Failure mode and effects analysis of LFP battery module
(磷酸鋰鐵電池模組失效模式分析)

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台灣電池協會
TAIWAN BATTERY ASSOCIATION
Taiwan Battery Association(TBA)

Taiwan 台灣 日本 Japan

2018 台日先端電池材料
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電池製造技術交流會

菲凡能源科技股份有限公司
Masterhold Int'l Co., Ltd

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  - 2011, Ph. D. degree in physics, National Cheng Kung University (NCKU), Taiwan
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- **Recent publications**
  - Electronic and optical properties of graphene nanoribbons in external fields, Phys. Chem. Chem. Phys. **18**, 7573 (2016).
  - Magnetoelectronic and optical properties of nonuniform graphene nanoribbons, Carbon **109**, 883 (2016).

台灣電池協會
Taiwan Battery Association(TBA)

Introduction

To raise the standard of Taiwan batteries industry and enhance the international competitiveness of the market, the Industrial Technology Research Institute (ITRI) established "Taiwan Battery Industry and Technology Development Union" in 1996, with more than 40 domestic battery industries which contain the up, middle and down-stream manufacturers. With the economy changes and the development of electronics industry, the multi-boom growth of the battery industry, The Taiwan Battery Association was formally founded in April 2006 . The Taiwan Battery Association (TBA) was established as a non-profit organization. It was devoted to meet the cooperation and development of Taiwan's battery industry, to enhance the international competitiveness of the battery industry, to assist in establishing the development strategy and direction of Taiwan's battery industry and to establish the battery industry's strategy and R&D alliances.

Mission

1. To promote cooperation and development of Taiwan's battery industry.
2. Enhance the international competitiveness of the battery industry.
3. To assist in establishing the development strategy and direction of Taiwan's battery industry.
4. Establishing the battery industry's strategy and R&D alliances among the up, middle and down-stream manufacturers.
5. To establish the exchange of communication among information、technology and business model.

Website: http://www.taiwanbattery.org.tw/

菲凡能源科技股份有限公司
Masterhold Int'l Co., Ltd

- **Established:** 2005
- **Address:** 8F., No.45, Fusing Rd., Sindian Dist., New Taipei City 231, Taiwan
- **Website:** http://www.masterhold.com.tw/
- **Main business:** $LiFePO_4$ battery design and production.
- **Current product:** Golf car battery, garbage truck batter, and electric energy storage system with/without solar power
- **Number of patents:** 30 in various countries
- **Award:** 2016 National sustainable development award (from National Development committee)

Outline

- Basic charge/discharge method of Li-ion battery
- Simple equivalent circuit model of battery
- General charge/discharge curve of LFP battery
- Failure mode and effects analysis: A case-by-case study
- Brief summary

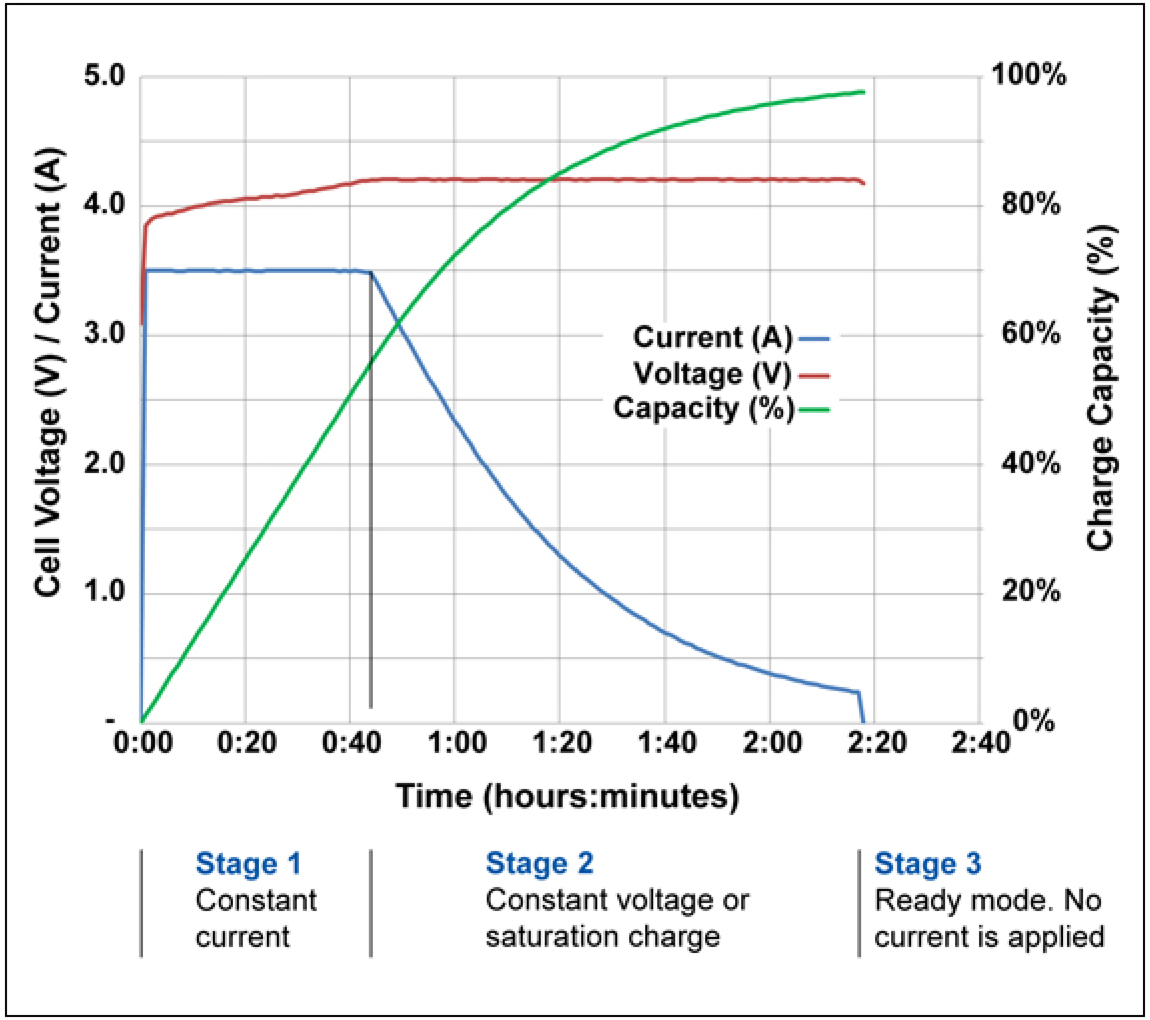
Basic charge/discharge method

CC-CV mode charge method

The battery is charged at a constant current until the voltage reaches a setting value, and then the voltage is held constant as the current decays to a cutoff current.

