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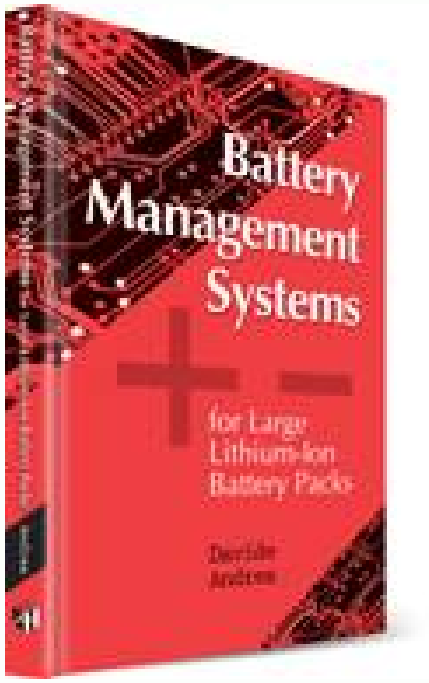
Li-Ion Myth-Buster



Poking holes into some common beliefs about Li-Ion cells and Li-Ion BMSs.

Davide Andrea
Elithion - Electronics for Lithium Ion

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EXTRA! EXTRA!

As heard this morning:

"With few large format cells, each cell is monitored.

With many small format cells, monitoring each cell is impractical."

Battery Power Conference 2010, 2,

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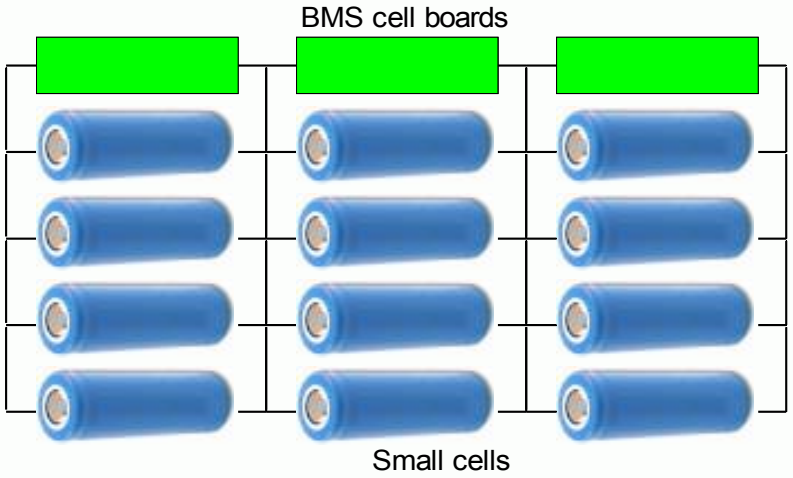
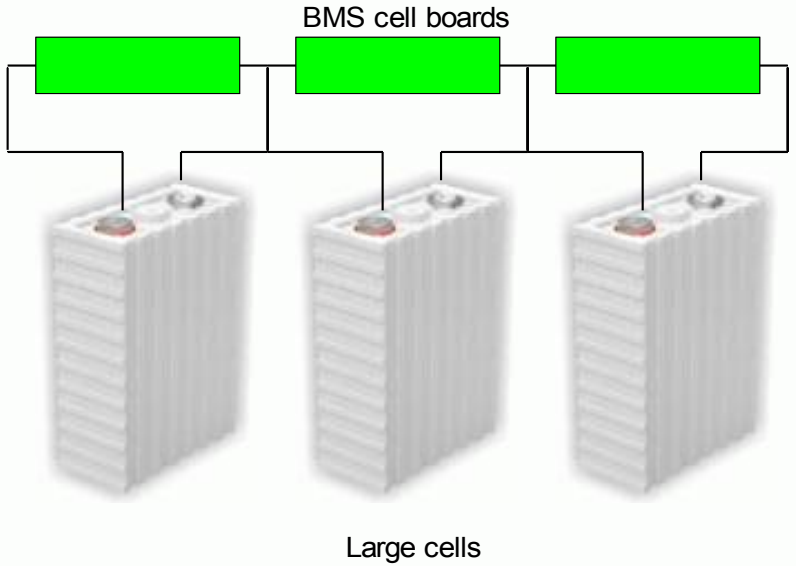
EXTRA! EXTRA!

