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Analysis and Non-Invasive Diagnostics of Bearing Faults in Three-Phase Induction Motors

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INTRODUCTION

Induction motors (IMs) are the most widely used electrical machine in the industry. Within IMs, bearing failures prevail, accounting for 40 % to 50 % of all motor failures. To diagnose these faults, the analysis of the stator electric current is implemented through the application of EPVA (Extended Park's Vector Approach) and STFT (Short-Time Fourier Transform). By hybridizing the two methods, it is intended to guarantee greater reliability in the diagnostics. In addition, the proposed hybrid technique contributes to a non-invasive, simple, and low-cost diagnosis when compared to conventional methods.

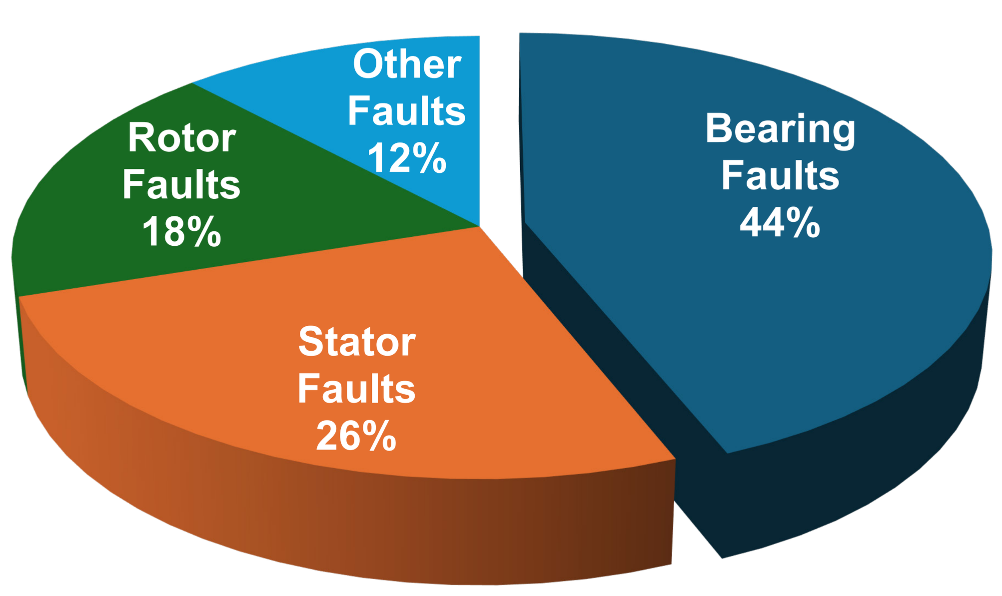

Figure 1 - Distribution of fault classes within three-phase IMs [1].

METHODS [2]

STFT	EPVA
• Analyses only one current.	• Uses the 3 stator currents - Ia, Ib, Ic.
• Analysis in the frequency and time domain.	• Analysis in the frequency domain, based on the Id and Iq modulus.

