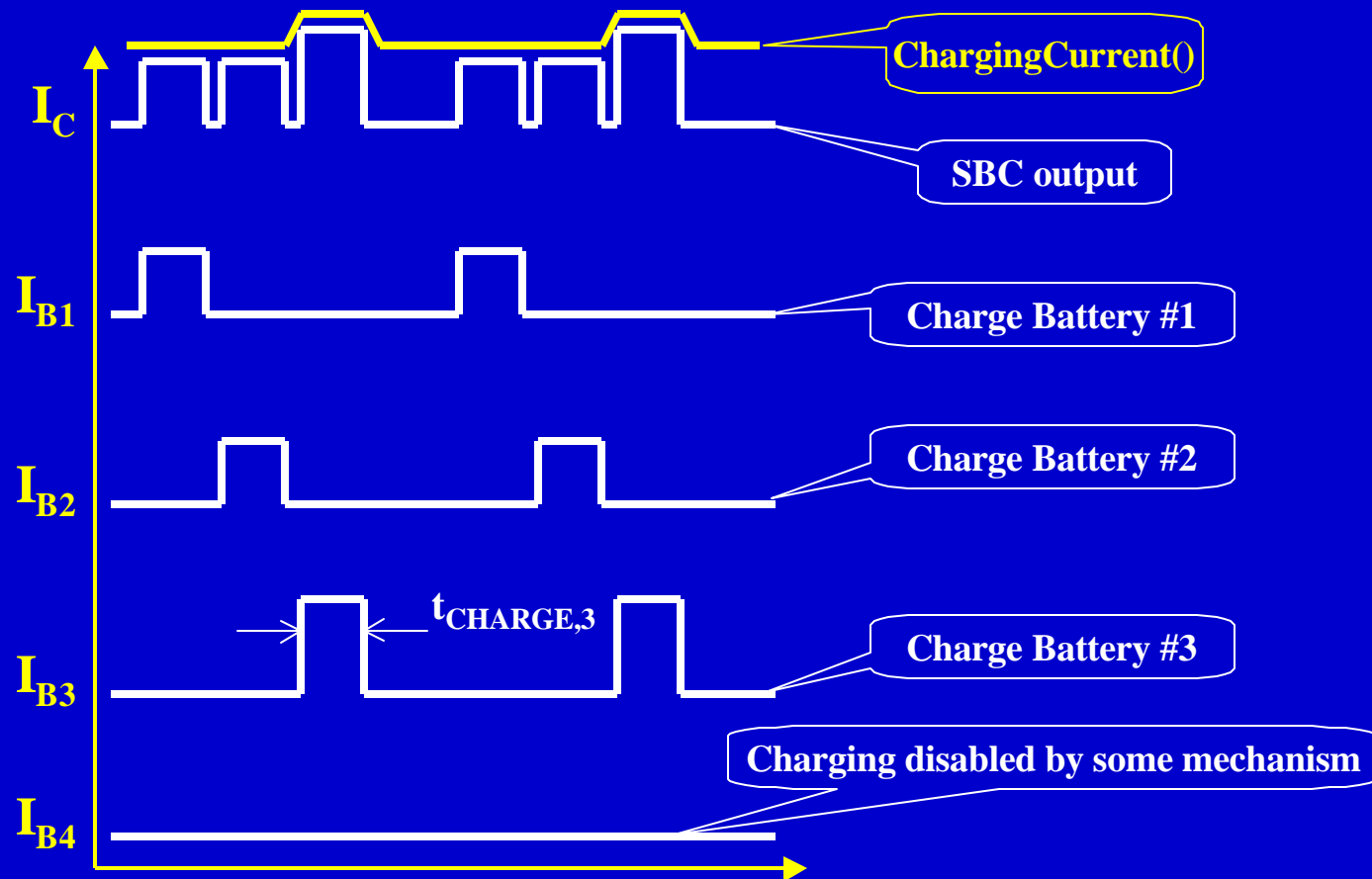
Multiple Battery Systems

System Power Supply

Vcc, +12v, -12v

DC (Unregulated/battery)

Note: SB #1 powering system
SB #2 charging

AC

AC-DC Converter (Unregulated)

Smart Battery #1

Smart Battery #2

Vbatt

Thermistor

SMBus

Vbatt

Thermistor

SMBus

System Host

Smart Battery Selector

SMBus

Thermistor

Smart Battery Charger

VCharge

Critical Events

Battery Data/Status Requests

SMBus

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Host-controlled "Pulse" Charging

- Let's charge up to 4 batteries
- Algorithm is in the Host-controlled SBC
- Disable broadcasting by battery
- The Host can look like it is pulse-charging each battery, in fact, the charger is time-sharing its output
- If time of each charge is < 10 sec, the Host must poll BatteryStatus()

A Host-controlled Charge Timing

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Host-controlled Multiple-battery Layout

