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Reduction of Harmonic Current Flow into DC Link Capacitors via Rectifiers in Series Hybrid Vehicles

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The electrification of automobile is advancing as part of efforts to decarbonize society. Among these trends, hybrid vehicles enable driving with reduced carbon dioxide emissions while utilizing existing fuel supply infrastructure. On the other hand, they face challenges such as higher prices compared to internal combustion engine driven vehicles due to the increased number of components, as well as the more installation space. Miniaturizing the traction equipments is an effective solution to these issues. For instance, in a series hybrid system as shown in Fig.1, DC-link capacitors are installed in the DC-link of the power conversion system with the PWM converter(rectifier) and traction inverter. The DC link capacitor is installed originally to maintain the constant DC voltage for the voltage source type power converter system, in addition, also to suppress adverse effects on the battery by absorbing harmonic currents. For this sake, they occupy a relatively large volume in the power conversion system.

In this paper, we aim at the downsizing the capacitance of the DC-link capacitor by reducing the harmonics current. Especially we focus on the 6th order harmonics current of the inverter, which is due to the switching operation of the inverter in single-pulse mode. Specifically, we propose a method to absorb the inverter generating harmonics currents because this harmonics component is relatively high among the capacitor harmonics current. To absorb the harmonics current, all of the lower-arm switch of the generator side converter turns ON in synchronization with the single-pulse mode voltage of the drive-side inverte.

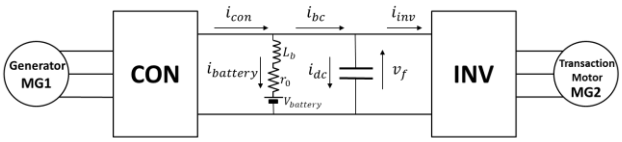

Fig. 1 Drive Circuit for the Series Hybrid System as Modeled in the Simulation

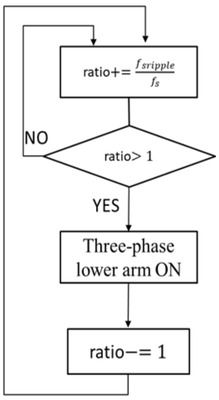

Fig. 2 Flowchart for Determining the Carrier

Figure 2 shows a flowchart for the three-phase lower arm ON control of the generator-side converter. The phase advance ratio of the triangular carrier is accumulated. When this accumulated value exceeds 1, the three-phase lower arms are turned ON,

Fig. 3 and Fig. 4 show simulation results of the DC-link capacitor current before and after the three-phase lower arm ON control. The maximum current in Fig.3, before applying the proposed method was approximately 8.0 A. As shown in Fig.4, the maximum current after applying this control method was approximately 6.0 A. Furthermore, an FFT analysis confirmed that the frequency components around the 6th harmonics component of the inverter voltage frequency were reduced by approximately half.

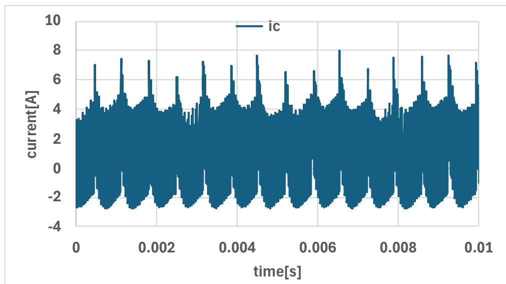

Fig. 3 Capacitor Current $\boldsymbol{i_c}$ without the Proposed Control Method

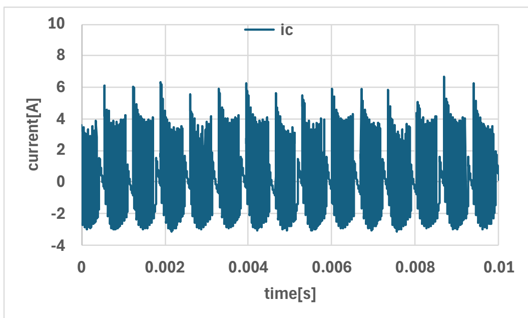

Fig. 4 Capacitor Current $\boldsymbol{i_c}$with the Proposed Control Method