

Investigation of EMC Testing During Charging and Discharging for On-board Bidirectional Chargers

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The increasing adoption of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) has led to more frequent connection of vehicles to public low-voltage power systems. In addition, the growing demand for energy management applications, such as Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G), has accelerated the introduction of on-board bidirectional chargers. These chargers operate not only in the conventional charging mode, in which power is supplied from the grid to the vehicle, but also in a discharging mode, in which stored energy is supplied from the vehicle back to the grid. As a result, future EMC requirements may need to consider both operating modes. However, applying the full set of EMC tests to both charging and discharging modes would increase the test burden significantly. Therefore, rationalization of EMC test methods is an important issue for future regulatory and evaluation frameworks.

In this study, EMC characteristics during charging and discharging were compared using a vehicle equipped with an on-board bidirectional charger. The evaluation focused on harmonic current emissions and conducted emissions because both are closely related to the interaction between the bidirectional charger and the AC power system. The test configuration was based on the REESS charging-mode setup specified in UN Regulation No. 10. A bidirectional power supply was used so that the same test setup could be applied to both modes: it operated as an AC source during charging and as a regenerative load during discharging. The tests were conducted under identical operating conditions, including AC connection, rated power of 11 kW, three-phase operation, 50 Hz commercial frequency, phase voltage of 230 V, phase current of 16 A, steady-state operation, and SOC control within 30–50%.

For the harmonic current emission test, the measurement was conducted in accordance with IEC 61000-3-2 and IEC 61000-3-12. Although all three phases were measured, the L1 phase was selected as a representative result because similar tendencies were observed among the phases. Figure 1 shows the harmonic current emission result. The harmonic spectra up to the 40th order exhibited similar tendencies between charging and discharging modes. Since the components above the second harmonic were sufficiently small, a quantitative comparison was performed using the fundamental current component. The maximum difference between the two modes was 0.20 Arms, corresponding to 0.11 dB. This indicates that the dominant current component was practically equivalent between the two modes.

For the conducted emission test, measurements were performed in accordance with CISPR 16-2-1 over the frequency ranges of 9 kHz to 150 kHz and 150 kHz to 30 MHz. Quasi-peak and average detector results were compared between charging and discharging modes, and the L1 phase was again used as a representative example. Figure 2 shows the conducted emission result. The spectral shapes, dominant frequency ranges, and noise levels were generally consistent between the two modes. The maximum amplitude difference was within 3 dB for both quasi-peak and average values, confirming a high degree of equivalence in conducted emission characteristics.

These results suggest that, when the same power conversion circuit and control system are used for both charging and discharging and only the direction of power flow differs, the EMC characteristics of the two modes can be highly correlated. Therefore, for such bidirectional charger configurations, there may be potential to rationalize future EMC test requirements by using charging-mode test results as a representative evaluation for discharging mode. Further work is necessary to verify whether similar equivalence can be observed for radiated emissions and immunity tests.

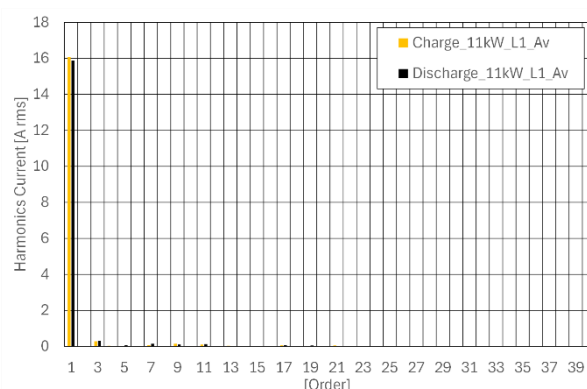


Fig.1 Harmonic Current Emission Test Results (Average)

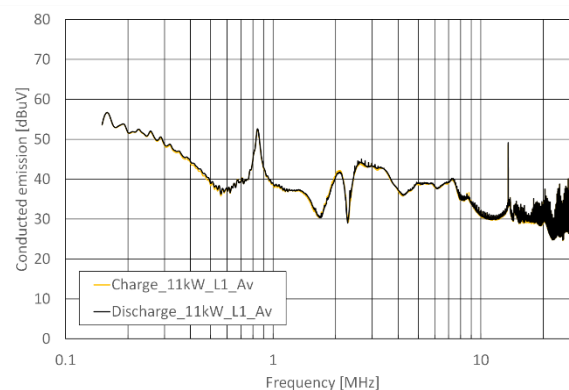


Fig.2 Conducted Emission Test Results(150k-30MHz, Average)