CC mode discharge method

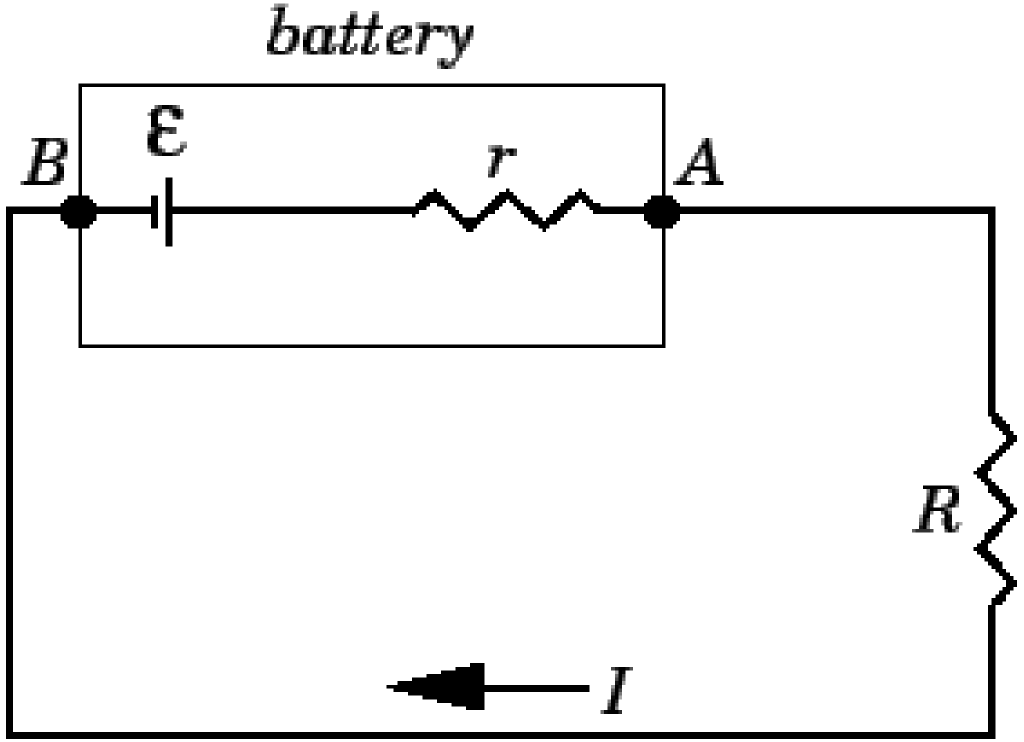
The battery is discharged at a constant current until the voltage reaches a setting value.



Equivalent circuit model of battery

- Open circuit voltage ε
- Internal resistance r
- Load resistance R
- Current I

- This model is suitable for explaining the static charge/discharge behavior of a real battery.



General charge/discharge curve of LFP battery

For example, a Charge-Discharge-Charge process.

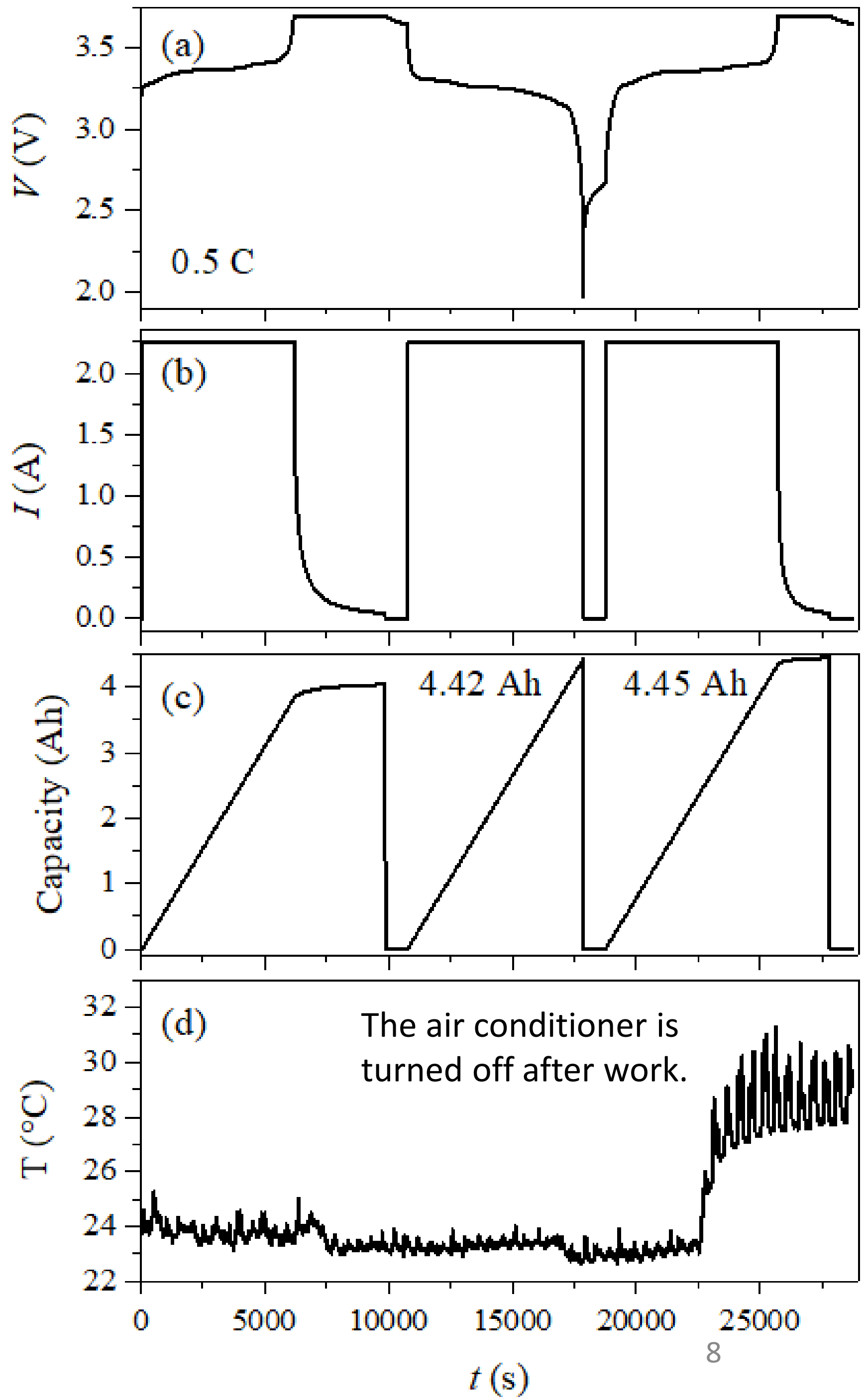
Rest:

After discharge (charge) process, the voltage will gradually increase (decrease).