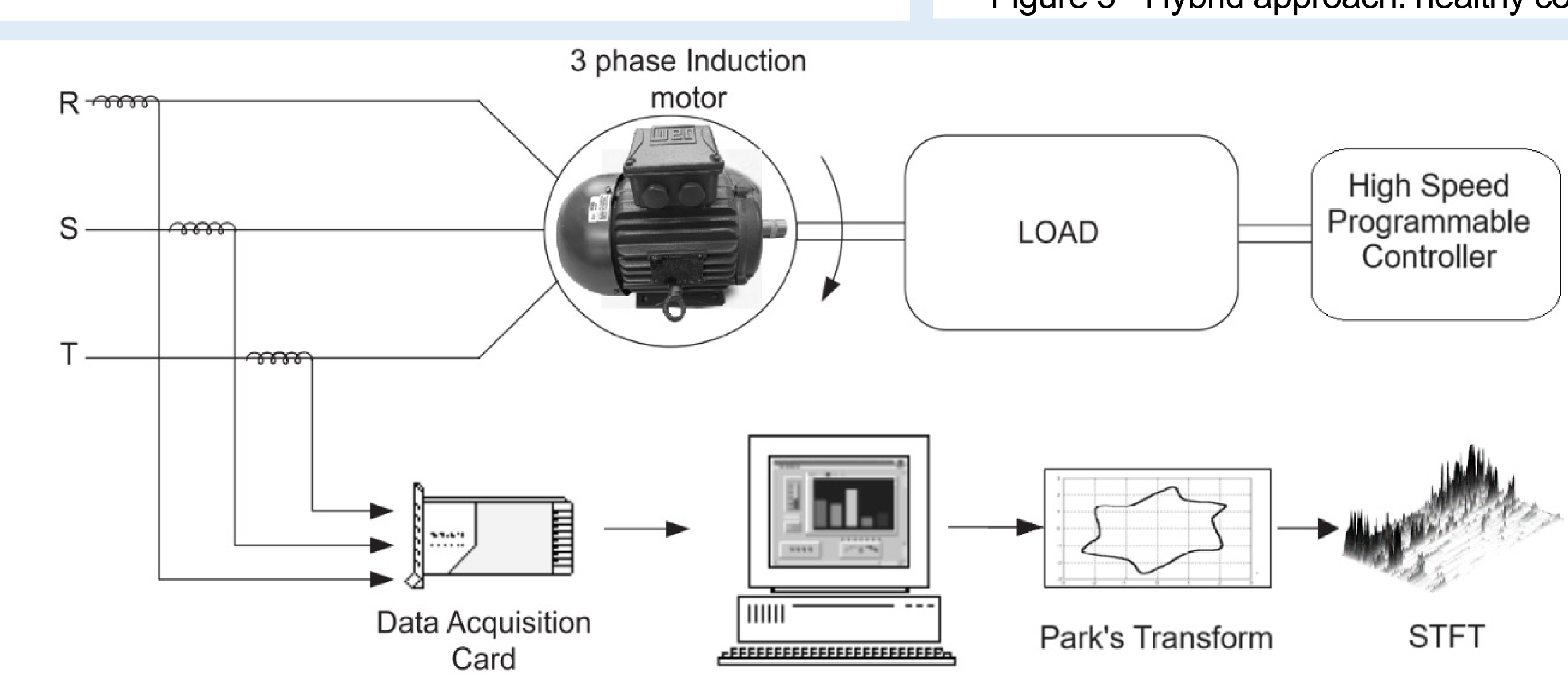

Figure 2 - Block diagram of the experimental setup [3].

