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Comparative Evaluation of Sliding Mode and PI-Based PWM Current Control for Six-Phase Induction Machine Drives

Gustavo Ojeda[1], Jorge Rodas[2], Osvaldo González[1,2], Christian Medina[2], Paola Maidana[2], Esteban Leguizamón[1], Néstor Villamayor[1]

[1]Master in Electronics Engineering, Universidad del Cono Sur de las Américas, Asunción, Paraguay
[2] CITHED, Facultad de Ingeniería, Universidad Nacional de Asunción, Luque, Paraguay

INTRODUCTION & AIM

Asymmetrical Six-Phase Induction Machines (ASPIM) offer inherent fault tolerance capability, reduced torque ripple, and improved reliability compared to a classical three-phase configuration [1]. However, they impose demanding requirements on current control strategies. This study presents a comparative evaluation of Sliding Mode Control (SMC) [2] and the well-established Proportional Integral regulator with Pulse Width Modulation (PI+PWM) [3], both modelled and implemented in MATLAB/Simulink using the same system and identical test condition profiles to ensure a fair comparison.

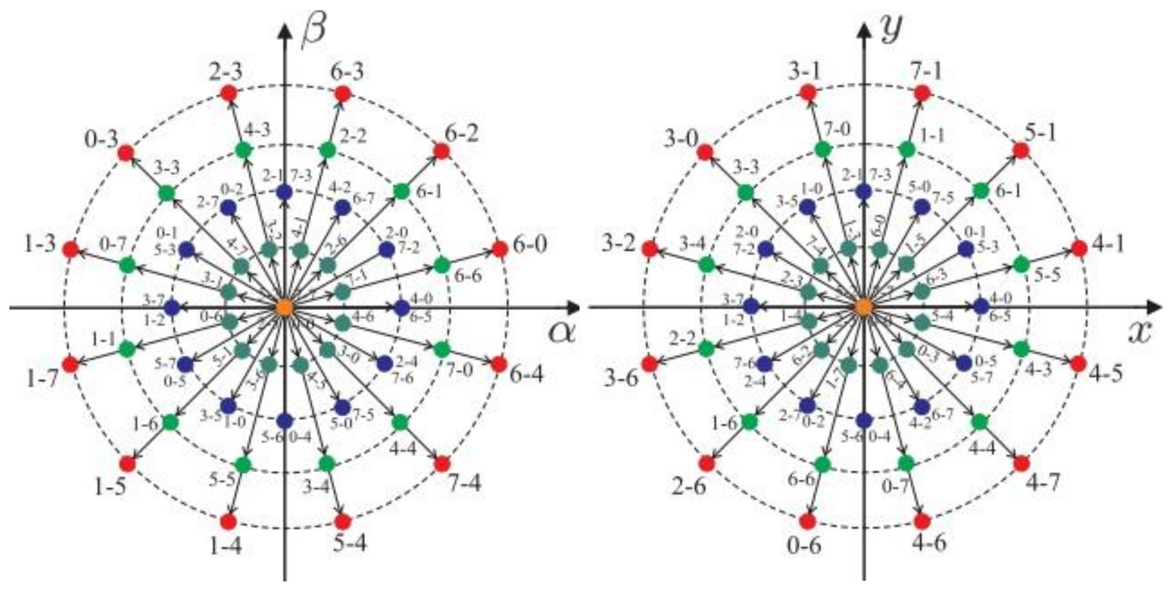

Fig. 1: Space voltage vector in the $(\alpha-\beta)$ and $(x-y)$ subspaces. [2]

METHOD

The mentioned controllers are evaluated using speed reversal tests at ±500 r/min (8 kHz sampling) and ±1000 r/min (12 kHz sampling), and further assessed under ±50% variations in magnetising inductance to analyse robustness.