The same BMS with work equally well with both formats.





FALSE

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Myths

A) Cells
B) Batteries
C) BMS
D) Balancing

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A: Cell myths

Group A:
Myths about Li-Ion cells

- Cell capacity myths
- Cell swelling myths

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Charge efficiency

Myth A1:

"A cell puts out less charge than you put into it"

FALSE

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Charge efficiency

Li-Ion charge efficiency = **100 %:**

Every electron that goes in
can come back out

(Though, energy efficiency is < 100 %)

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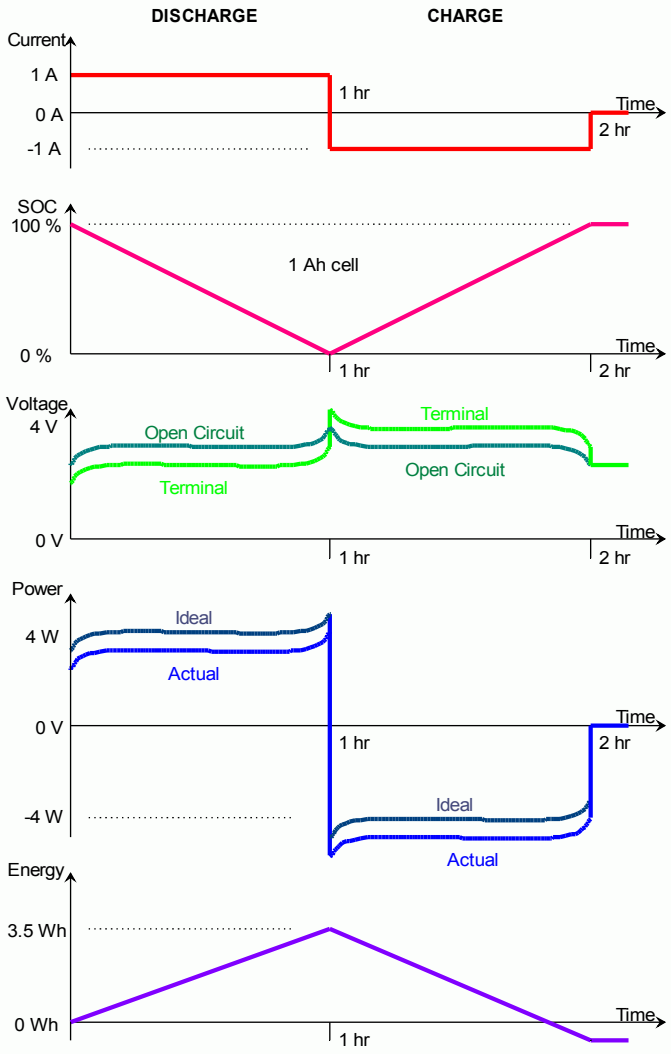
Charge efficiency



