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A Study of Inductance Estimation Method of Battery Pack for LC Resonance Prediction of Electric Vehicle Powertrain

Toshitaka Iwase[1)] Yasuyuki Moriyama[1)] Tohru Shibata[1)] Yihuang Wang[1)]

Yuichiro Nakashima[1)]

1) Toyota Technical Development Corporation,
1-9 Imae, Hanamoto-cho, Toyota, Aichi, 470-0334, Japan

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In recent years, there has been a growing movement toward the realization of a decarbonized society. The transition to electrification in the automotive industry is occurring in many countries, and it is expected that there will be a rapid transition from conventional gasoline-powered vehicles and HEVs(Hybrid Electric Vehicles) to BEVs(Battery Electric Vehicles).

In some BEV systems, a battery pack, an inverter, and a motor are directly connected. The smoothing capacitor in the inverter, the inductance components of the battery pack and wiring harnesses(W/H) are connected in series, forming an LC resonance circuit. Therefore, electrical harmonic resonance may occur, causing motor torque oscillation and noise generation due to excessive current/voltage fluctuations. Thus, resonance countermeasures are issues for the powertrain of BEVs.

To predict resonance, it is necessary to know the components such as capacitance and inductance, but there is no way to know the inductance component of a battery pack except by measuring it. Establishing an estimation technique for inductance components will be an effective countermeasure, since a large rework in development may occur after the actual battery packs are produced due to the resonance of the powertrain in BEVs including battery packs.

In general, the inductance of a closed circuit can be expressed theoretically as the sum of the internal inductance generated inside the current path, and the external inductance generated by the magnetic flux interlinked to the closed circuit. In the case of a battery, however, it is difficult to know the current paths inside the battery and the boundaries to calculate the external inductance, so the theoretical equation cannot be used without identifying those parameters. To solve this problem, we devised a method to create a virtual battery closed circuit by replacing the actual battery current path with a cylindrical virtual one. Then, we performed identification of those parameters based on the measured values of the battery cells. The identification was performed with 2 series cells, which is the minimum configuration of a battery pack, and the results were extended to estimate the inductance of battery packs with more cells as shown in Fig.1.

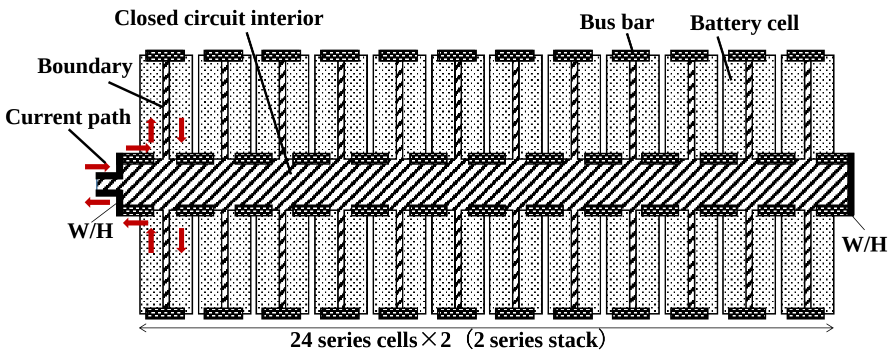

Fig.1 The battery pack to be verified

To verify the inductance estimation results, a battery pack was used as the validation target, which was of two series stacks consisting of 24 series cells each. The validity of the devised method was verified while the target estimation accuracy was set within an error rate of 10% to identify a resonance frequency.

The estimated and measured values were compared while changing distance between the 2 series stacks. As shown in Fig.2, the maximum error was 98 nH with an error rate of about 5% as shown in Fig.3, achieving the target estimation accuracy. The estimation technique described in this paper is expected to be one of the effective countermeasures against reworks caused by the resonance in the development of BEV powertrains.

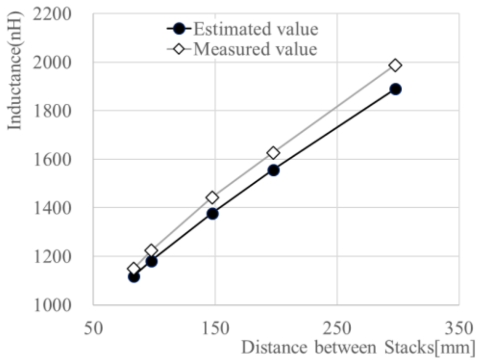

Fig. 2 Comparison of estimated and measured values

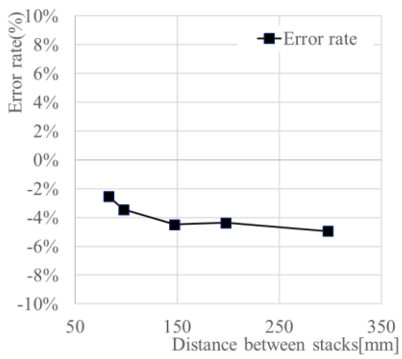

Fig. 3 Error rate of estimation

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