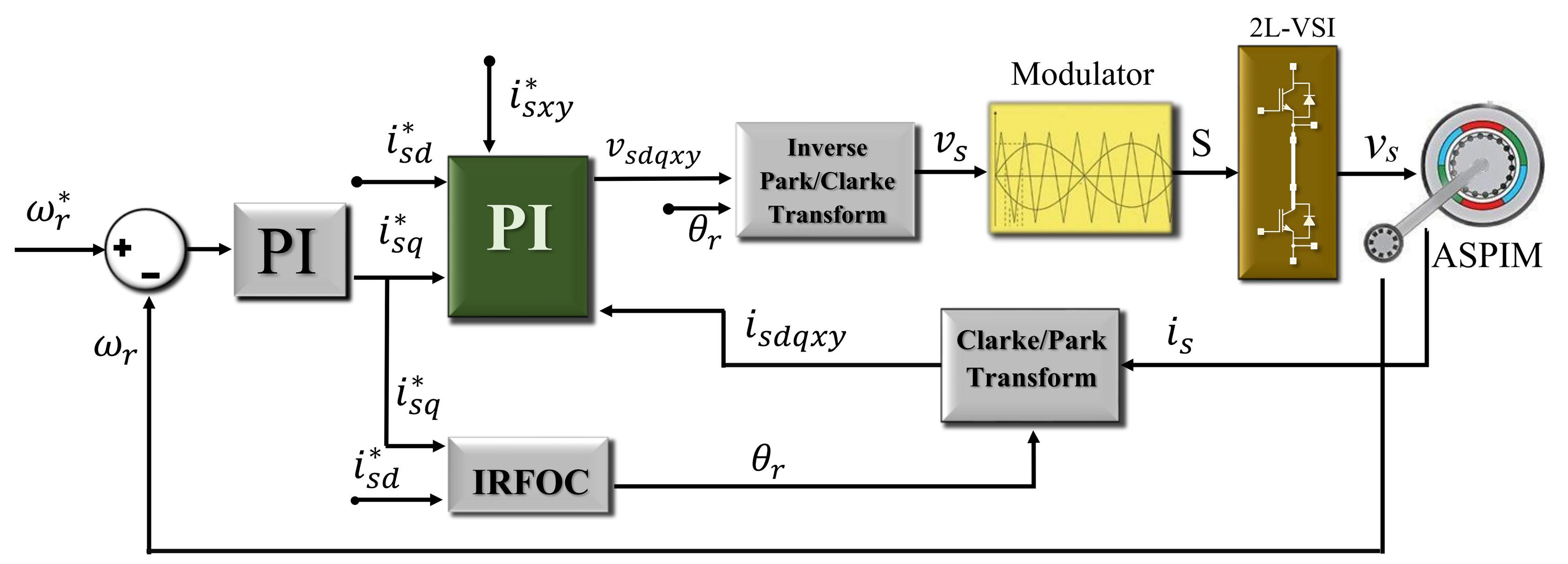

Fig. 2: Block diagram of the PI+PWM system for the ASPIM.

