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Power control strategies Based on Peak and Frequency for Hybrid Type Batteries

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ABSTRACT: Two different power control strategy are examined for the hybrid battery system with the high power density type battery pack and the high energy density type battery pack for electric vehicle. The frequency basis control strategy method 1 is more implicit to design the power controller based on the frequency component of the load power and appropriate to the longer life long of the battery. However, the relation between the design parameters in both control strategies must be revealed in the future work.

KEY WORDS: Electric Vehicle, Hybrid Energy Storage System, Lithium-ion Battery, Power Flow Control, Energy Management

1. INTRODUCTION

For pure electric vehicles, high power density type battery is sometimes installed in combination with the high energy density type battery [1] to enhance the power density of the whole battery pack as shown in Fig. 1. In this case, charge and discharge power of the high energy density type battery pack is preferred to be lower to prolong its life long. The variation range of the energy for the high power density type battery is preferred to be narrow to reduce the amount the volume of the additional battery. For these sakes, two types of power control strategies are studied in this paper, one is based on the frequency range of load power, and another one is based on the peak of the load power, as shown in Fig. 2 and Fig. 3. These strategies are examined by a 1kW class scaled down inverter and permanent magnet synchronous motor drive system with an inertial load.

2. POWER CONTROL STRATEGIES

In Fig. 2 [2], higher power component of the load power (motor power P_{mot}) fed by high power density type battery pack and its power stands for P_{HP} . The energy of the high power density type battery pack E_{HP} is managed by the proportional controller (the gain $1/T_F$) to keep the difference of E_{ref} and E_{HP} within an available range of SOC. Where $1/T_F$ is a cut off frequency of the high pass filter and it determines the frequency range of the load power, which is fed by the higher power density battery pack.

Fig. 3 shows the flow chart of the power control strategy to limit the power to be fed by the high energy density type battery pack. In this control method, the load power under the limit power P_{batref} is only fed by the high energy density type battery pack, and the peak load power more than the limit power is designed to be fed by the high power density type battery pack. In addition, the high power density type battery pack is given the priority to be

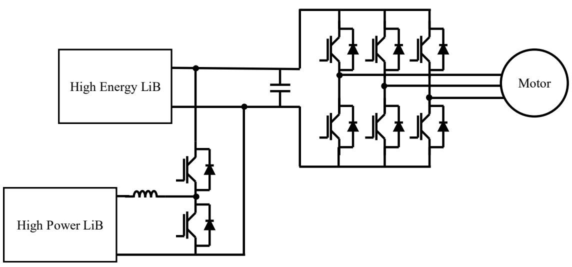

Fig. 1. Hybrid battery pack system for EV traction system.

