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Evaluation of Receiving Power Control for Dynamic Wireless Power Transfer Using Pulse Density Modulation

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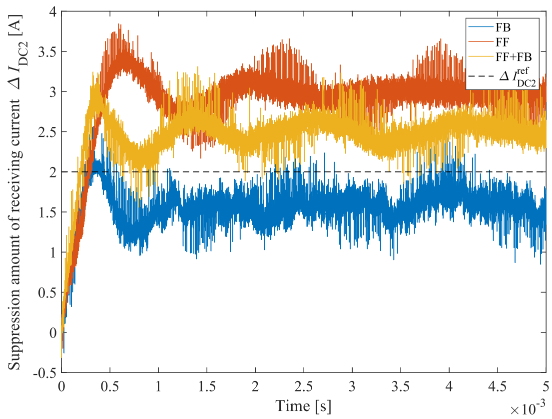
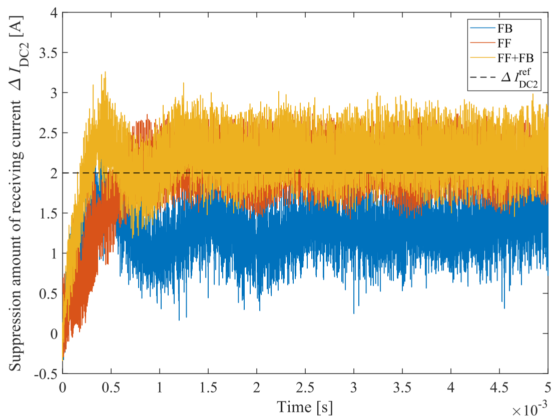
Dynamic wireless power transfer (DWPT) is widely studied to improve the short cruising distance and long charging time of battery electric vehicles. The receiving power control is very important to avoid the battery from overcharging. The authors have reported the receiving power control using an active rectifier and pulse density modulation (PDM). The PDM has the advantage that the switching loss can be zero by the zero current switching (ZCS). However, in the previous experiments, the ZCS was inaccurately done by using a low-sampling-frequency AD converter. In addition, the evaluation of the control performance was not deeply discussed. In this paper, the ZCS is improved using a comparator circuit which generates a digital signal and can increase the sampling frequency. The receiving current controller consists of a feedforward controller and feedback controller. The feedforward controller is designed based on the plant model which is identified by the experimental measurement results of a step response. The feedback controller which was used in the previous study is used.

Concentrated PDM (CPDM) and distributed PDM (DPDM) are experimentally evaluated. Fig. 1 shows the step response of the receiving current control on static WPT condition. The CPDM cannot follow the reference without the feedback controller because the relation between the duty ratio and the suppression amount of the receiving current is not linear. On the other hand, the DPDM can follow the reference without the feedback controller with a short settling time and small transient oscillation. The feedback controller is necessary because the receiving current changes by the dynamic change of the coupling coefficient on the DWPT condition. Fig. 2 shows the experimental results of receiving current control on DWPT condition. As can be seen from the blue line in the figure which shows the diode mode response, the receiving current dynamically changes. Thanks to the feedback controller, both the CPDM and DPDM can regulate the receiving current to the reference value under the DWPT condition. The settling value of the CPDM is a little smaller than one of the DPDM due to the nonlinear characteristics mentioned above. The DPDM can control the receiving current more accurately. By using the DPDM and combining the feedback control and feedforward controller, the receiving current is accurately and quickly controlled during the DWPT, which can avoid the battery overcharging.

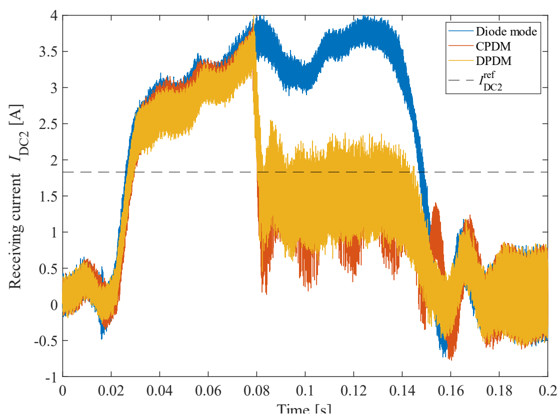


(a) CPDM



(b) DPDM

Fig. 1 Step response of receiving current control (Static WPT condition)



Fig, 2 Experimental results of receiving current control on DWPT condition