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# Survey on Commutation Torque Ripple Reduction in BLDC Motor

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***Abstract*** *– Brushless DC Motors (BLDCM) are widely used in automated industrial applications like Computer Numerical Control (CNC) machinery, aerospace applications and in the field of robotics. But it still suffers from commutation torque which mainly depends on speed and transient line commutation interval. This paper presents a reduction of torque ripple performance of brushless DC (BLDC) motor drive system using different converter and inverter.*

***Keywords****: Brushless direct current motor (BLDCM), dc-bus voltage control, modified single-ended primary-inductor converter, 3-level diode clamped multilevel inverter (3-level DCMLI), torque ripple,*

## I. Introduction

The brushless DC motor (BLDCM) is receiving widespread attention for industrial applications because of its high efficiency, low maintenance capability, longer life span, low noise and easy-to-drive features. The BLDCM, with a trapezoidal back-electromotive-force (EMF) waveform, is widely used in robotics, aerospace, automotive, washing machines, medical and heating, ventilation and air conditioning applications because of highly desirable features, such as high torque/weight ratio, high-speed capabilities, good dynamics and thermal efficiency. Commutation of the BLDCM is controlled electronically, which eliminates many problems associated with brushes of conventional DC motors. However, the inverter and the controller used for electronic commutation increase the cost of the BLDCM compared with the conventional DC motor [2].

Brushless DC (BLDC) machines are extensively used in various industry applications such as power tools, vehicles, robots, compressors, pumps and home appliances due to the advantages of simple control, robustness and high power density. However, compared with a permanent magnet synchronous machine (PMSM), the BLDC machine’s large torque ripple is the major shortcoming that limits its application in high precision servo systems and noise-sensitive applications [3].

BRUSHLESS DC (BLDC) motor with the advantages of small size, high power density and easy control and operation, has been widely used in the areas of aviation, automobile electronics and household appliances. Torque ripple will be caused if conventional current control method is employed when the back-EMF is non-ideal trapezoidal waveform. Commutation occurs in every 60° electrical angle in BLDC drives, and commutation torque ripple will be caused if the currents of non-commutated windings cannot trace reference current during commutation. Torque ripple will cause vibration, noise, and speed ripple, thus degrading motor’s control performances [4].

Torque ripple, which occurs during commutation period, has always been one major factor in preventing BLDCM from achieving high performance. Two general approaches have been proposed to reduce the torque ripple. The first approach is to improve the motors geometrical structure. The second approach is to control the winding currents to overcome the disturbances [7].

## II. Literature Survey

V. Viswanathan et al. [1] “Commutation Torque Ripple Reduction in BLDC Motor using modified SEPIC converter and three level NPC inverter”, In this paper, a commutation torque ripple reduction circuit has been proposed using 3-level DCMLI with modified SEPIC converter and a dc-bus voltage selector circuit. A laboratory-built drive system has been tested to verify the proposed converter topology. The suggested dc-bus voltage control strategy is more effective in torque ripple reduction in the commutation interval. The proposed topology accomplishes the successful reduction of torque ripple in the commutation period and experimental results are presented to compare the performance of the proposed control technique with the conventional 2-level inverter, 3-level DCMLI, 2-level inverter with SEPIC converter and the switch selection circuit-fed BLDCM. In order to obtain significant torque ripple suppression, quietness and higher efficiency, 3-level DCMLI with modified SEPIC converter and the voltage selector circuit is a most suitable choice to obtain high-performance operation of BLDCM. The proposed topology may be used for the torque ripple suppression of BLDCM with the very low stator winding inductance.

V. Viswanathan et al.[2] "Approach for torque ripple reduction for brushless DC motor based on three-level neutral-point-clamped inverter with DC–DC converter", In this paper, a novel topology has been proposed to suppress the commutation torque ripple of a BLDCM using two SEPIC converters and a MOSFET-based three-level NPC inverter. The SEPIC converters are used to adjust the dc-link voltage and thus to suppress the torque ripple during the commutation period. To verify the feasibility of the proposed topology, simulation and experiments were conducted using low and high speeds. The results of this paper have demonstrated that the proposed topology can effectively reduce the commutation torque ripple. Therefore, the proposed solution has high potential for vehicular and aerospace applications in which torque ripple minimization is of great importance.