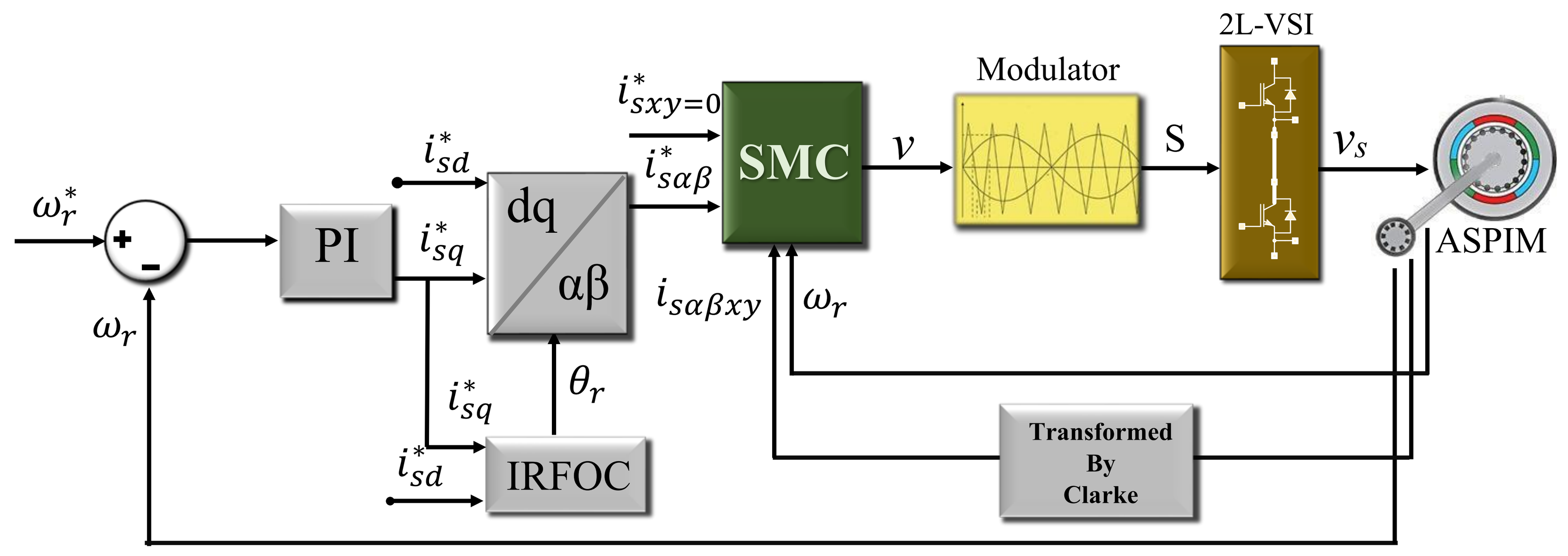

Fig. 3: Block diagram of the SMC system for the ASPIM.

RESULTS & DISCUSSION

The results show that PI+PWM achieves significantly lower steady-state current tracking error, with root mean square error (RMSE) typically below 0.02 A, compared to 0.05 – 0.08 A for SMC. In terms of current quality, SMC maintains a total harmonic distortion (THD) of approximately 1.3% at low speed and 1.05% at high speed. In comparison, PI+PWM consistently remains below 1.1% and 0.9%, respectively, demonstrating stable performance across both operating conditions.

