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Enhanced SVPWM Strategy for Harmonic Suppression in Asymmetrical Six-Phase Induction Machines

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INTRODUCTION

Multiphase induction machines have emerged as an attractive alternative to conventional three-phase systems due to their higher reliability, fault tolerance, and improved power distribution capability. Among them, asymmetrical six-phase induction machines (ASPIMs) are particularly suitable for high-performance applications such as electric transportation and renewable energy systems [1]. Through vector space decomposition (VSD), machine variables are split into the torque-producing α−β subspace and the secondary x−y subspace, mainly linked to harmonic components and additional losses. Therefore, suppressing the x−y components is essential to improve current quality and reduce torque ripple [2]. In this context, this paper proposes an enhanced Space Vector Pulse Width Modulation (SVPWM) strategy to minimize harmonic components in the secondary subspace while preserving proper voltage synthesis in the torque-producing plane. The proposed method achieves lower stator current THD and reduced torque oscillations compared with conventional PWM techniques.

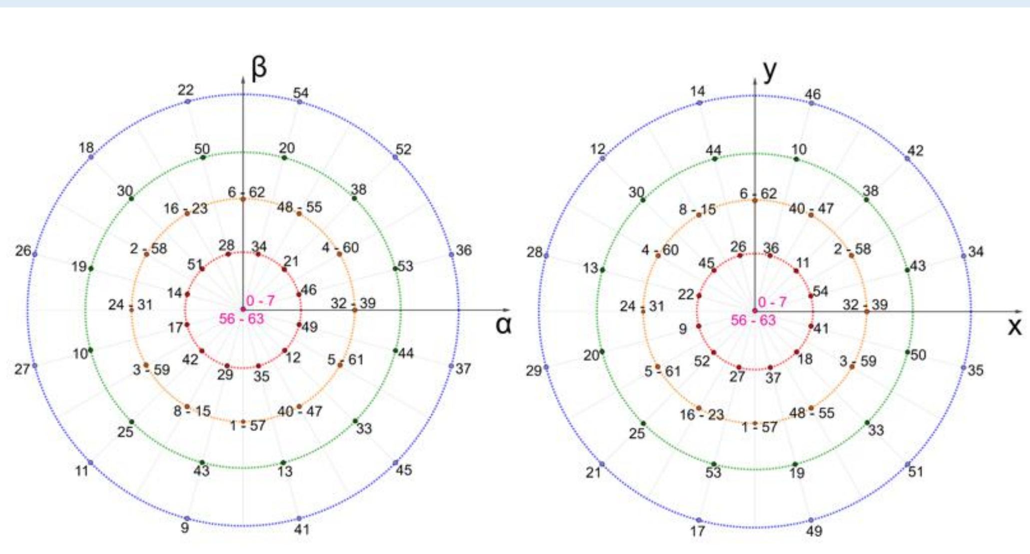

Figure 1 – VSD of the ASPIMs in α−β subspace (left) and x−y subspace (right) [1].