DCIR:

A voltage drop at the beginning of discharge.

A voltage raise at the beginning of charge.



Failure mode and effects analysis: A case-by-case study

1. Cell
2. Pack/Module

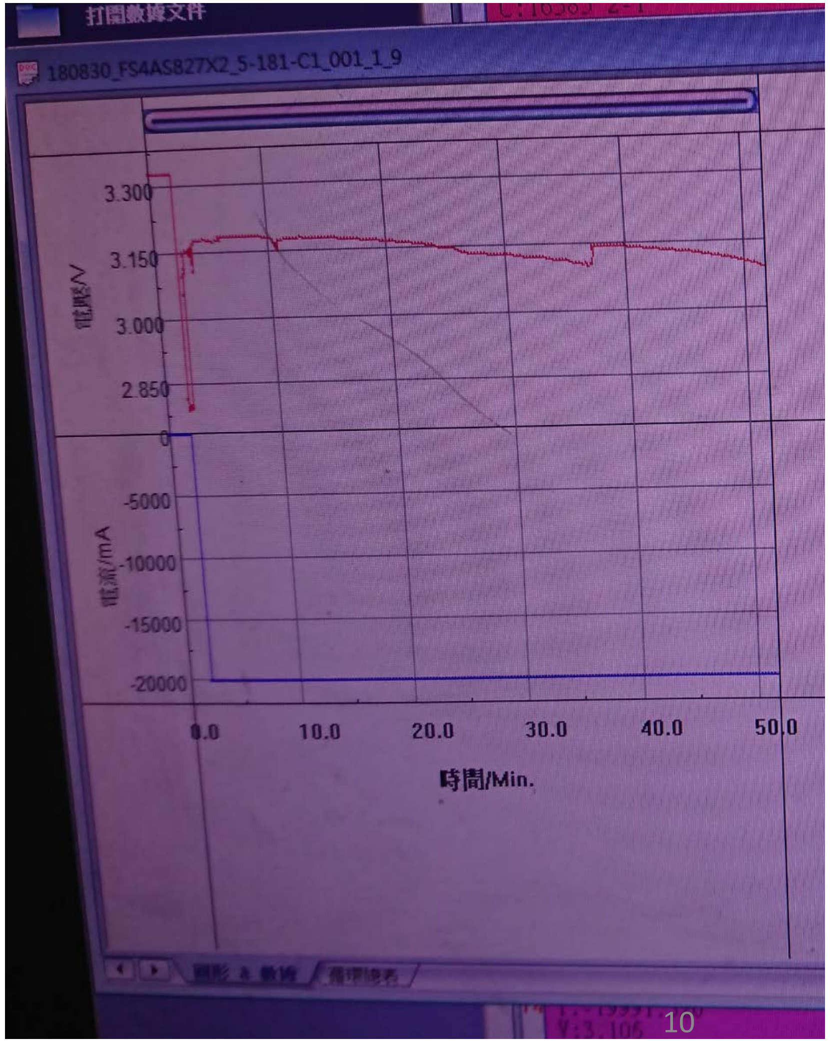
The following cases are picked from RD database.

Case 1: Bad cell (abnormal Charge/discharge curve)

The discharge curve isn’t smooth.

The cell won’t pass the quality test. (Fail)

During factory visit.



Case 2: Extremely abnormal Charge/discharge curve of a used LFP battery

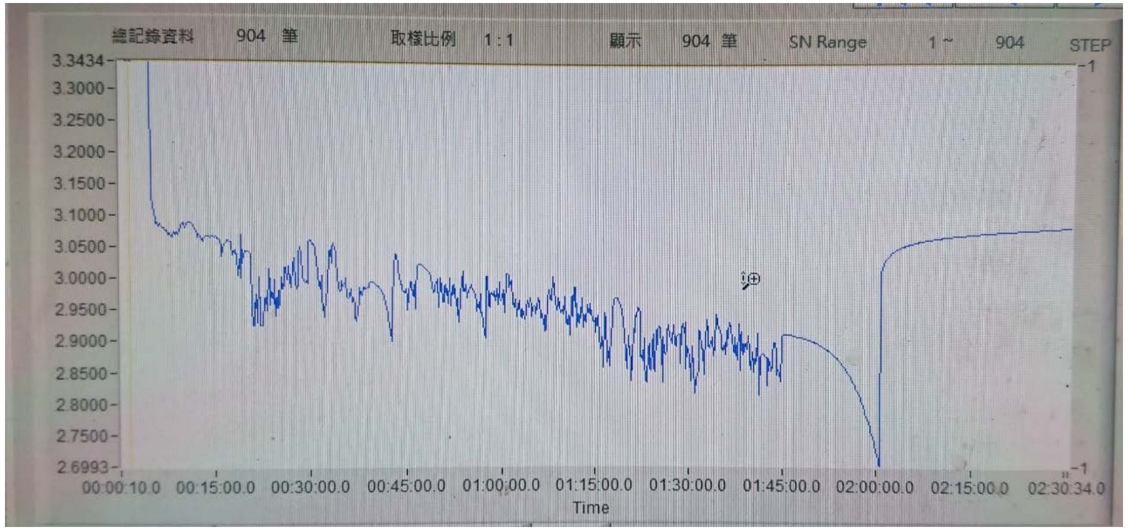
Up: discharge

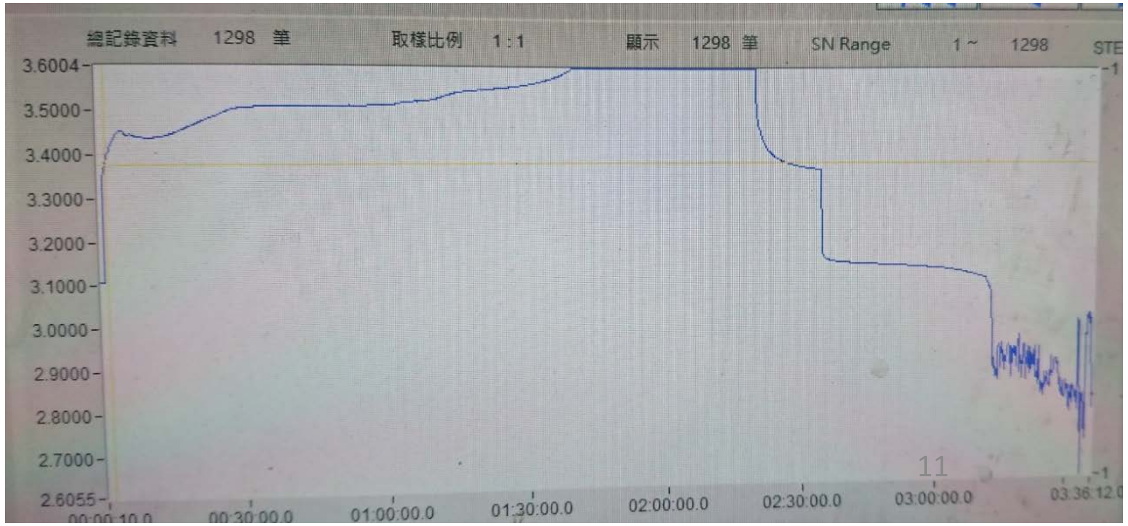
Down: charge to discharge

Severe oscillation is exhibited.