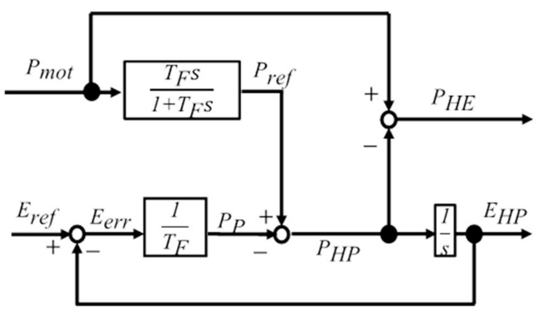

Fig.2 method1: frequency domain basis power control system

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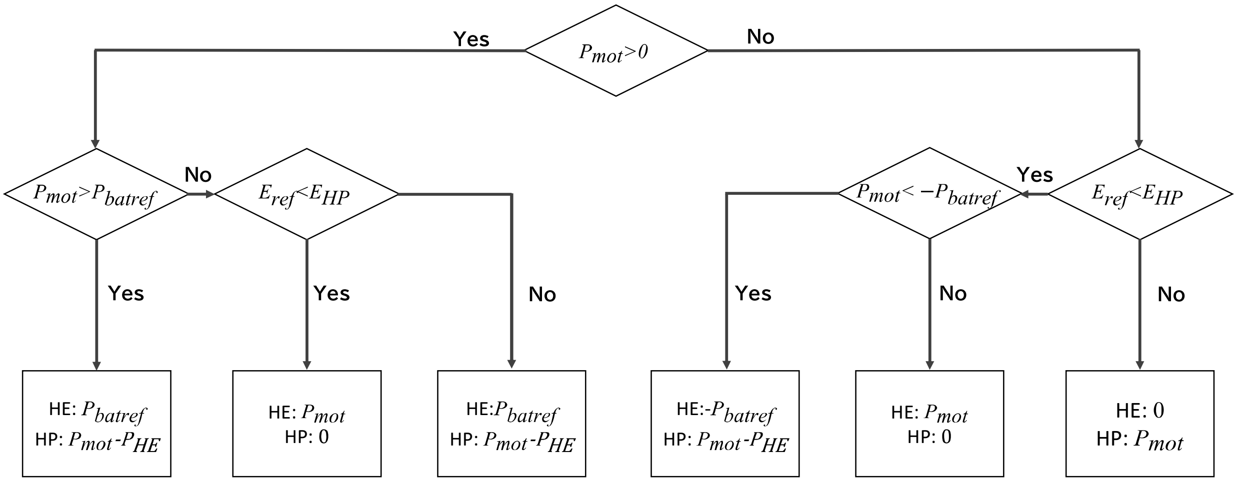


Fig.3. method 2: power control strategies based on peak load power

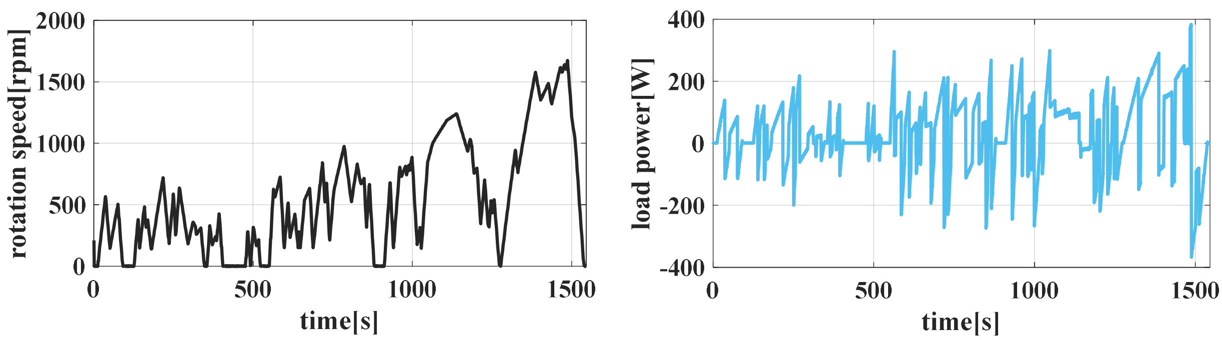
charged by the regenerative power over the high energy type battery pack according to its energy.

3. PEAK POWER CUT AND ENERGY MANAGEMENT PERFORMANCE

Generally speaking, the lower frequency component of load power has more impact to the feeding energy by the battery, and the higher frequency component have more impact to the power capability of the battery. Therefore, the explicit design of the power and energy characteristics of the battery is enabled by the cut off frequency of the filter $1/T_F$ in the frequency basis control strategy in Fig. 2. On the other hand, only the peak power limit P_{batref} is the design parameter and determines the dealing energy of the high energy density type battery pack by avoiding charging and discharging the higher load power. The design philosophy of both control strategy is different, but they aim at the same control object, such as prolonging the life long and reducing the amount of the battery pack.

Both control strategies are examined and evaluated by a 1 kW class inverter and PMSM scale down EV traction model with an inertial load. The load pattern of the motor is assumed as shown in Fig. 4, which is based on WLTC mode.

Fig. 5 shows the experimental results of both control methods. Fig. 5 (a) and (b) shows the results with the time constants of T_F=60s and T_F=120s, which are the frequency components of the load power lower than around 0.167Hz and 0.084Hz are fed by the high energy density battery pack. Where P_{HP} and P_{HE} stand for the power fed by the high power density battery pack and by the high energy density battery pack. P_{HE} in the case of the T_F=120s is smoother than the case of T_F=60s. The energy of the high energy density battery pack, HE energy is almost common in the both cases of T_F=60s and T_F=120s. But the energy of the high power density battery pack HP energy fluctuate more in the case of T_F=120s than in the case of T_F=60s. Thus, the case of T_F=60s is better from the view point of downsizing the high power density type battery pack.



(a) Rotational speed (b) Load power

Fig. 4. Load profiles of the 1 kW class scale downed experimental system.