Tiantian Sheng et al.[3] "Torque Ripple Mitigation for Brushless DC Machine Drive Systems Using One-Cycle Average Torque Control", This paper reviews the state-of-the-art control algorithms to reduce the torque ripple for BLDC machines with non-ideal trapezoidal back EMF. The present algorithms can be divided into two major categories. The first category calculates the optimal current waveform and uses that as the current command to reduce the torque ripple. The second category uses observers to estimate the stator flux linkage and torque. All these methods need accurate information of the back EMF and rotor position. The contribution of this paper is to propose a torque ripple mitigate algorithm based on the one-cycle average torque control. This method does not require the information of back EMF and accurate rotor position. Only one voltage sensor and one current sensor are needed to detect the DC bus voltage and current. The operation principle of the one-cycle average torque control algorithm is presented in detail. The flux linkage and electromagnetic torque behavior in each control cycle is analyzed. Both simulations and experiments are conducted to verify the proposed control algorithm. The torque ripple spectrum analysis demonstrates the one-cycle average torque control algorithm is able to reduce the 6th, 12th, 18th, 24th torque harmonic components by more than 70%.

Changliang Xia et al.[4] "Torque Ripple Reduction in Brushless DC Drives Based on Reference Current Optimization Using Integral Variable Structure Control", A torque ripple reduction method for BLDC drives based on current optimization control using IVSC is proposed in this paper. Torque ripple is reduced by current optimization in both two-phase conduction mode and commutation mode in accordance with back-EMF waveforms, respectively. Luenberger full-order observer, whose stability is demonstrated by selecting an appropriate Lyapunov function candidate, is designed to estimate three-phase line back-EMF waveforms in real time. Optimal currents of non-commutated windings during commutation are obtained by commutation control with two-phase switching mode or three-phase switching mode. Because IVSC has the advantages of broad-band noise-suppressing capacity and strong robust against external disturbances, current controllers using IVSC are designed to realize current optimization control in this paper. The output of IVSC controller is composed of continuous equivalent component and switching component, therefore, the advantages of IVSC are fully utilized while the negative effect of chattering phenomenon is avoided. The stability of control law using IVSC is further demonstrated by selecting an appropriate Lyapunov function candidate. The control method proposed in this paper can reduce torque ripple and improve the control performance of motor over wide load range and speed range, and the experimental results validate the effectiveness of the proposed method. What should be pointed out is that if three-phase switching mode is used during commutation, commutation time is extended, switching loss increases and efficiency decreases since three switches are controlled simultaneously even though the number of commutations of switches is not added, however, it is worthy of the extra cost because commutation torque ripple is reduced effectively and smooth torque is obtained.

Giuseppe Buja et al.[5] "Torque Ripple-Free Operation of PM BLDC Drives with Petal-Wave Current Supply", of a PM BLDC drive has been carried out, intended to provide the drive with true torque ripple-free operation. The method has been explained and the trajectory of the supply currents in the α,β plane has been determined, resembling the petal of a flower. From the current vector, the phase currents have been derived and their characteristics have been examined. Differently from the square-wave current supply, that one with the petal waveform can be successfully impressed into the motor, as proven experimentally, and this improves the torque performance of a PM BLDC drive substantially. Indeed, besides eradicating the torque ripple plaguing the drives with the motor supplied with square-wave currents, the petal-wave current supply benefits the drive with i) a 5% higher torque for an equal rms value of the phase currents, ii) a constant torque-speed characteristic up to the base speed, and iii) a linear decrease of the torque with the speed under voltage limitation.