Cell

inflation + electrolyte leakage





Case 3: Judge cell quality

The salesman told me that some **very good** reused cells are worthy for purchasing.

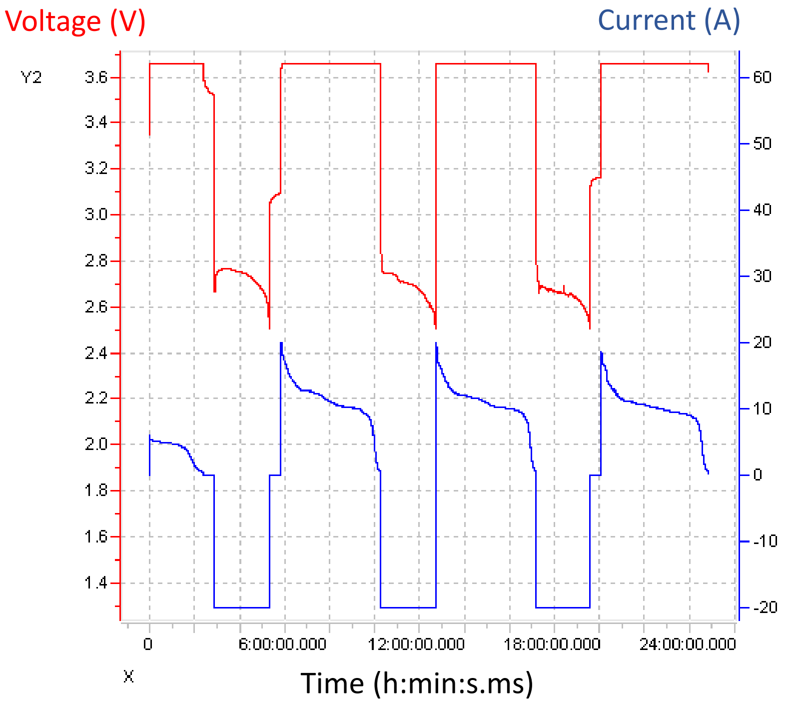
ΔV = 0.1 V after 3 cycles

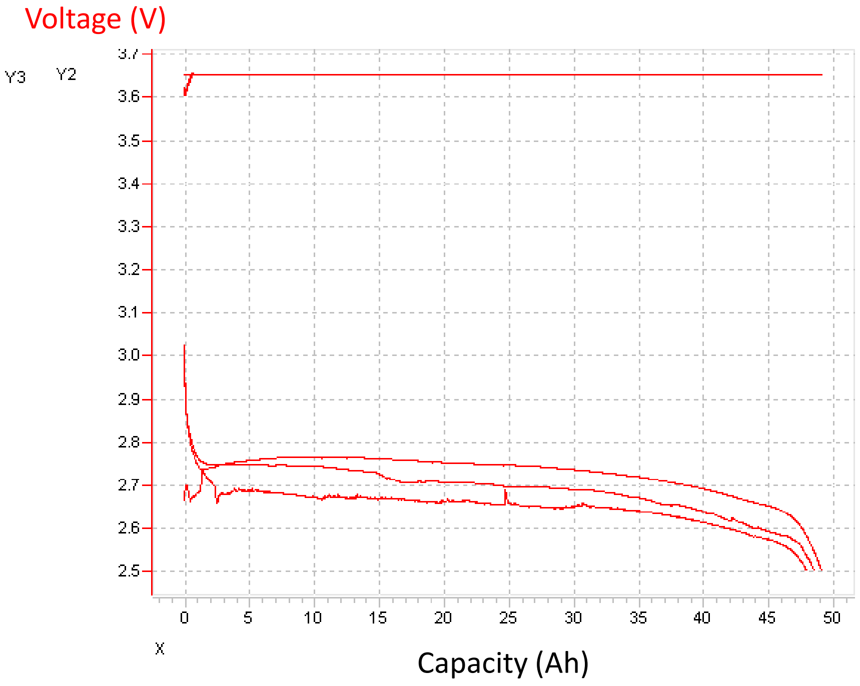
Non-smooth curves

Conclusion: Reject.

Save money.

(about 1 million USD)