EXPERIMENTAL RESULTS

Comparison of Stator Current THD

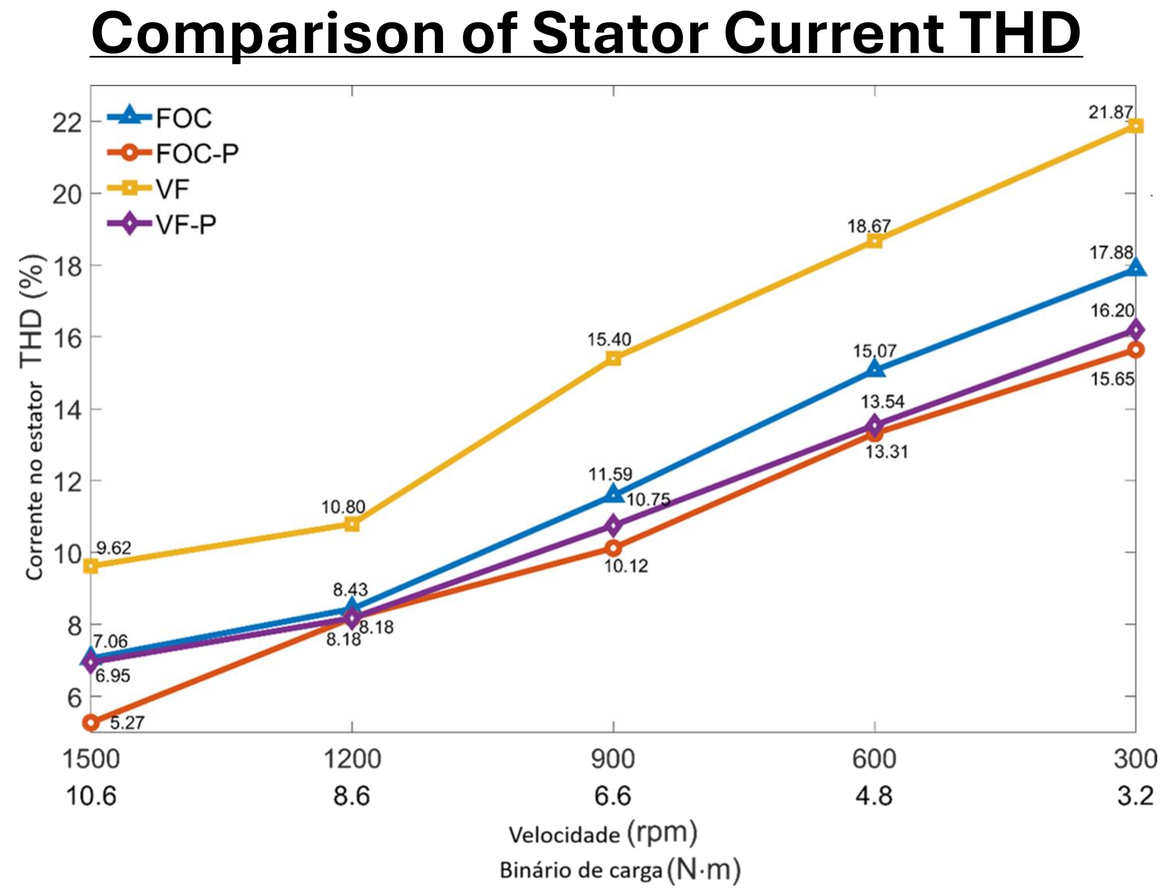

Figure 3 - STFT analysis: healthy condition (left) and fault condition (right), at half load.