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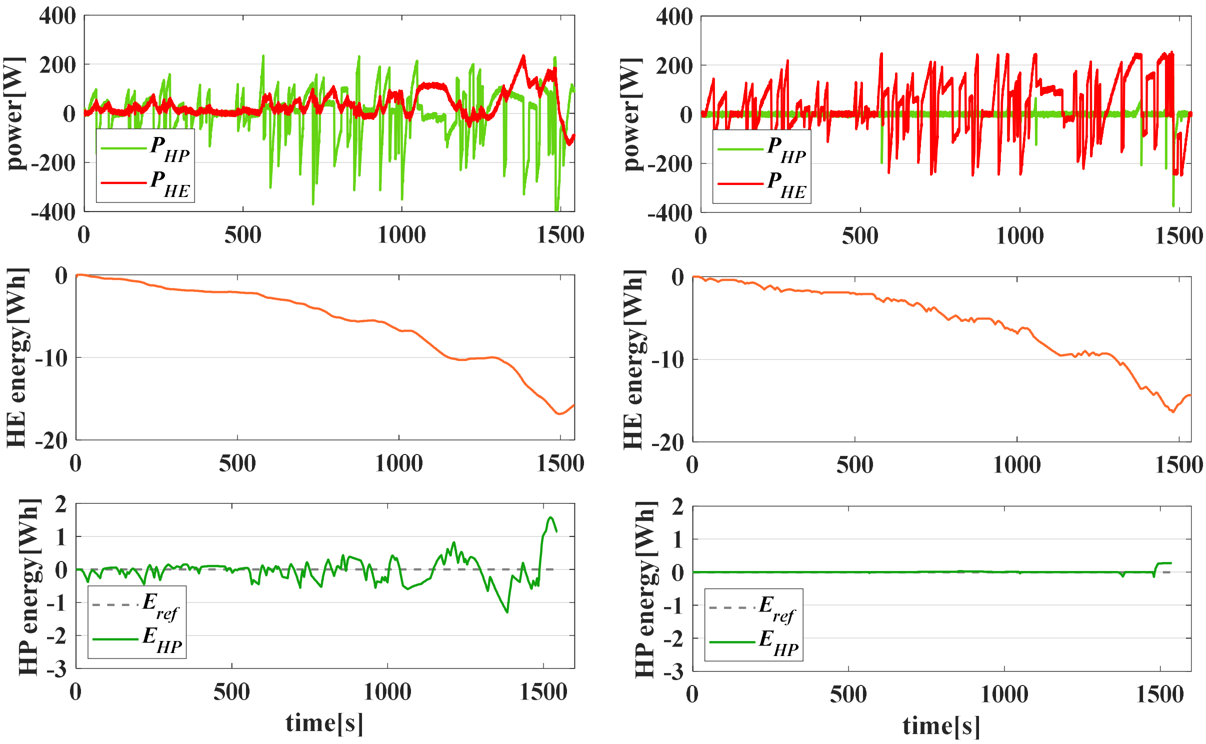
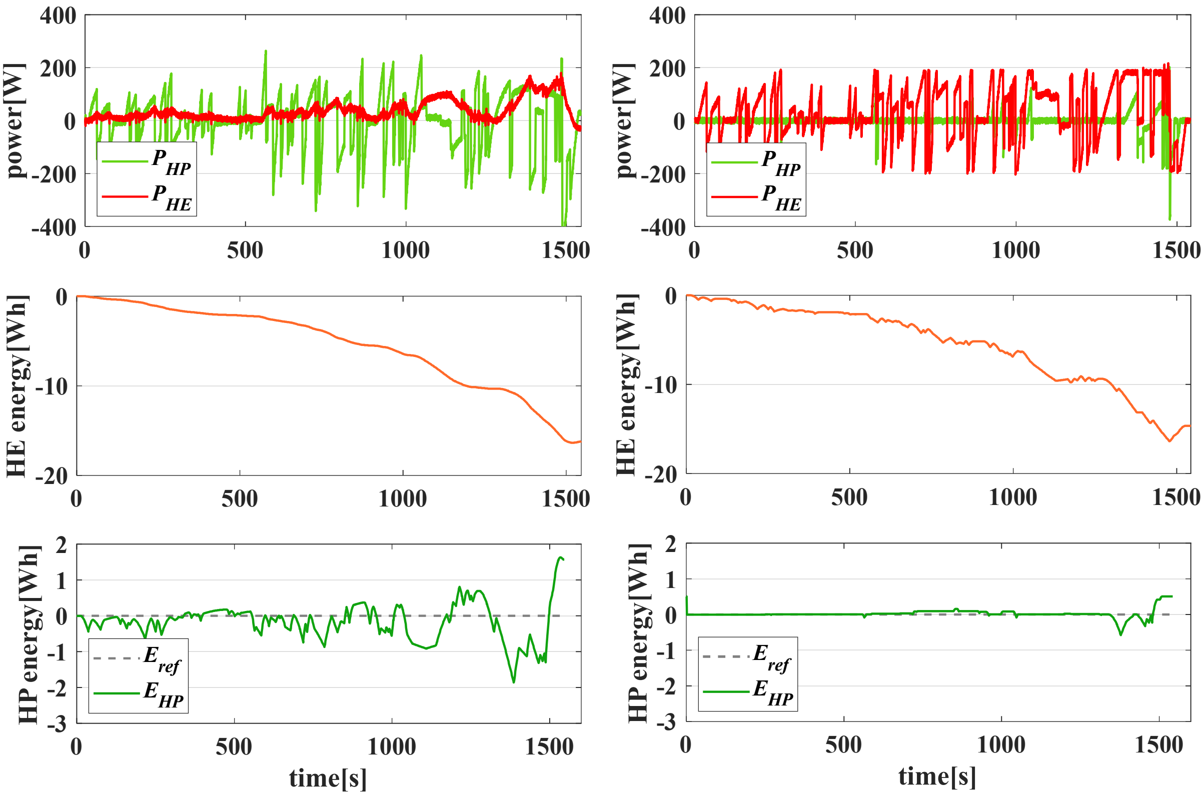


