EVB Operating Temperature simulation

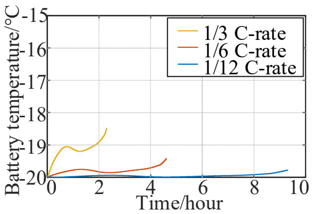
According to the ETC model in [1], specifically developed for low-temperature conditions, we simulate the variation of C_t when discharging at three different C-rates under −20°C based on the A123 26650 LiFePO4 (LFP) battery [2], which parameter listed in Table VI.

When the surface area of the battery is determined, its temperature variation is primarily influenced by the charging/discharging current or power, typically measured by the C-rate. The C-rate measures the discharging current or power relative to the battery's maximum capacity or energy.

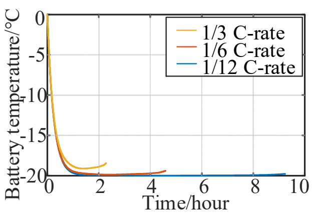
Here, three specific C-rates, 1/3, 1/6, and 1/12, are selected to simulate the impact of C-rates on C_t under low temperature. The selection is based on the current situation of the rated power of V2R chargers and EV batteries. Chargers with V2R functionality typically have a peak charging power limited to approximately 10 kW. Current EVs, on average, possess a rated energy of 71.8 kWh, as reported in [3], with most of the rated energy ranging between 30 kW and 120 kW. Thus, the C-rate in charging/ discharging is between 1/12 C-rate to 1/3 C-rate.

Fig. 1(a) shows that when the initial C_t matches the ambient temperature of −20 °C, the maximum temperature increase is less than 1.5°C across all C-rates before full discharge. This indicates low C-rate discharging does not significantly raise battery temperature in cold conditions. Fig. 1(b) depicts a scenario where the initial C_t is higher than the ambient temperature due to prior operation, gradually dropping from 0°C to −20°C within an hour.

Thus, when the EVB operates for over an hour, C_t can be approximated as the ambient temperature.



(a)



(b)

Fig. 1. Temperature variation of the battery during discharge at different C-rates: (a) Initial battery temperature equals the ambient temperature; (b) Initial temperature is higher than the ambient temperature.

Table I. Parameters of the A26650 LiFePO4 Cell.

Specifications	Value
Mass m_{cell}/g	76
Surface area A/mm^2	26×55
Heat transfer coefficient h/W/(m$^2\cdot$ K)	16.43
Heat capacity c_p/J/(kg $\cdot$ K)	1067.63
Nominal capacity/Ah	2.5
Nominal voltage/V	3.3
Internal impedance (1 kHz)/mΩ	6
Storage temperature/°C	−40°C~60°C
Operating temperature/°C	−30°C~55°C

References

[1] Y. Zheng, "Study on electro-thermal models and warm-up control of lithium-ion batteries at low temperatures," M.S. thesis, College Mech. Vehicle Eng., Chongqing Univ., Chongqing, China, 2021.

[2] A123Systems. *High Power Lithium Ion ANR26650m1*. Accessed: Sep. 6, 2023. [Online]. Available: https://www.buya123products.com/uploads/vipcase/844c1bd8bdd1190ebb364d572bc1e6e7.pdf

[3] EV Database, Useable battery capacity of full electric vehicles. Accessed: Jul. 05, 2024. [Online]. Available: https://ev-database.org/cheatsheet/useable-battery-capacity-electric-car