Speed Test

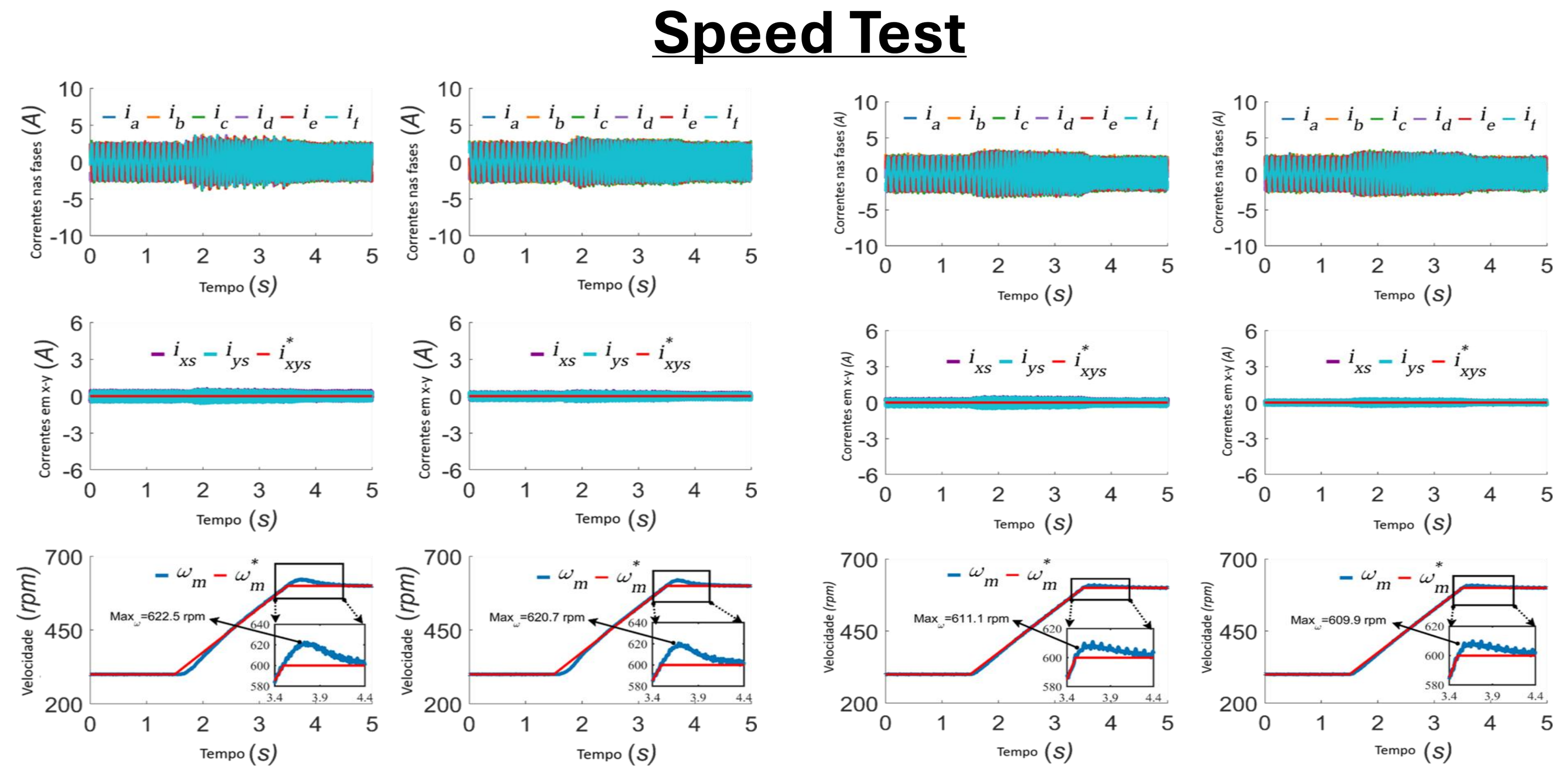

Figure 4 – Classic vs proposed control velocity test - V/f (left) and FOC (right)

