

Experimental Evaluation of Inverter Power Losses for BLDC Drive under Different PWM Techniques

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GOAL OF THE STUDY

The study aims to experimentally evaluate inverter power losses in a brushless DC (BLDC) motor drive under different pulse-width modulation (PWM) techniques. The objective is to compare conduction and switching losses across various PWM strategies—such as sinusoidal PWM, space vector modulation, and discontinuous PWM—to identify control methods that achieve higher efficiency, reduced harmonic distortion, and improved overall inverter performance.

METHODOLOGY OF THE INVESTIGATION

An experimental testbench was built using a T-Motor F60 Pro IV BLDC motor driven by a Texas Instruments BOOSTXL-DRV8305 inverter, controlled via a LAUNCHXL-F28379D board implementing real-time PWM algorithms in MATLAB/Simulink. A sensorless field-oriented control (FOC) strategy was used, with real-time measurement of inverter voltage, current, and speed. Eight PWM schemes were tested under identical conditions, and inverter conduction and switching losses were computed from measured data to assess efficiency differences among modulation methods.

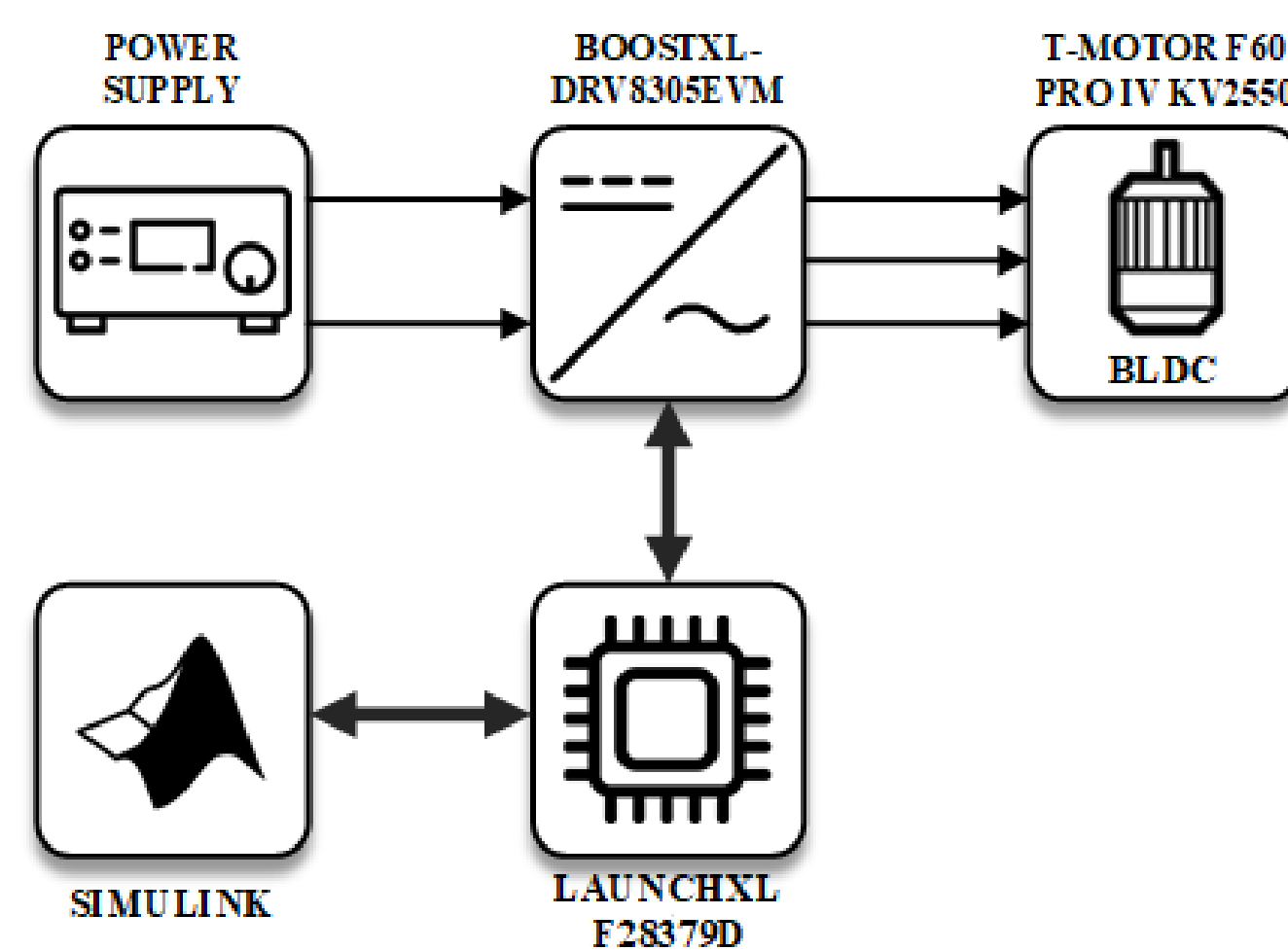


Fig. 1. Block diagram of the experimental setup.



Fig. 2. Photo of the experimental setup.

