Analytical Characterization of CM and DM Performance of Three-phase Voltage-source Inverters Under Various PWM Patterns

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Yang Huang¹, Jared Walden¹, Andrew Foote¹, Hua Bai¹, Dingguo Lu², Fanning Jin², and Bing Cheng²

¹ Min H. Kao Department of Electrical Engineering & Computer Science, The University of Tennessee, Knoxville, TN, USA
² Mercedes Benz North America, Redford Charter Twp, MI, USA
Overview

Background and motivation:
- The need for analytical models and tools to investigate common-mode (CM) and differential-mode (DM) signals in motor drive systems is evident in previous literature;
- An analytical model of CM voltage and phase-current ripple, instead of simulation-based model, is highly demanded to optimize the performance of the overall motor drive system;
- We need to provide the approach for engineers to evaluate the performance of different PWMs under various operation points.

CM/DM modeling
- DM modeling: Phase current ripple prediction based on the equivalent circuit under different vector states;
- CM modeling: CM voltage/current prediction and spectrum analysis based on Double Fourier Integral (DFI);
- Evaluate the CM- and DM-performance of different modulation schemes: SVPWM, AZSPWM, DPWM1 and DPWMMin;

Conclusion:
- A comprehensive consideration of the three-phase motor drive system by building analytical models of CMV and DMI for various PWM control is proposed;
- The DFI model quantifies existing sideband harmonics in AZSPWM CMV, together with the DMI model predicting current ripple and THD.
- Such analytical model provides a powerful tool, allowing a comprehensive vision for further evaluations.
Simulation Result

- Use DFI based CM model and ripple prediction model to estimate the CM performance and current THD of different PWMs.
- Specifications: \( f_0 = 50 \) Hz, \( f_s = 10 \) kHz, \( V_{dc} = 150 \) V.

Fig. 4 Equivalent circuit for current ripple prediction

Fig. 5 Equivalent circuit for current ripple prediction
Experimental Result

- AZSPWM reduces the CMV @fs, but from the CM energy point of view, due to the aroused sideband components. At low modulation index, DPWMMin can gain similar CM reduction performance with much smaller current ripple.

Fig. 7 CM current spectrum @fs (MI=0.2)

Fig. 8 Equivalent circuit for current ripple prediction

<table>
<thead>
<tr>
<th>fs=10 kHz</th>
<th>SVPWM</th>
<th>AZSPWM</th>
<th>DPWM1</th>
<th>DPWMMin</th>
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<tbody>
<tr>
<td>Energy</td>
<td>2.5*10^{-5}</td>
<td>0.33*10^{-5}</td>
<td>0.64*10^{-5}</td>
<td>0.36*10^{-5}</td>
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TABLE. III CME of various
Acknowledgements

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