Dynamic Test

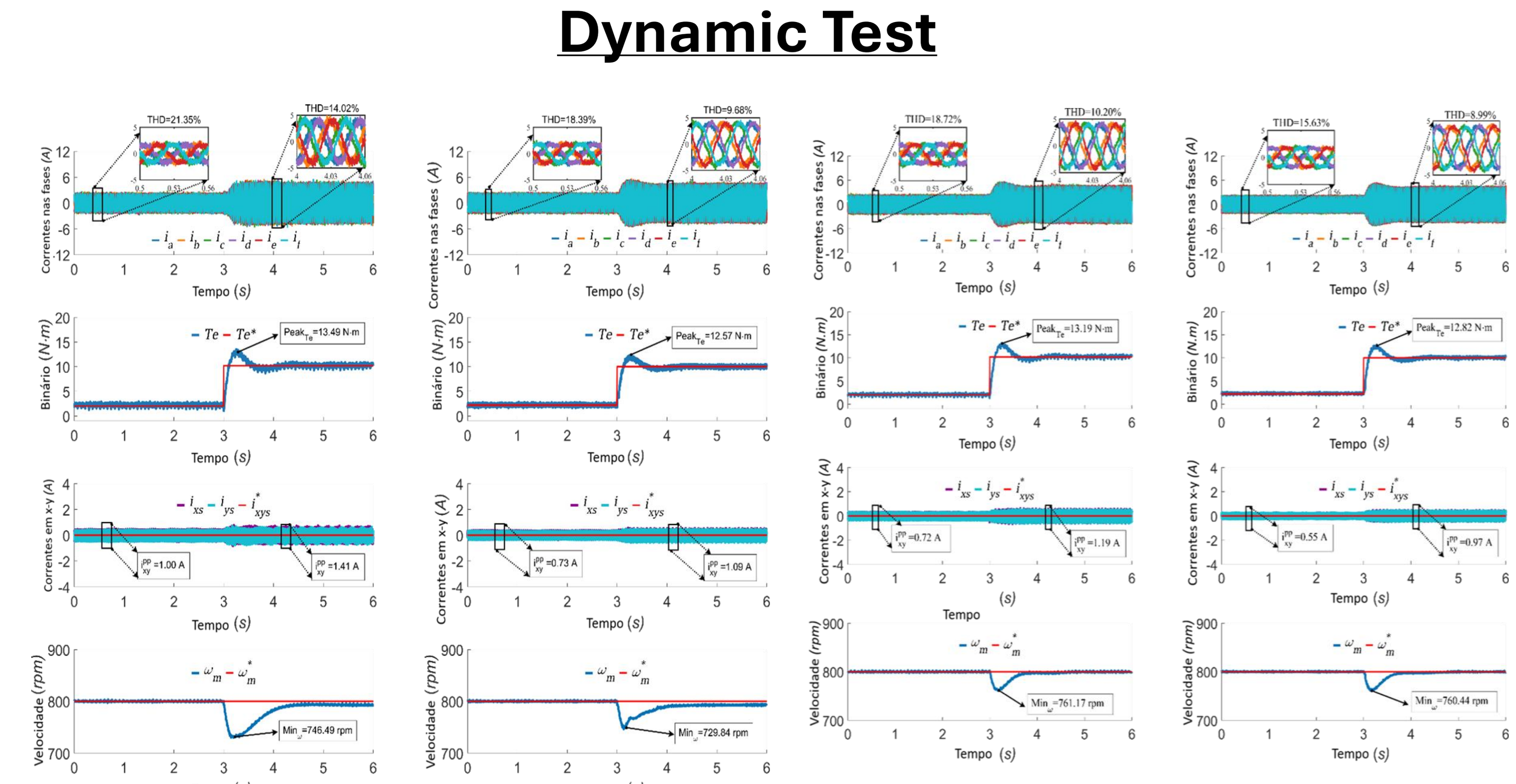

Figure 5 - Classic vs proposed control dynamic test - V/f (left) and FOC (right)

PROPOSED METHOD

The vector space is divided into 12 sectors of 30°, each split into two 15° subsectors (Type A and B), forming 24 regions. In each subsector, selected active and zero vectors are applied to accurately synthesize the reference voltage vector in the α−β plane as given by [3] :

$$\frac{1}{T_{sw}}(t_1V_1 + t_2V_2 + t_3V_3 + t_4V_4 + t_0V_0) = V_{ref}$$

While simultaneously cancelling the components in the x−y subspace as given by [3] :

$$J(t) = \left\| \sum_i t_i v_{i,xy} \right\|^2$$

Finally, duty cycles are computed from the selected vectors and used to generate the IGBT switching signals of the 2L-VSI as given by [3] :