MAIN RESULTS FROM THE STUDY

Sinusoidal PWM provided smooth current waveforms but resulted in the highest total losses (≈ 2.08 W). Space Vector Modulation (SVM) slightly improved efficiency (≈ 2.07 W) through better DC-bus utilization and balanced switching. Discontinuous PWM (DPWM) methods significantly reduced switching losses—DPWM60 achieved the lowest total loss (≈ 1.25 W), nearly 40% lower than sinusoidal PWM. Modified clamping schemes with $\pm 30^\circ$ shifts further optimized efficiency while maintaining acceptable current waveform quality. However, extended 120° DPWM methods, although reducing switching stress, increased current distortion. Overall, optimized DPWM strategies provided the best trade-off between efficiency, switching stress, and harmonic performance.

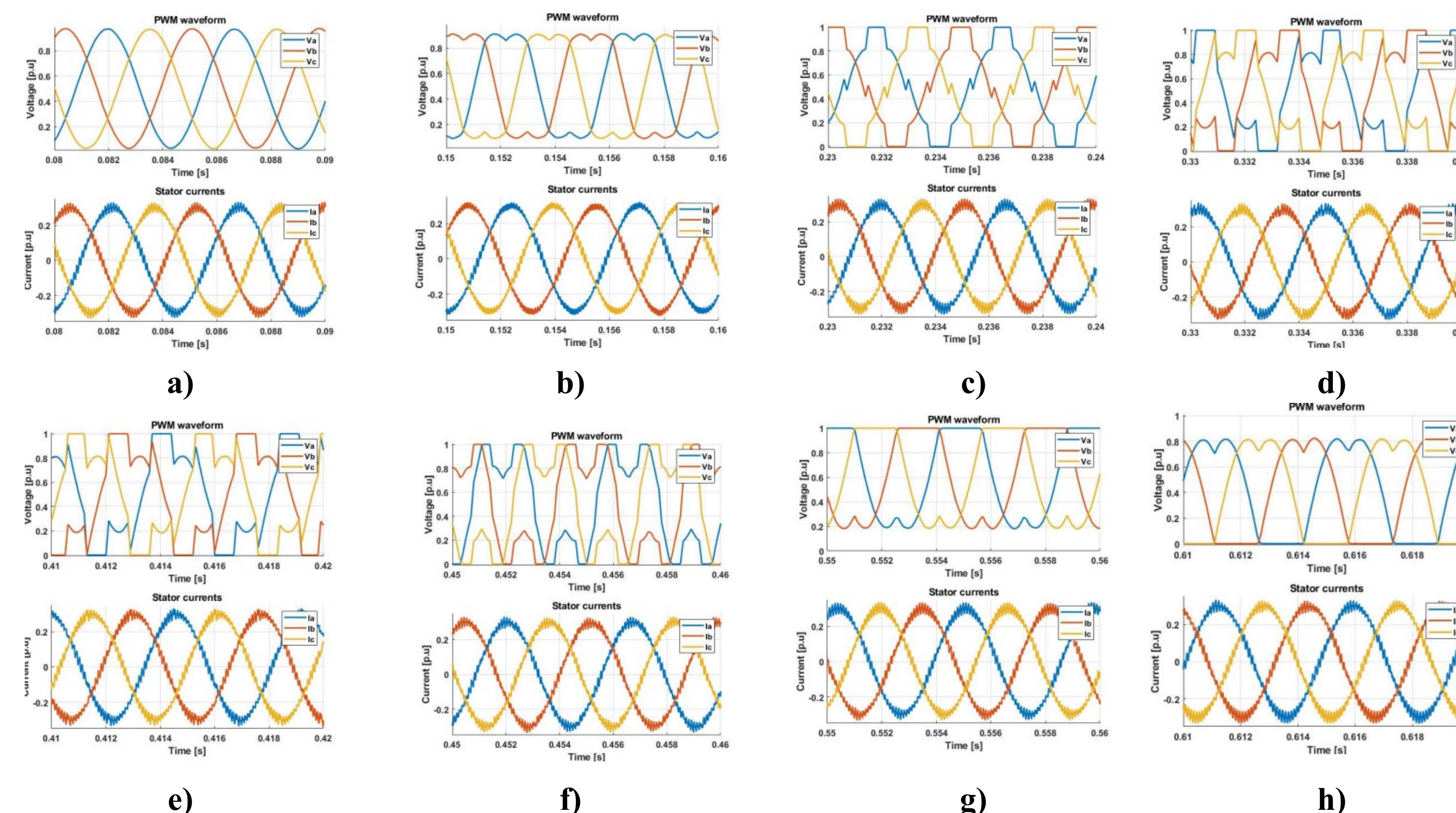


Fig. 3. Sinusoidal PWM (a), Space vector modulation (SVM) (b), 60° Discontinuous PWM (c), Discontinuous PWM ($+30^\circ$ Shift) (d), Discontinuous PWM (-30° Shift) (e), 30° Discontinuous PWM (f), 120° Discontinuous PWM (Positive DC Component) (g), 120° Discontinuous PWM (Negative DC Component) (h),

CONCLUSIONS

The results show that inverter power losses in BLDC drives are strongly influenced by the PWM strategy. Continuous methods like sinusoidal PWM provide smooth currents but higher switching losses, while discontinuous PWM techniques reduce losses and improve efficiency. Space Vector and third-harmonic injection PWM offered the best balance between current quality and efficiency, making them suitable for high-performance and energy-efficient BLDC drive applications.

ACKNOWLEDGMENT

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