Roger Gules et al.[6] "A Modified Sepic Converter With High Static Gain For Renewable Applications", Two new topologies of non isolated high static gain

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converters are presented in this paper. The first topology without magnetic coupling can operate with a static gain higher 10 with a reduced switch voltage. The structure with magnetic coupling can operate with static gain higher 20 maintaining low the switch voltage. The efficiency of proposed converter without magnetic coupling is equal to 91.2% operating with input voltage equal to 12 V, output voltage equal 120 V and output power equal 100 W. The efficiency of proposed converter with magnetic coupling is equal to 95% operating with input voltage equal to 12 V, output voltage equal 240 V and output power equal 100 W. The commutation losses of the proposed converter with magnetic coupling are reduced due to the presence of the transformer leakage inductance and the secondary voltage multiplier that operates as a non dissipative clamping circuit to the output diode voltage.

## III. Commutation Torque Ripple in BLDCM

Ideally, the current drawn by the BLDCM, with trapezoidal back EMF, takes the form of rectangular waveform [7] as shown in Fig.1. This kind of current waveform will produce a constant torque. Practically, the smoothness in torque waveform is not observed and torque ripple is prevalent. Various non – linearity in the machine will result in the disruption of the ideal rectangular current waveform thereby resulting in torque ripple. The excitation current waveforms do not change instantaneously and a variable commutation time for different speeds is observed [7] as shown in Fig.2.

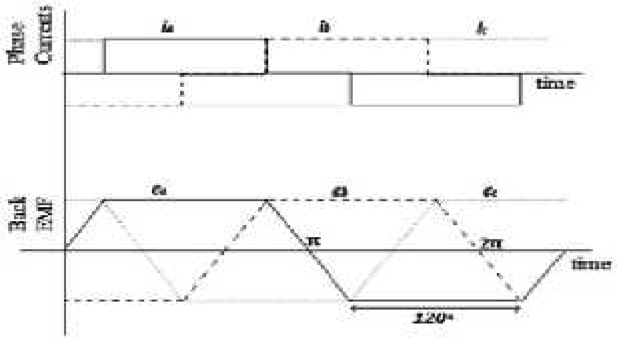

Fig.1. Ideal Current and back emf waveform

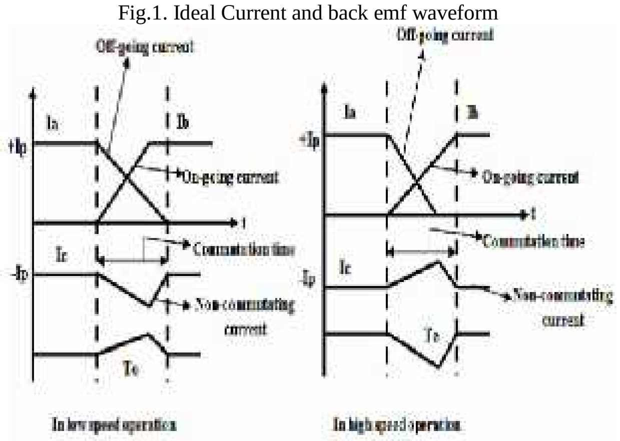

Fig.2. Commutation Currents and Torques

During this commutation time, Torque ripple occurs due to the difference between the time taken by the ongoing phase "b" current to reach the saturation value and the time taken by the off going phase "a" current decay to zero. In order to eliminate the dip in the Torque waveform, the difference in the commutation time for ongoing and off going phase currents should be made zero [7] as shown in Fig.3. This torque dips can be reduced by suitable dc link voltage control method during the commutation time. This can be achieved by using proposed MSEPIC in B LDCM drives.

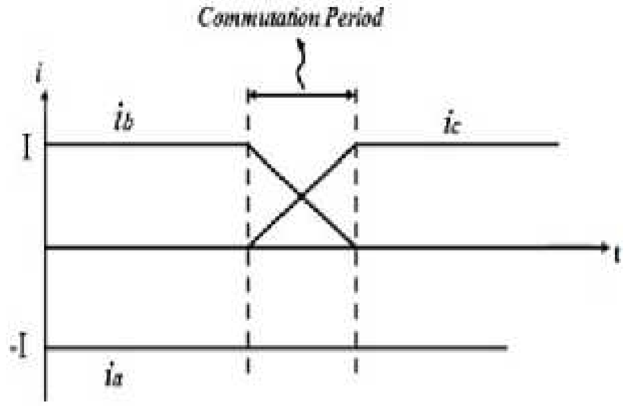

Fig.3. Current waveform for the torque ripple compensation

## IV. SEPIC converter

Diodes and voltage bridges are useful for reducing voltage by a set amount, but can be inefficient. Voltage regulators can be used to provide a reference voltage. Additionally, battery voltage decreases as batteries discharge which can cause many problems if there is no voltage control. The most efficient method of regulating voltage through a circuit is with a dc-dc converter. There are 5 main types of dc-dc converters. Buck converters can only reduce voltage, boost converters can only increase voltage, and buckboost, Cúk, and SEPIC converters can increase or decrease the voltage [10].