$$D_k = \frac{1}{T_{sw}} (\sum_{i=1}^{6} t_i * s_{k,i})$$

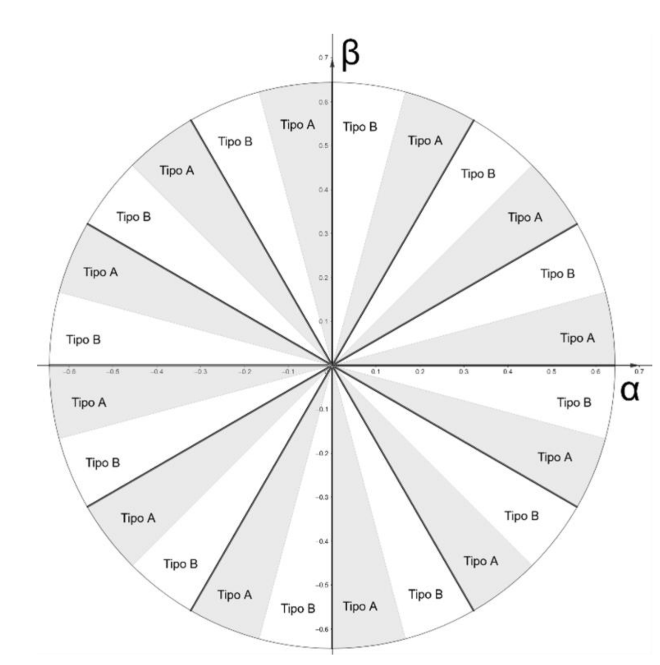

Figure 6 - Type A and Type B subsections and their corresponding mirroring.

CONCLUSIONS

The proposed SVPWM strategy reduces stator current THD and suppresses x−y subspace components, while improving DC-link voltage utilization. As a result, the drive exhibits enhanced efficiency, stability, and current and torque quality.

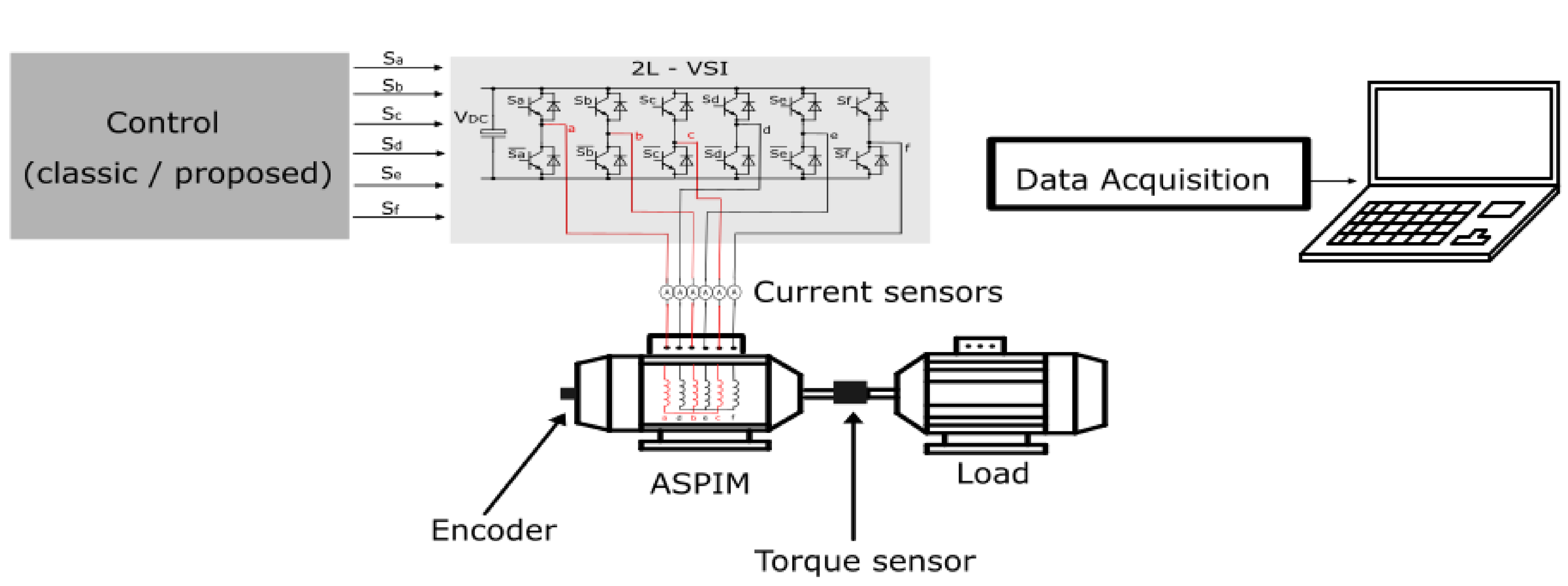

Figure 2 - Block diagram of the experimental setup.

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