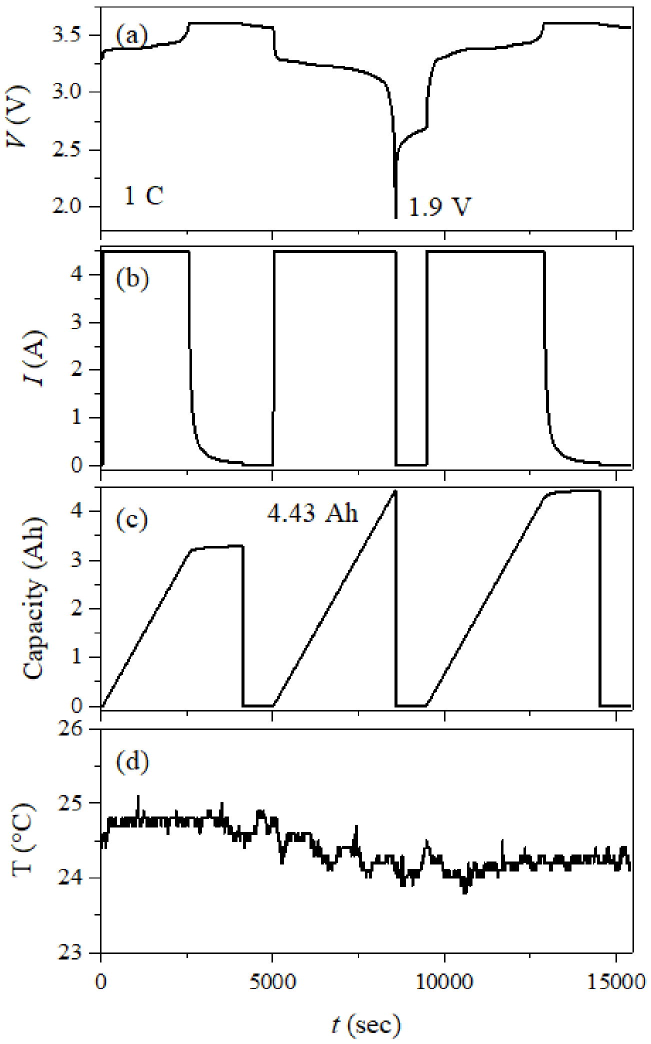


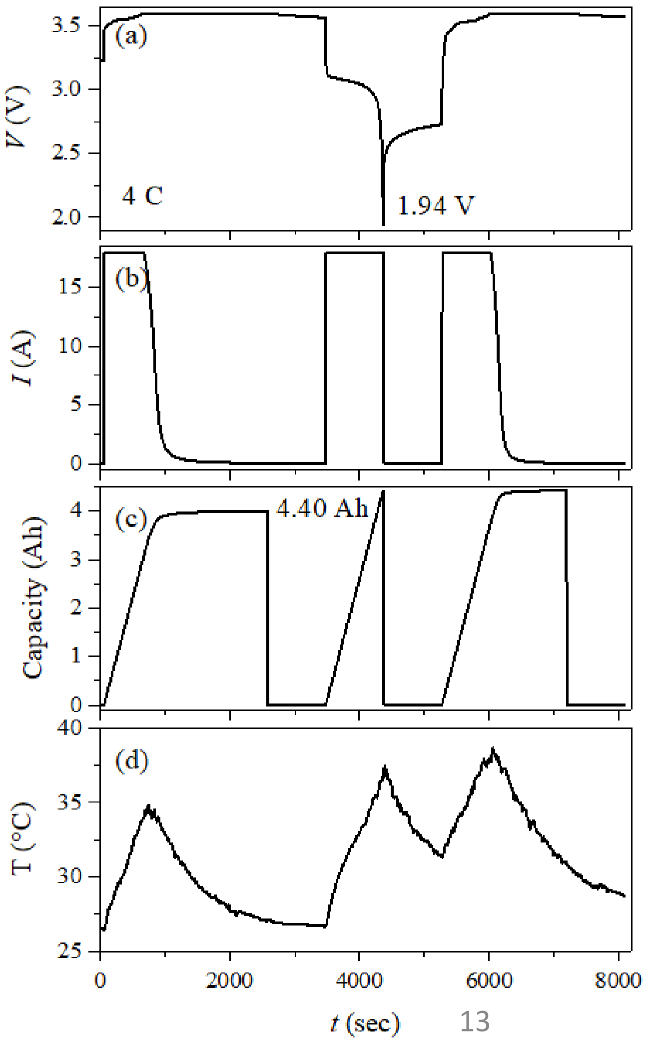


Case 4: A reasonable behavior of a cell charging/discharging at various C-rate.

Left: 1 C

Right: 4 C



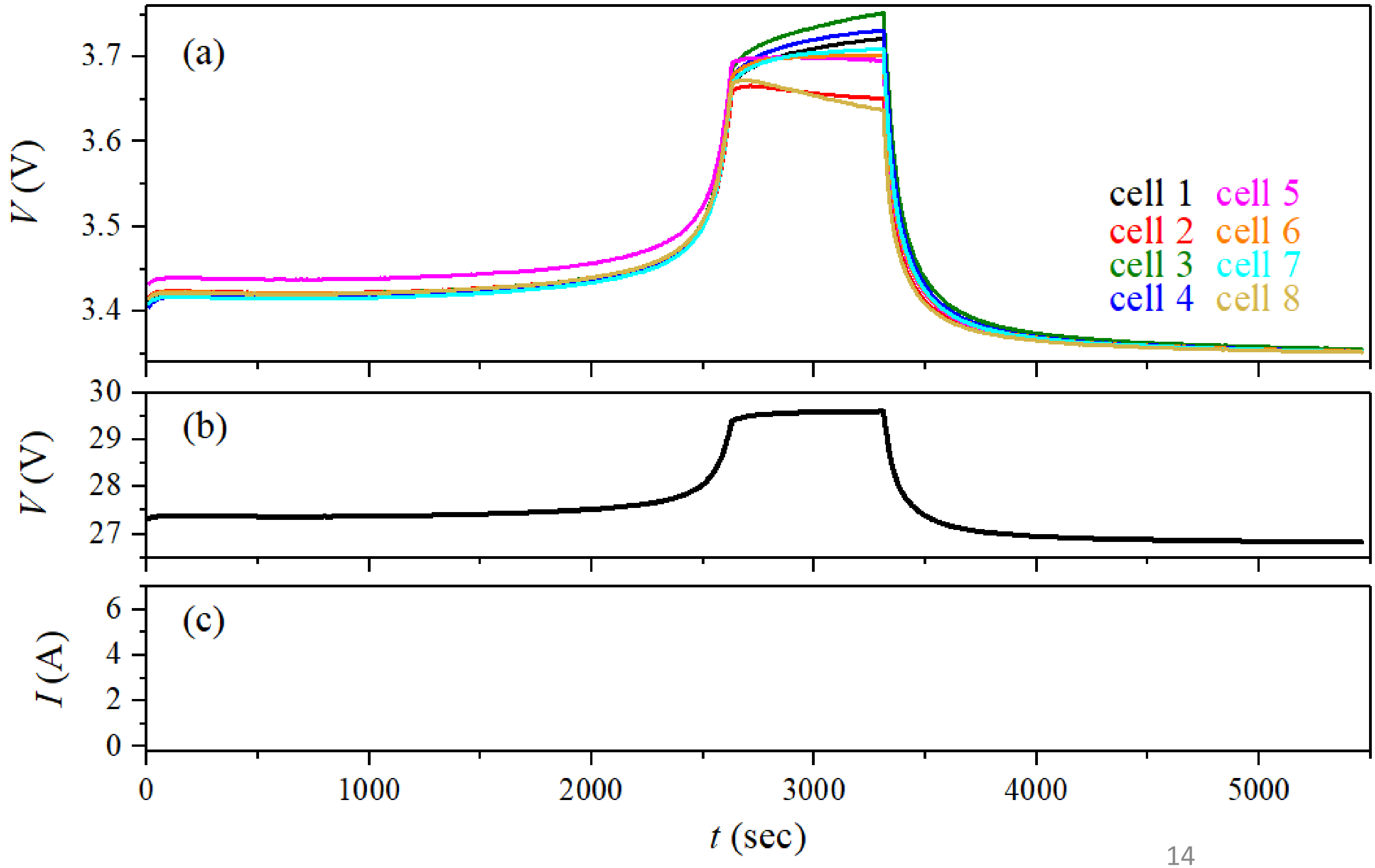


Cell: A123 AHR32113 Ultra-B 4.5 Ah

Case 5: Why the battery become unbalance at CV mode?

The 8s battery is made by new cells with high consistency.

When the battery is charged at CV mode with a high voltage near the battery limitation, the voltage unbalance appear, although the unbalance cannot be observed from the total voltage.