The power circuit of the classical SEPIC converter is presented in Fig.4. The step-up and step-down static gain of the SEPIC converter is an interesting operation characteristic for a wide input voltage range application. However the switch voltage is equal the sum of the input and output voltage [6].

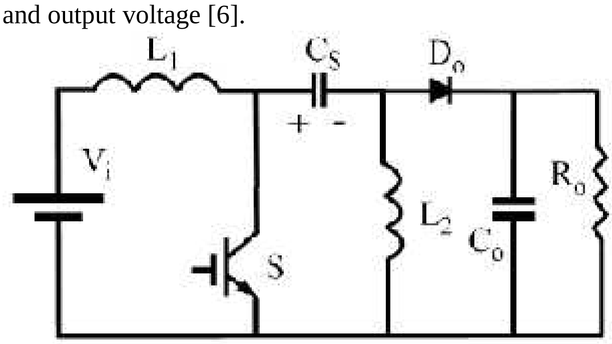

Fig.4. Classical SEPIC converter

## V. Conclusion

This paper has studied a reduction of torque ripple of the BLDC motor drive system and the performance of the BLDC motor. There are many research papers are surveyed related to the Commutation Torque Ripple Reduction in BLDC Motor in this paper. It presents basic concept of Commutation Torque Ripple in BLDCM. It also presents the introduction of SEPIC Converter.

## References

[1] Viswanathan, V., and Jeevananthan Seenithangom. "Commutation torque ripples reduction in BLDC motor using modified SEPIC converter and three-level NPC inverter." IEEE Trans. Power Electron 33 (2017): 535-546.

[2] Viswanathan, V., and S. Jeevananthan. "Approach for torque ripple reduction for brushless DC motor based on three-level neutral-point-clamped inverter with DC–DC converter." IET Power Electronics 8.1 (2014): 47-55.

[3] Sheng, Tiantian, et al. "Torque-ripple mitigation for brushless DC machine drive system using one-cycle average torque control." IEEE Transactions on Industrial Electronics 62.4 (2015): 2114-2122.

[4] Xia, Changliang, et al. "Torque ripple reduction in brushless DC drives based on reference current optimization using integral variable structure control." IEEE transactions on industrial electronics 61.2 (2014): 738-752.

[5] Buja, Giuseppe, Manuele Bertoluzzo, and Ritesh Kumar Keshri. "Torque ripple-free operation of PM BLDC drives with petal-wave current supply." IEEE Transactions on Industrial Electronics 62.7 (2015): 4034-4043.

[6] Gules, Roger, et al. "A modified SEPIC converter with high static gain for renewable applications." Power Electronics Conference (COBEP), 2011 Brazilian. IEEE, 2011.

[7] REDDY, T. SRIPAL, and K. PAVANI. "Communication Torque Ripple Reduction in Brushless DC Motor using Modified SEPIC Converter and Current Control Technique." (2016).

[8] Jogarao, R., Mouliswararao Reddy, and G. Ashok. "Analysis of Commutation Torque Ripple Minimization for Brushless DC Motor Based on SEPIC Converter." International Journal of Engineering Research and Applications 6.10 (2016): 5-11.

[9] G.V.Saiganga “Reduction of Torque Ripple Content in the BLDC Motor”, SSRG International Journal of Electrical and Electronics Engineering (SSRG-IJEEE)-Special Issue ICRTECITA April 2018.

[10] Sharp, Gregory. "Sepic Converter Design and Operation." partial completion of the requirements for a BS degree from WPI.