Ensure the pulse charging system maintains battery presence detection.
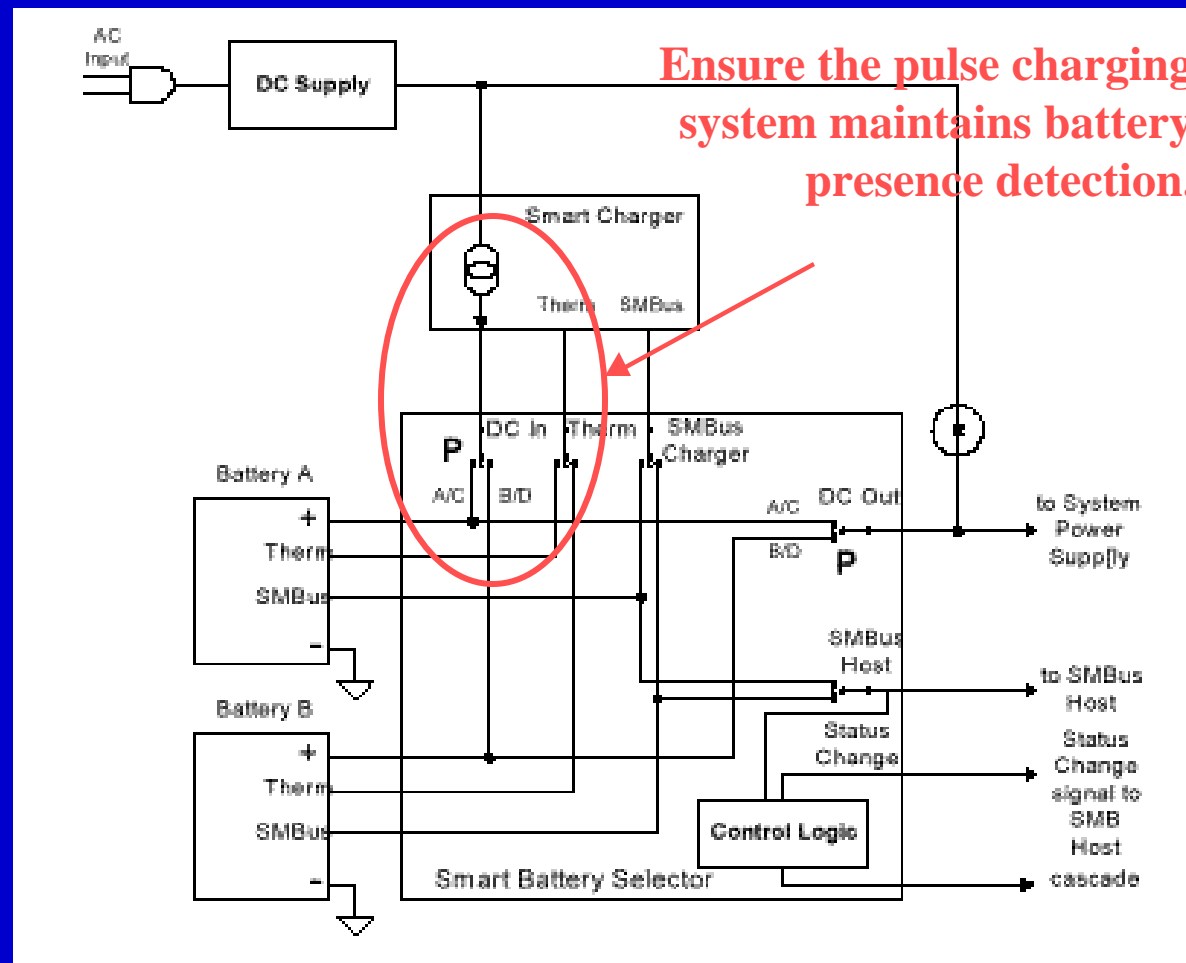
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Thermistor Pin Issues

- Two time-limited wake-up modes
  - 0 to 500Ω is a mode which time-limits wake-up charging = THERM_UR
  - 30kΩ - 100kΩ permits wake-up charging for a specific time period = THERM_COLD
- 3kΩ to 30kΩ permits indefinite wake-up charging

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Thermistor Pin Examples

- Smart Charger is compliant with either:

Therm — <500Ω or 10kΩ — T

(a)

Therm — Smart Battery control

(b)
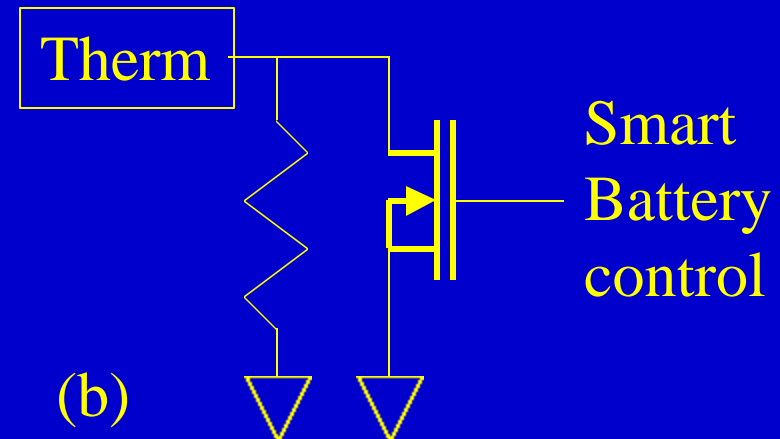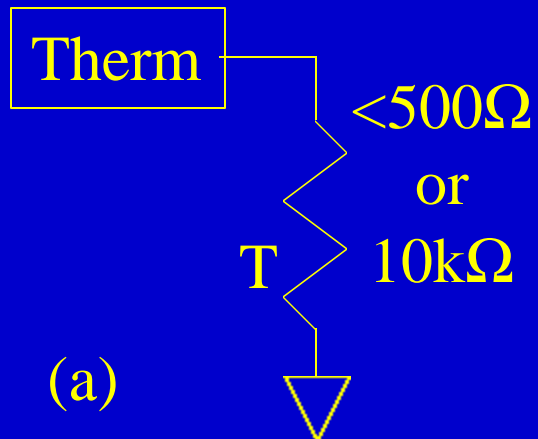
Summary Review

- Keep safety first in mind!!!
- Use the litmus test for a SBC to help avoid non-compliant architectures
- Make charger system partitioning decisions around the Host. Is battery-controlled or host-controlled charging desired?
- Use multiple-battery systems with care
- Design Thermistor pin as a failsafe device

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