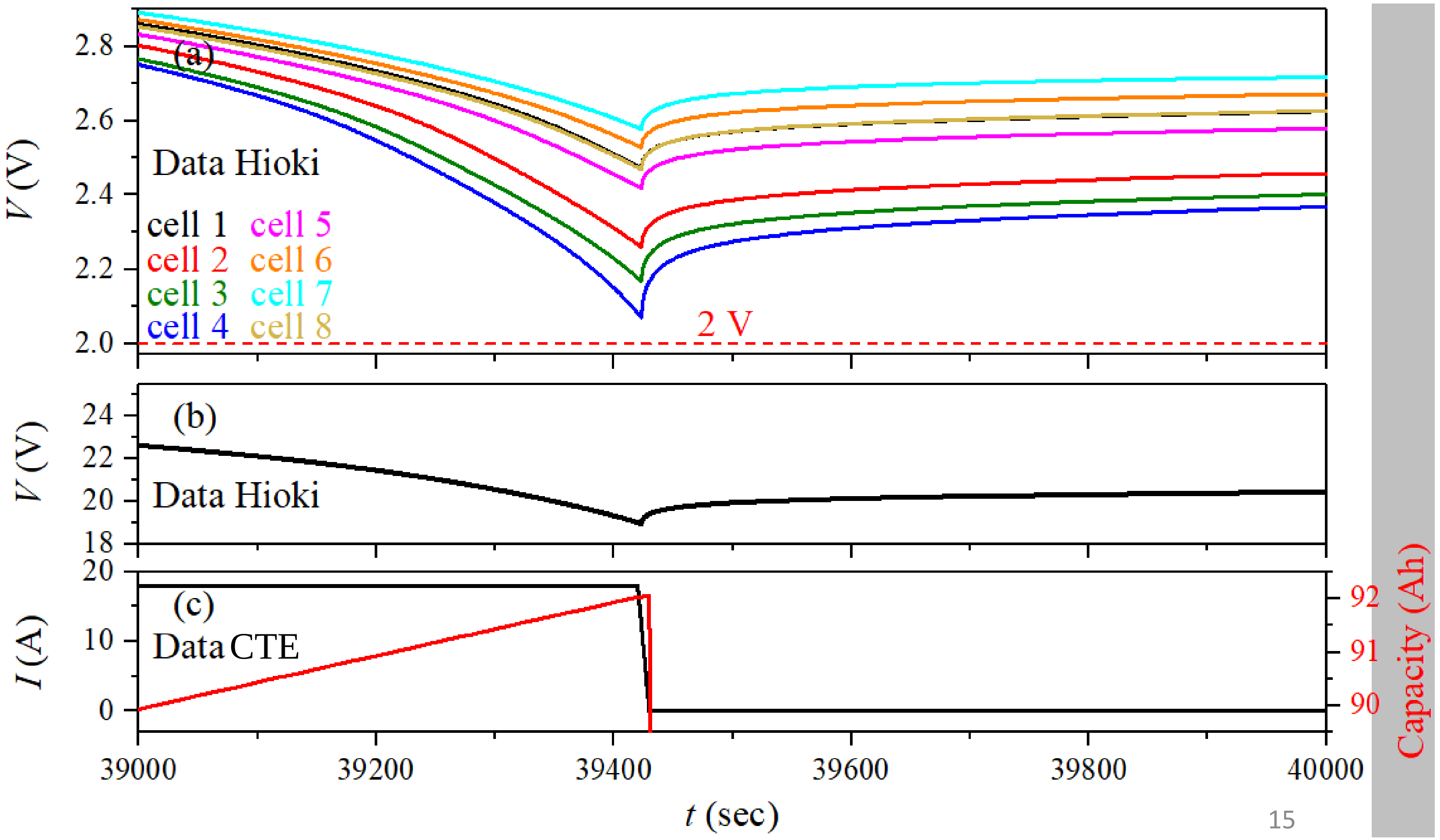


Case 6: Why the cutoff voltage isn't at 2 V per cell?

BMS setting: the relay will be turned off once one of the cells is under 2 V.

Some people have a question. Why the power is cut before the voltage reaches 16 V?

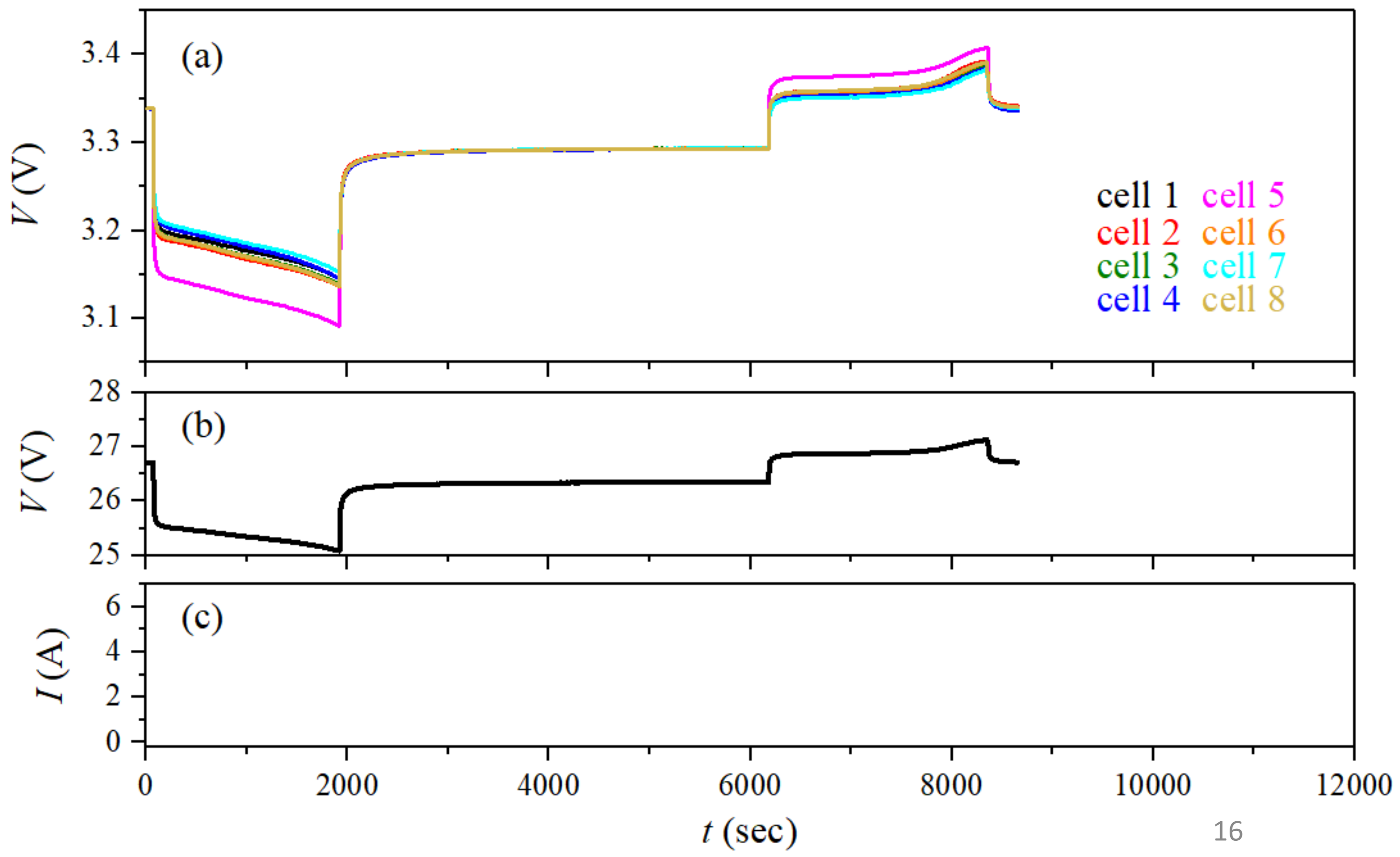
(This is an 8s system.)