1 A in for 1 hour, 1 A out for 1 hour

SOC: 100 %, to 0 %, back to 100 %: charge efficiency is 100 %

Charge voltage is higher than OCV, lower during discharge

Charge power is more than discharge power

Energy doesn't go back down to 0: energy efficiency is < 100 %

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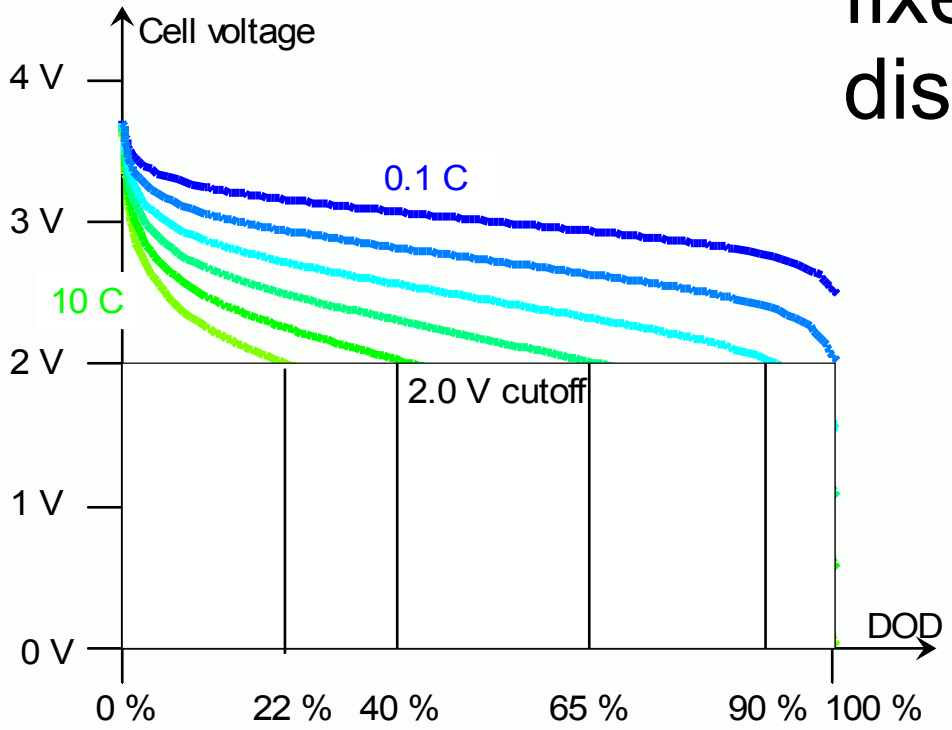
Capacity vs rate

Myth A2:

"Cell capacity depends on rate of discharge"

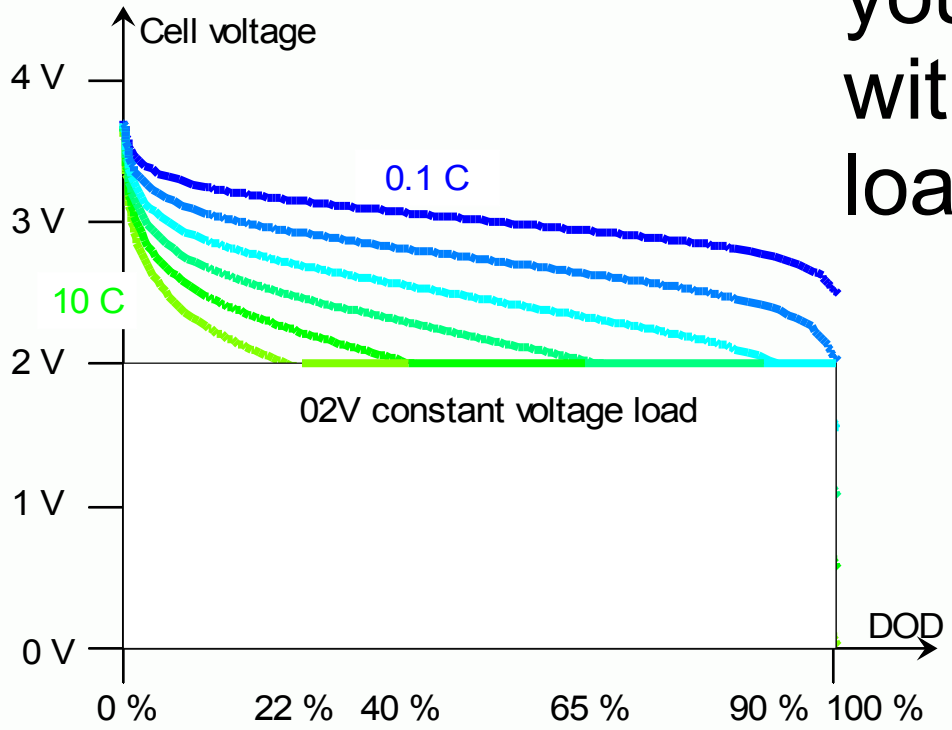
FALSE

Capacity vs rate



Yes, at high discharge a fixed cutout will stop discharge sooner

Capacity vs rate



But the rest is still there; you can still get it out, with a constant voltage load.