(a) method1 T_F=60[s]

(c) method2 P_{batref}=236[W]



(b)method1 T_F=120[s]

(d) method2 P_{batref}=181[W]

Fig. 5. Experimental results with both control methods

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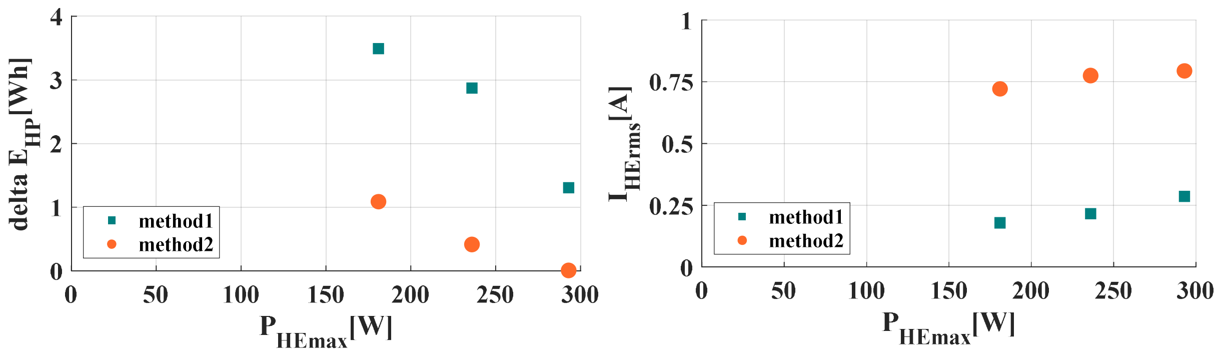

(a)Energy fluctuation of the high energy density battery (b) RMS current of high energy density battery

Fig. 6. Operation characteristics of both methods

Comparing the cases of (a) and (b) for mode 1 with the cases of (c) and (d) for mode 2, P_{HE} fluctuate obviously more, and it may cause to reduce the lifespan of the high energy density battery pack. The operation characteristics in Fig. 6 shows that more energy in high energy density battery pack leads to the less power fluctuation. The RMS current does not change widely. Thus, the impact of the control strategy is not major in different control method in these cases.

6. Conclusion

Two different power control strategy are examined for the hybrid battery system with the high power density type battery pack and the high energy density type battery pack for electric vehicle. The frequency basis control strategy method 1 is more implicit to design the power controller based on the frequency component of the load power and appropriate to the longer life long of the battery. However, the relation between the design parameters in both control strategies must be revealed in the future work.

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