Case 7: Something wrong in manufacturing process will be figured out.

The 8s battery is made by new cells with high consistency.

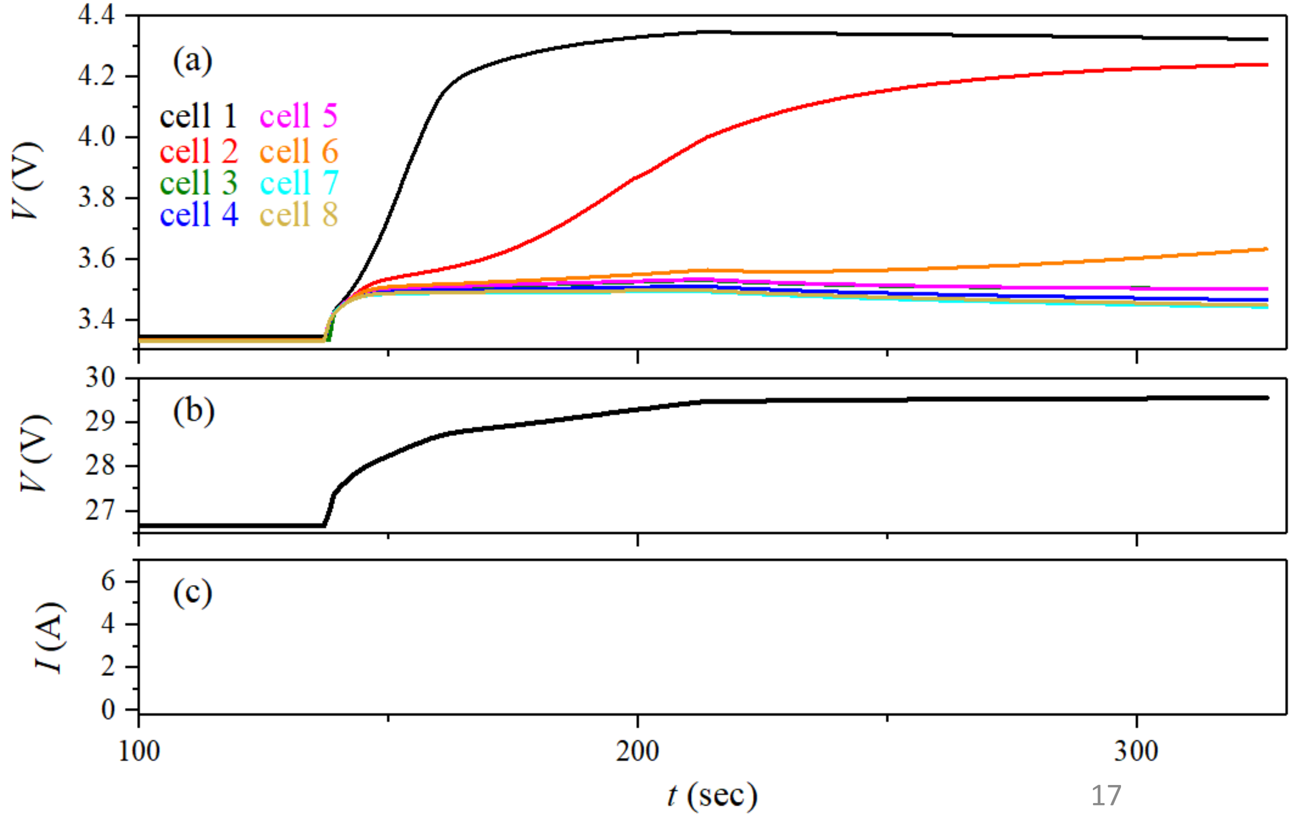
Why the 5th cell exhibit a larger DCIR than others?



Case 8: A poor battery charging without BMS.

The voltages of bad cells rise too fast.