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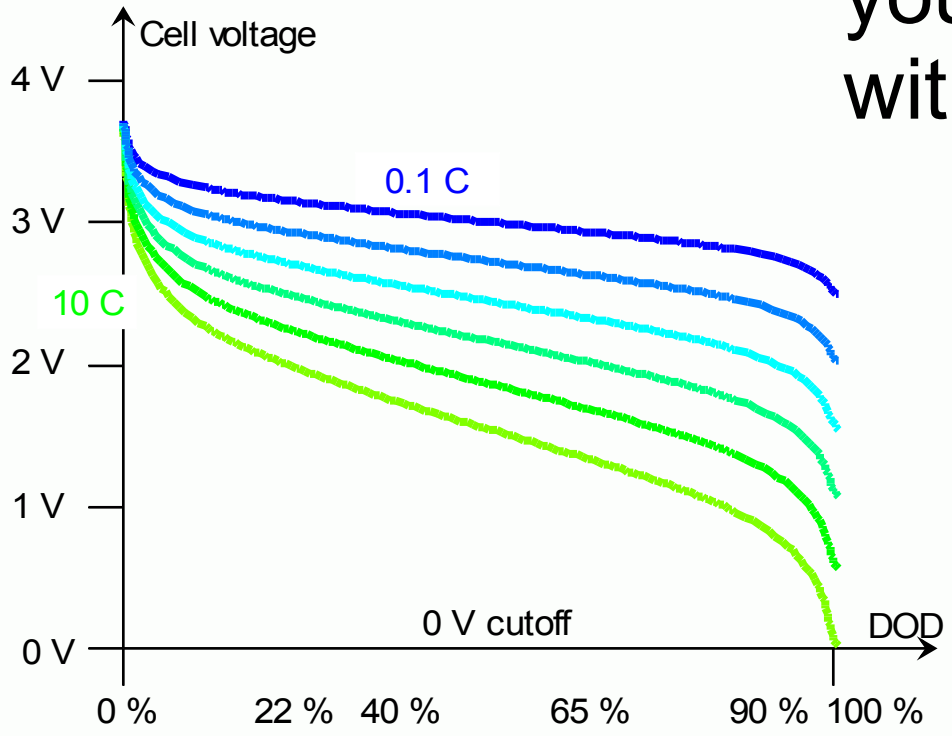
Capacity vs rate



But the rest is still there;
you can still get it out,
with a lower cutout

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Capacity vs cycles

Myth A3:

"Cell capacity decreases with number of cycles"

MIX

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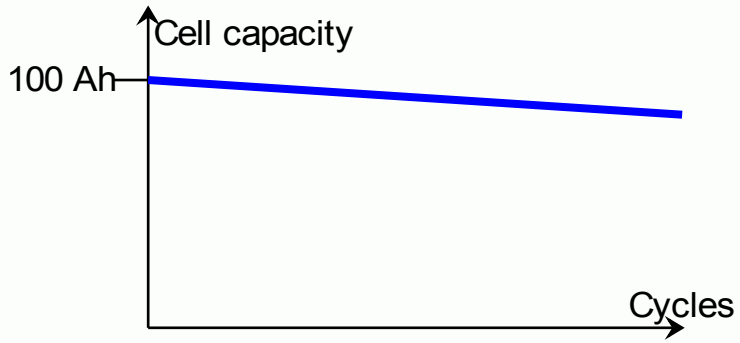
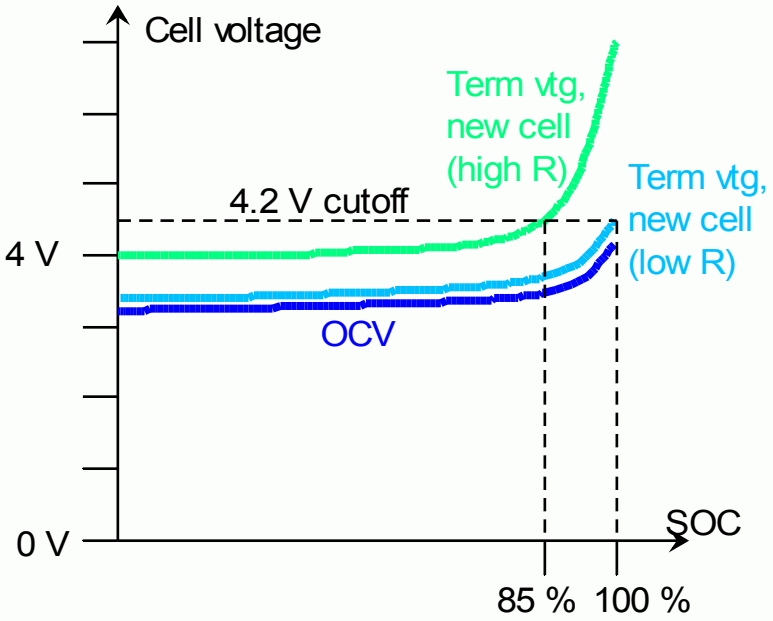
Capacity vs cycles