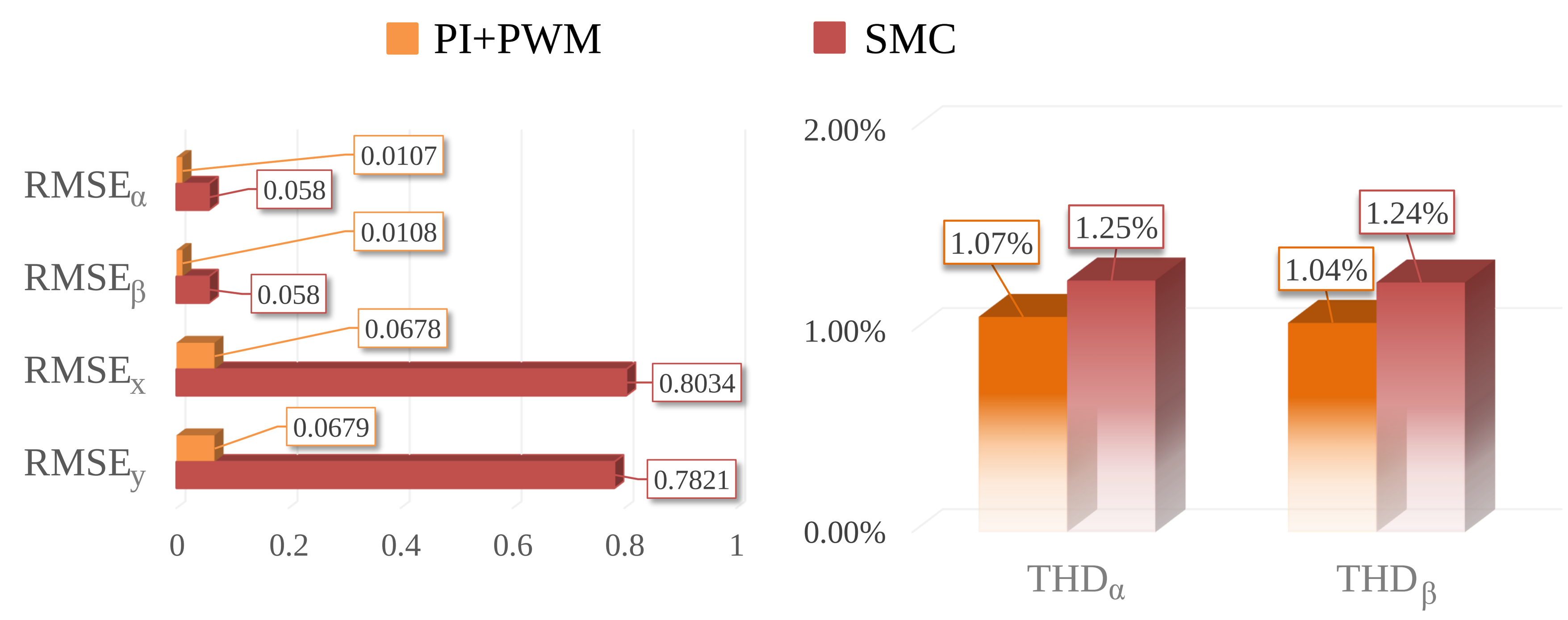

Fig. 4: SMC vs. PI+PWM controller performance: RMSE [A] and THD results at 8 kHz and 500 r/min.

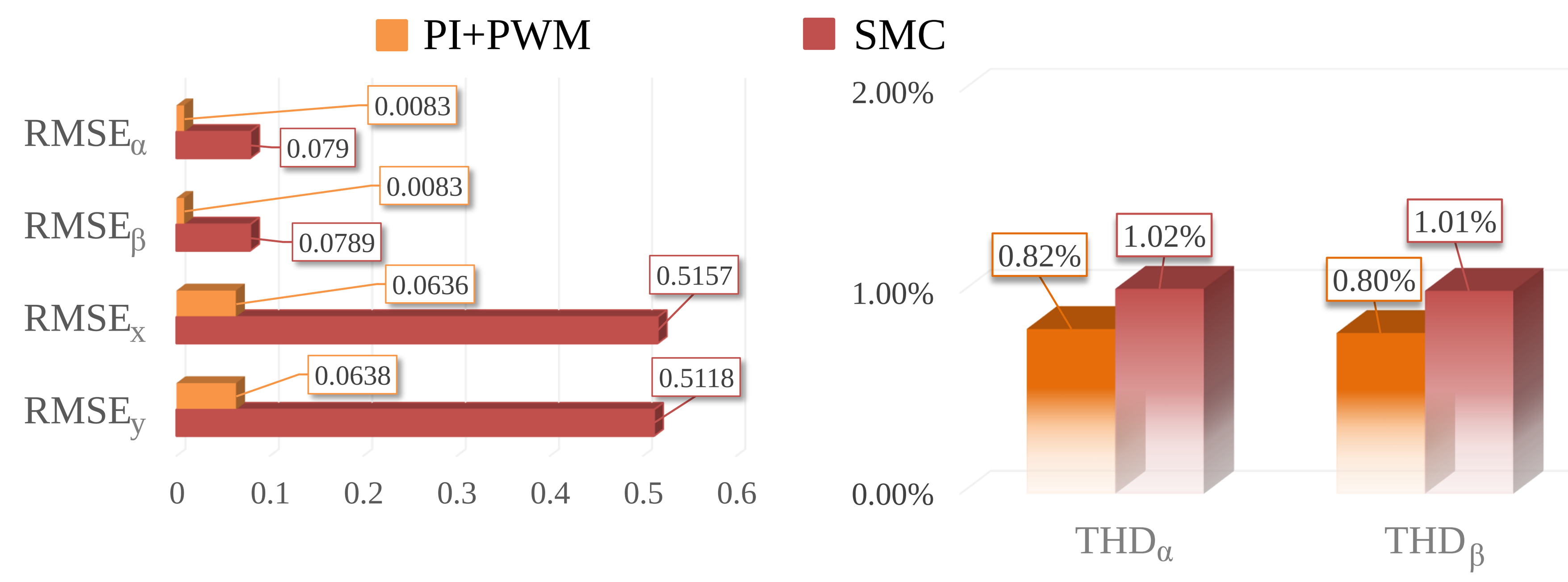

Fig. 5: SMC vs. PI+PWM controller performance: RMSE [A] and THD results at 12 kHz and 1000 r/min.

CONCLUSION

Consequently, PI+PWM emerges as a low-complexity and effective solution for industrial applications with limited computational resources. In contrast, SMC remains advantageous in scenarios requiring strong disturbance rejection and robustness to significant parameter variations.

FUTURE WORK / REFERENCES

Future work includes expanding the comparison of SMC and PI+PWM under different load and speed conditions, and validating the current-control results experimentally to identify potential improvements in parameter tuning and chattering reduction.

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