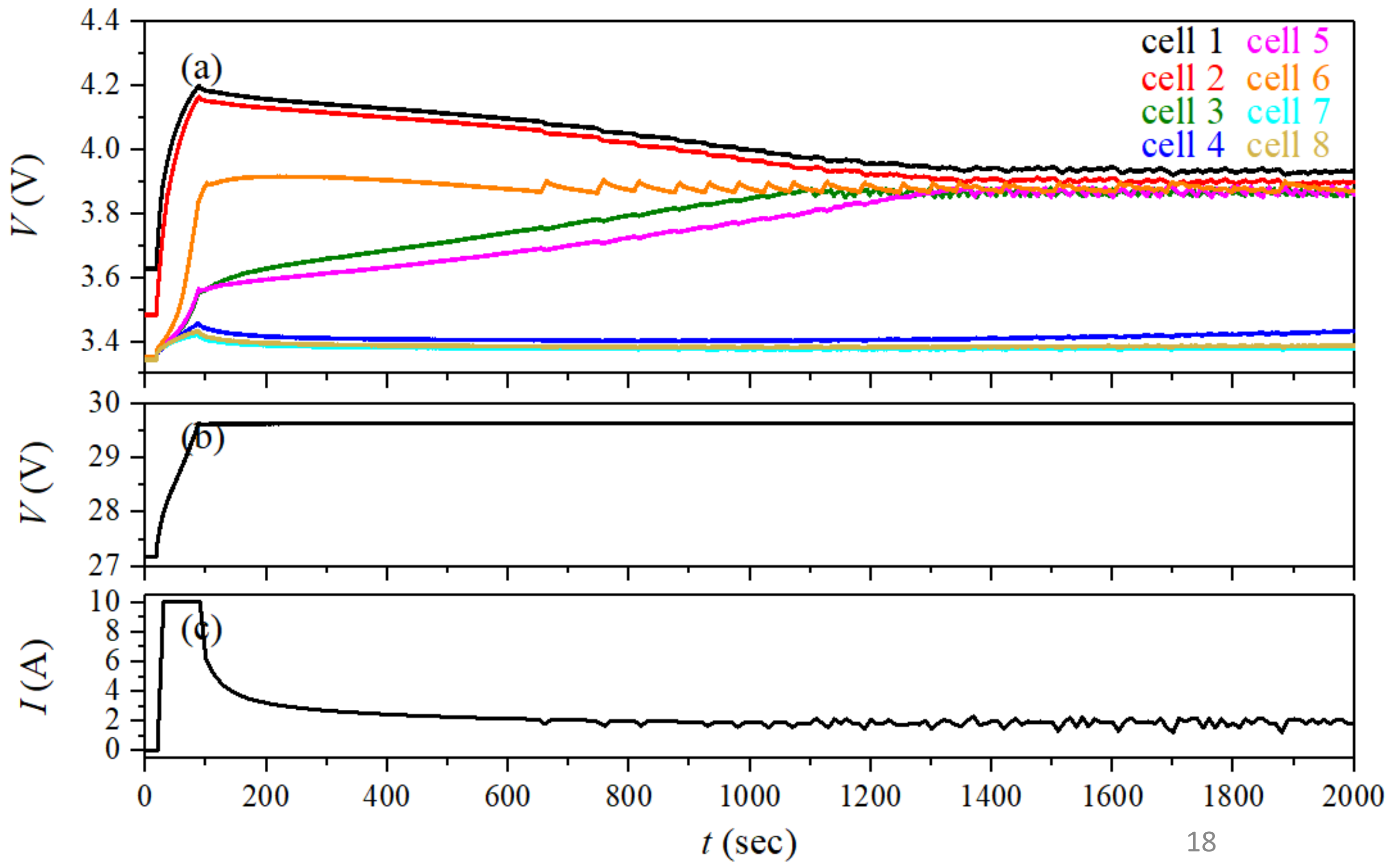
The total voltage won't tell you the overcharging.



Case 9: A poor battery charging with BMS of passive balance.

The overcharging is under controlled.

3 types of cell behaviors.



Case 10: Someone has adjusted the instrument.

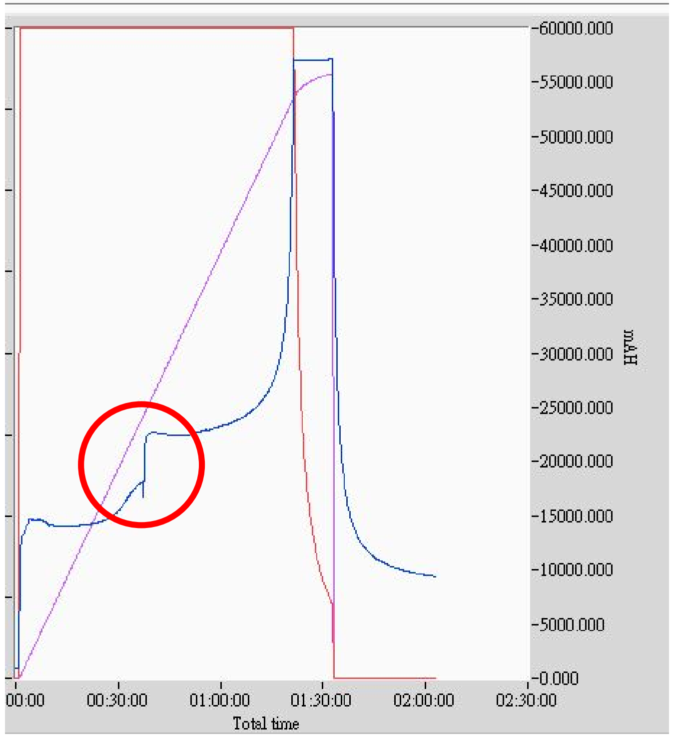
The curve should exhibit a smooth variation.

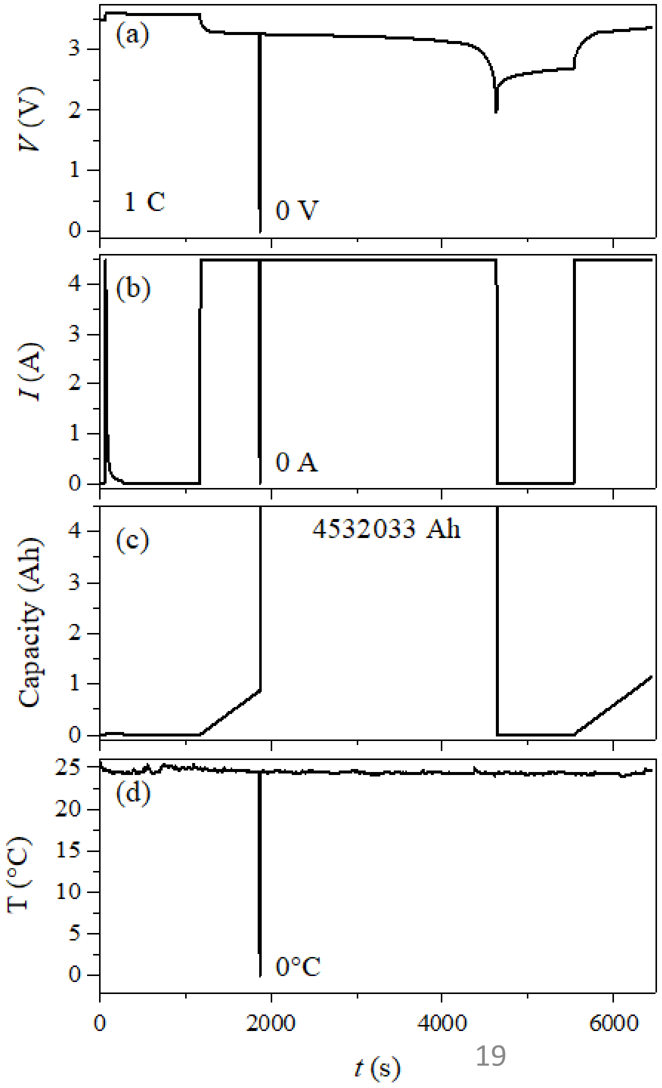
Some discontinuous behavior comes.

After inquiry, the instrument has been turned off.

Left: turn on after a period of time

Right: turn immediately





Brief summary

The analysis of the charge/discharge curve is helpful for judging the quality of cells and figuring out some strange behaviors of the battery module.

Especially, many unusual behaviors won’t exhibit on the appearance.

It’s important to establish the charge/discharge profile database for effective manufacturing and troubleshooting.

ご清聴いただき ありがとうございました

Thank you for your attention!

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