Degradation =
capacity loss



Higher resistance
+ fixed cutoffs =
unused capacity

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C: BMS myths

Group C:
"I don't need a BMS" myths

- Cutoff myth
- Small SOC range myth
- Extra cells myth

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No BMS: I use a cutoff

C1: "I don't need a BMS
my charger has a high voltage limit"

C2: "I don't need a BMS
my load has a low voltage cut-off"

FALSE FALSE

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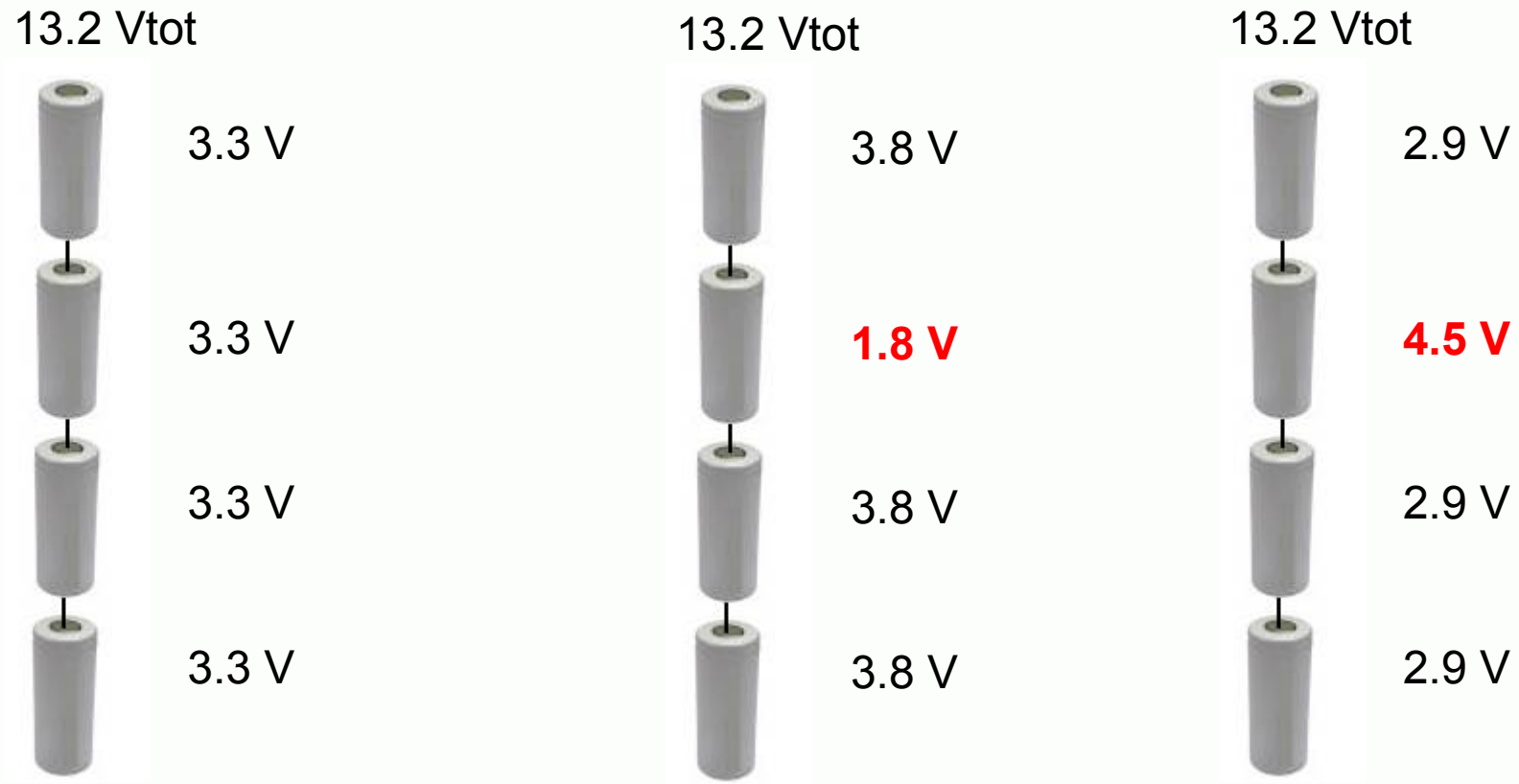
No BMS: I use a cutoff

