IMPROVED DIRECT TORQUE CONTROL IN DUAL INVERTERS USING FLEXIBLE SECTOR DETECTOR AND DUTY CYCLE TECHNIQUES

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DEDICATION

Special Dedication to:

My Respected Supervisor and Co-Supervisor,

Dr. Auzani bin Jidin and Dr. Azrita binti Alias

Thank you for your vital support, motivation, guidance, and supervision in accomplishing this research.

My Beloved Parents,

Aihsan bin Adam and Rosnah binti Mohd

For supporting and encouraging me to complete this research

Thank you for your firm and gentle soul, which makes me who I am today.

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Thank you for your love, patience, and understanding.

May God bless and protect them with happiness.

ABSTRACT

Direct Torque Control of Open-End Winding Induction Motor (DTC-OEWIM) is one of the techniques in motor drive applications that provides a robust and straightforward structure with excellent dynamic torque control. It controls the induction motor at both ends by using the dual-inverter circuit. Despite its outstanding performance, the DTC-OEWIM technique has several drawbacks. When the dual-inverter circuit is supplied with mismatched DC voltages, the direction of the medium voltage vectors will deviate and no longer tangential to the circular flux locus. This will causes significant stator flux droop and distortion in the stator currents, leading to poor torque regulation. Even though the DTC-OEWIM technique is famous for reducing torque ripples by using short voltage vectors, it is still unable to minimize them, especially during low-speed operations entirely. A flexible sector detector proposes to overcome the problems by generating a new sector that ensures the deviated voltage vectors are tangential to the circular flux locus. The study explored the potential of the proposed technique under steady-state and transient-state operation. Another objective was to design the duty cycle control technique to limit the surge torque slope during low-speed operation. Integrating duty cycle ratios into the default inverter switching restricts the torque increment and torque decrement rate. The proposed techniques were compared with the default DTC-OEWIM system and verified through simulation and experimental work. For simulation, MATLAB/Simulink software was used to design the complete system, using the exact parameters as in the hardware experimental setup. For experimental works, the setup consists of a dSPACE DS1104 controller, two units of a two-level inverter connected in a dual-inverter configuration, and a 1.1kW induction motor with a 2kW DC generator as a load. The results show a significant improvement: 1) the minimization of stator flux droop and distortion in stator currents, which in turn improves the torque regulation and 2) the reduction of torque ripples by up to 50% and the improvement in switching frequency during low-speed operation. In conclusion, the proposed technique effectively improves DTC-OEWIM while maintaining the simple structure of the DTC system.

PENINGKATAN KAWALAN DAYAKILAS LANSUNG DALAM DWI PENYONGSANG MENGGUNAKAN PENGESANAN SEKTOR BOLEH LENTUR DAN TEKNIK KITAR TUGAS

ABSTRAK

Kawalan Dayakilas Lansung daripada Motor Aruhan Belitan Tamatan Terbuka (DTC-OEWIM) adalah salah satu teknik dalam aplikasi pemacu motor yang menyediakan struktur yang teguh dan ringkas dengan kawalan dayakilas dinamik yang sangat baik. Ia mengawal motor aruhan pada kedua-dua tamatan dengan menggunakan litar dwi-penyongsang. Walaupun prestasinya yang cemerlang, teknik DTC-OEWIM mempunyai beberapa kelemahan. Apabila litar dwi-penyongsang dibekalkan dengan voltan DC yang tidak sepadan, arah vektor voltan sederhana akan terpesong dan tidak lagi bertangen dengan bulatan lokus fluks. Sistem ini mengalami lelaian fluks pemegun yang besar dan juga gangguan pada arus pemegun yang membawa kepada pengaturan kilas yang lemah. Walaupun teknik DTC-OEWIM terkenal kerana keupayaanya untuk mengurangkan riak dayakilas dengan menggunakan vektor voltan pendek, ia masih tidak dapat meminimumkan sepenuhnya terutamanya semasa operasi berkelajuan rendah. Oleh itu, sebuah pengesan sektor yang boleh lentur dicadangkan untuk mengatasi masalah tersebut dengan menghasilkan sektor baru yang memastikan vektor voltan yang tersisih bersentuhan dengan bulatan lokus fluks. Kajian ini meneroka potensi teknik yang dicadangkan dalam operasi keadaan mantap dan keadaan berubah. Satu objektif lain ialah untuk merekabentuk teknik kawalan kitar tugas bagi mengehadkan kemuncak cerun dayakilas ketika operasi kelajuan rendah. Ia dilakukan dengan mensepadukan nisbah kitar tugas ke dalam pensuisan penyongsang yang asal untuk mengehadkan kadar peningkatan dan penurunan dayakilas. Teknik-teknik yang dicadangkan telah dibandingkan dengan sistem DTC-OEWIM yang asal dan disahkan melalui kerja simulasi dan eksperimen. Bagi simulasi, perisian MATLAB/Simulink digunakan bagi merekabentuk sistem yang lengkap dengan menggunakan parameter yang sama seperti dalam penyediaan eksperimen. Bagi kerja eksperimen, penyediaan penuh terdiri daripada pengawal dSPACE 1104, dua unit penyongsang dua aras yang disambungkan dalam tertatarajah dwi-penyongsang dan motor aruhan 1.1kW dengan penjana DC 2kW sebagai beban. Hasil kajian menunjukkan peningkatan yang bererti; 1) pengurangan lelai fluks pemegun dan gangguan pada arus pemegun, yang seterusnya meningkatkan kawalan dayakilas; dan 2) pengurangan riak dayakilas sehingga 50% dan penambahbaikkan didalam frekuensi pengsuisan dan sekali lagi semasa operasi kelajuan rendah. Kesimpulannya, teknik yang dicadangkan berkesan dalam menambah baik struktur DTC-OEWIM sambil mengekalkan stuktur mudah sistem DTC.

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