There's no way of knowing the state of individual cells from the pack voltage.



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No BMS: I use a cutoff

Top balancing won't help

Fully charged,
Top balanced

14.4 Vtot

3.6 V

3.6 V

3.6 V

3.6 V

Discharged.
All same capacity

11.2 Vtot = LV cutoff

2.8 V

2.8 V

2.8 V

2.8 V

Discharged.
One has low capacity

11.2 Vtot = LV cutoff

3.2 V

1.6 V

3.2 V

3.2 V

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No BMS: I use a cutoff

- Yes: a CCCV will protect a top-balanced pack: when the pack voltage is at the max, all the cell voltages will be equally at the max.
- However, when discharging without a BMS, the voltage of the least capacity cell will drop too far and be damaged.

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No BMS: I use a cutoff

Bottom balancing won't help

Fully discharged,
Bottom balanced

12.0 Vtot

Charged.
All same capacity

14.4 Vtot = Charger CV

Charged.
1 has low capacity

14.4 Vtot = Charger CV

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No BMS: I use a cutoff

- Yes: a LV cutoff will protect a bottom-balanced pack: when the pack voltage is low, all the cell voltages will be equally low.
- However, when charging without a BMS, the voltage of the least capacity cell will go too high.

  And that's a fire danger!

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No BMS: I mind the SOC

Myth #C3:

"I'll won't use
the entire SOC range,
so I don't need a BMS"

FALSE

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Nice and easy: no BMS

The assumptions are that:

1) The pack SOC is known

2) All the cells are at that same SOC

Not so.

Without a BMS, the pack SOC is not known (and even a BMS doesn't always know the SOC)

More cells: no BMS

Myth #C4:

"Extra cells are cheaper than a BMS"

FALSE

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More cells: no BMS

The assumption is that a pack without a BMS will simply slowly degrade. So, instead of buying a $ 1000 BMS, I'll buy 10 extra cells.

Not so.

A SINGLE overcharge or over-discharge event can kill a cell. And it will keep on happening after you replace that cell.

D: Balancing myths

Group D:
Myths about cell balancing

- Balance purpose myths
- Balance point myths

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Balancing purpose

D1: "Balancing protects a battery"

D2: "Balancing compensates for variations in cell capacity"

 FALSE

 FALSE

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Balancing purpose

The point of balancing is to maximize battery capacity.

Balancing brings all the cells to the same SOC at ONE point.

The SOC is balanced.

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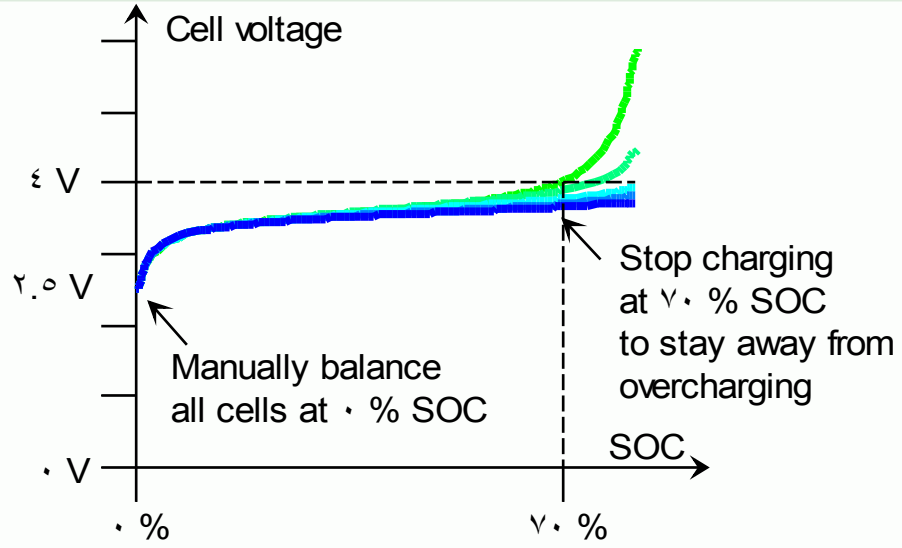
Bottom balancing

Myth D4:

"Bottom balancing protects the cells"

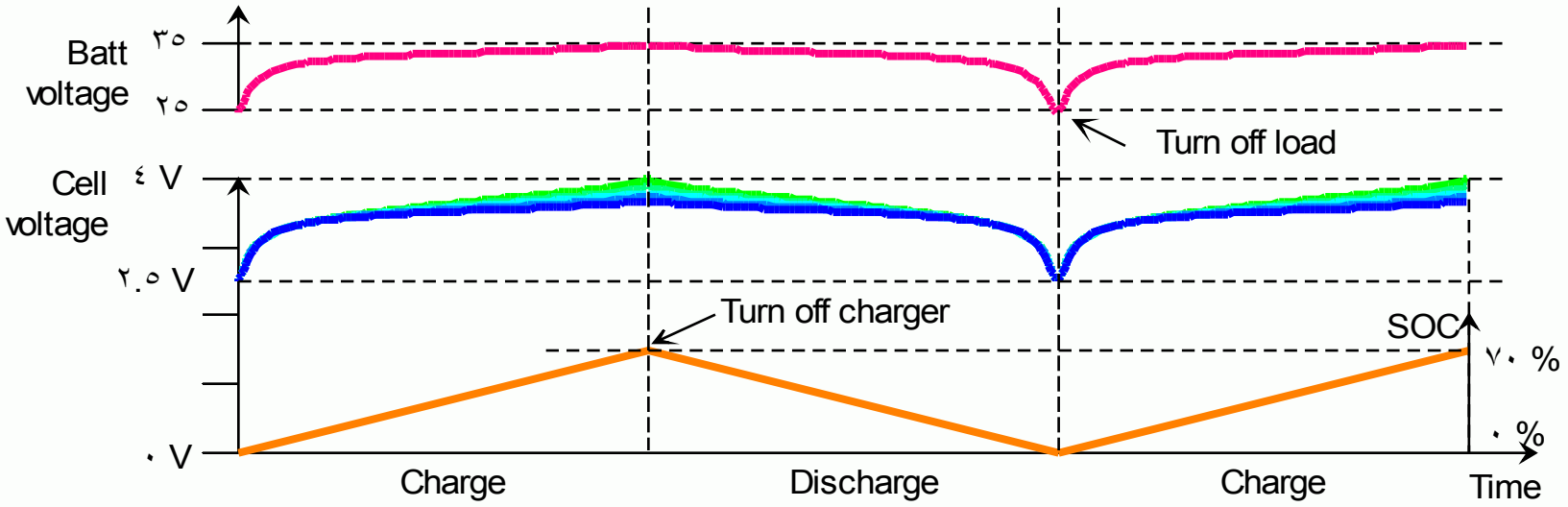
MIX

Bottom balancing

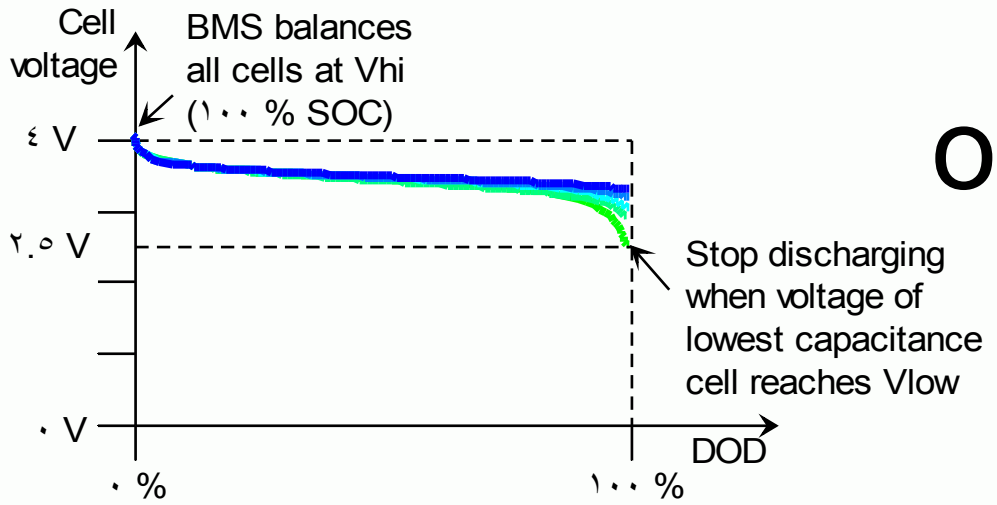


No BMS & limited charge:

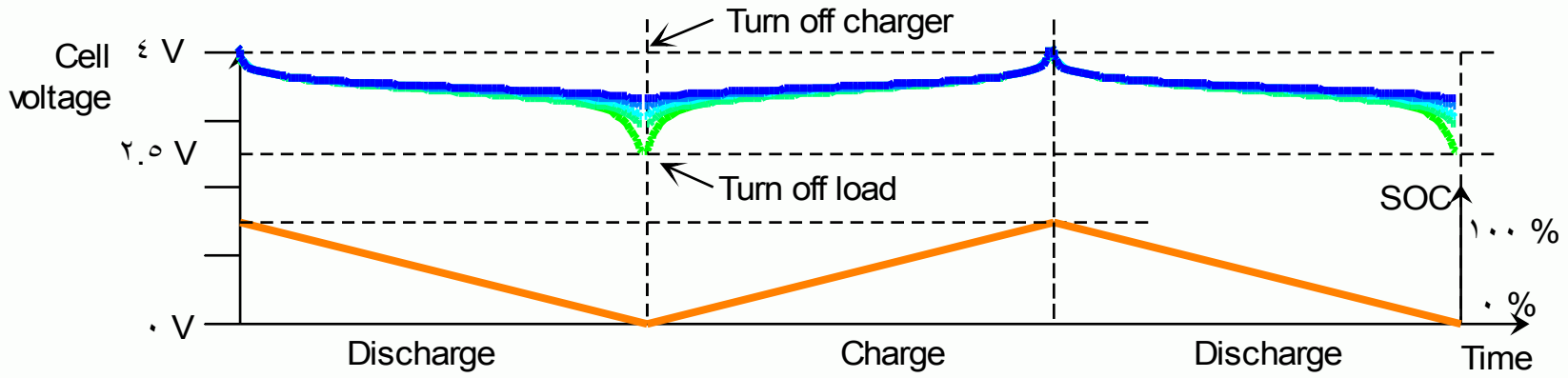
bottom balance may work



Bottom balancing



Otherwise, only top balance makes sense



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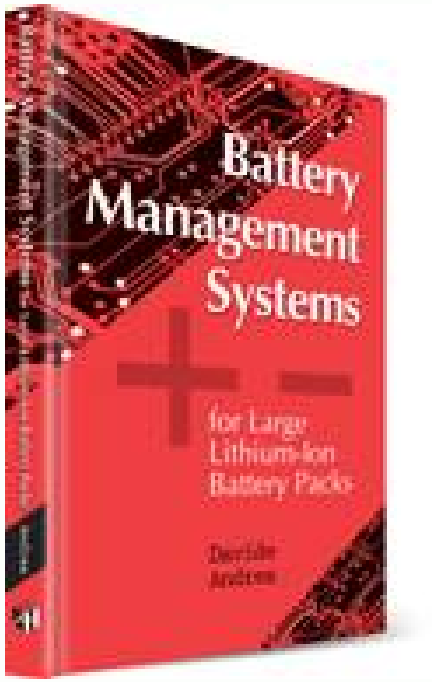
Thank you



"Battery Management Systems for Large Lithium Ion Battery Packs"
Davide Andrea

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