EXPERIMENTAL RESULTS

Test 1: STFT

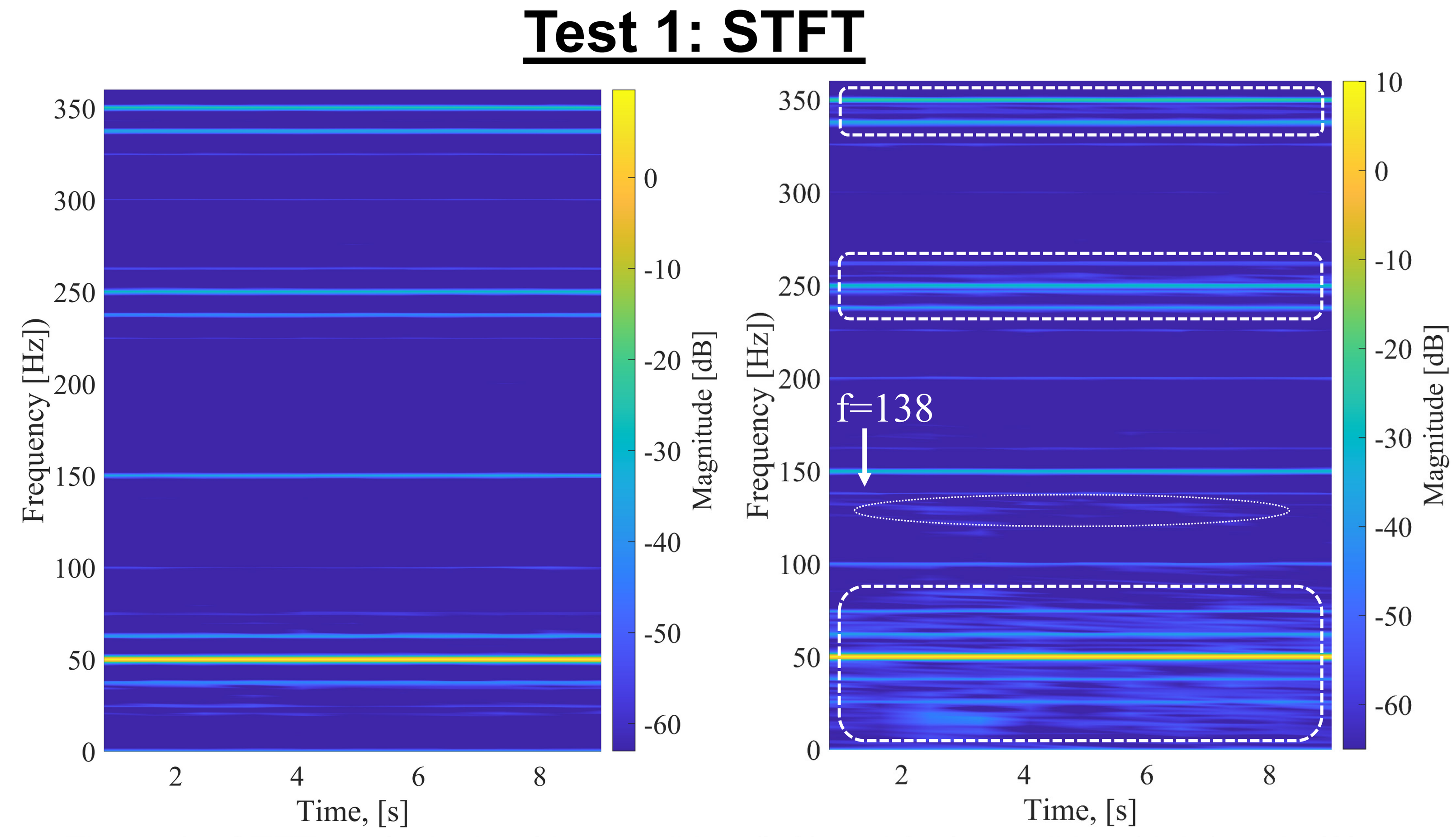

Figure 3 - STFT analysis: healthy condition (left) and fault condition (right), at half load.

Test 2: EPVA

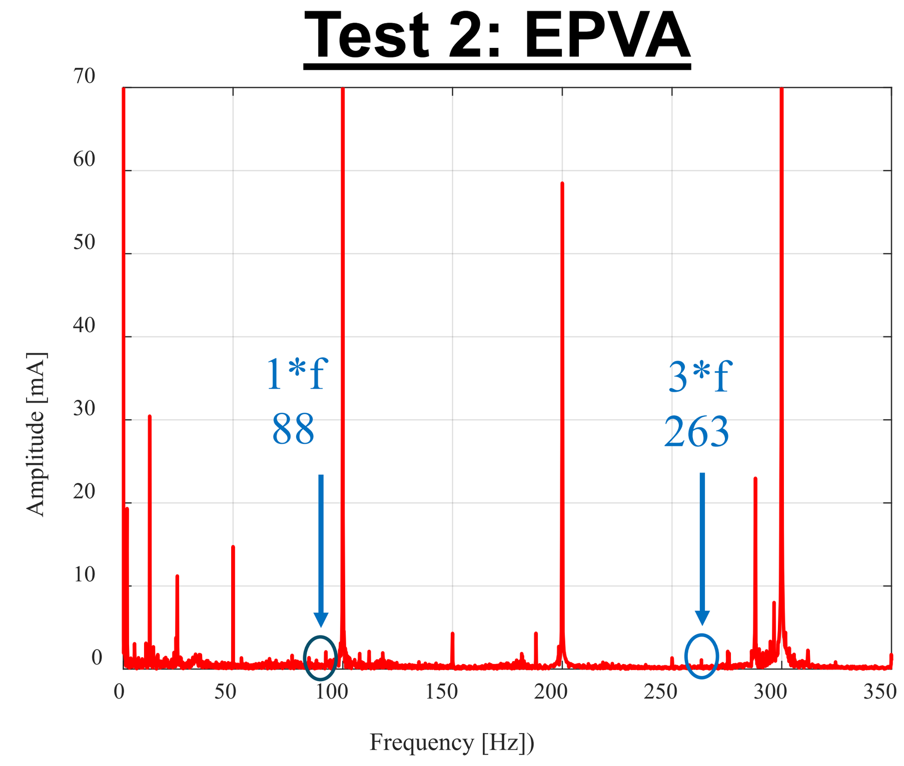

Figure 4 - EPVA analysis: fault condition, at half load.

Bearing failure

Outer race failure with 2 mm hole, SKF bearing 6206-2Z

SKF bearing 6206-2Z	Outer ring f_{bor}
Half load	87.659 Hz

Frequency in the STFT

$$f_{STFT} = |f_s \pm k f_n|$$

Frequency in the EPVA

$$f_{EPVA} = k * f_n$$

$$k = 1, 2, 3, \ldots$$

Test 3: Hybrid approach

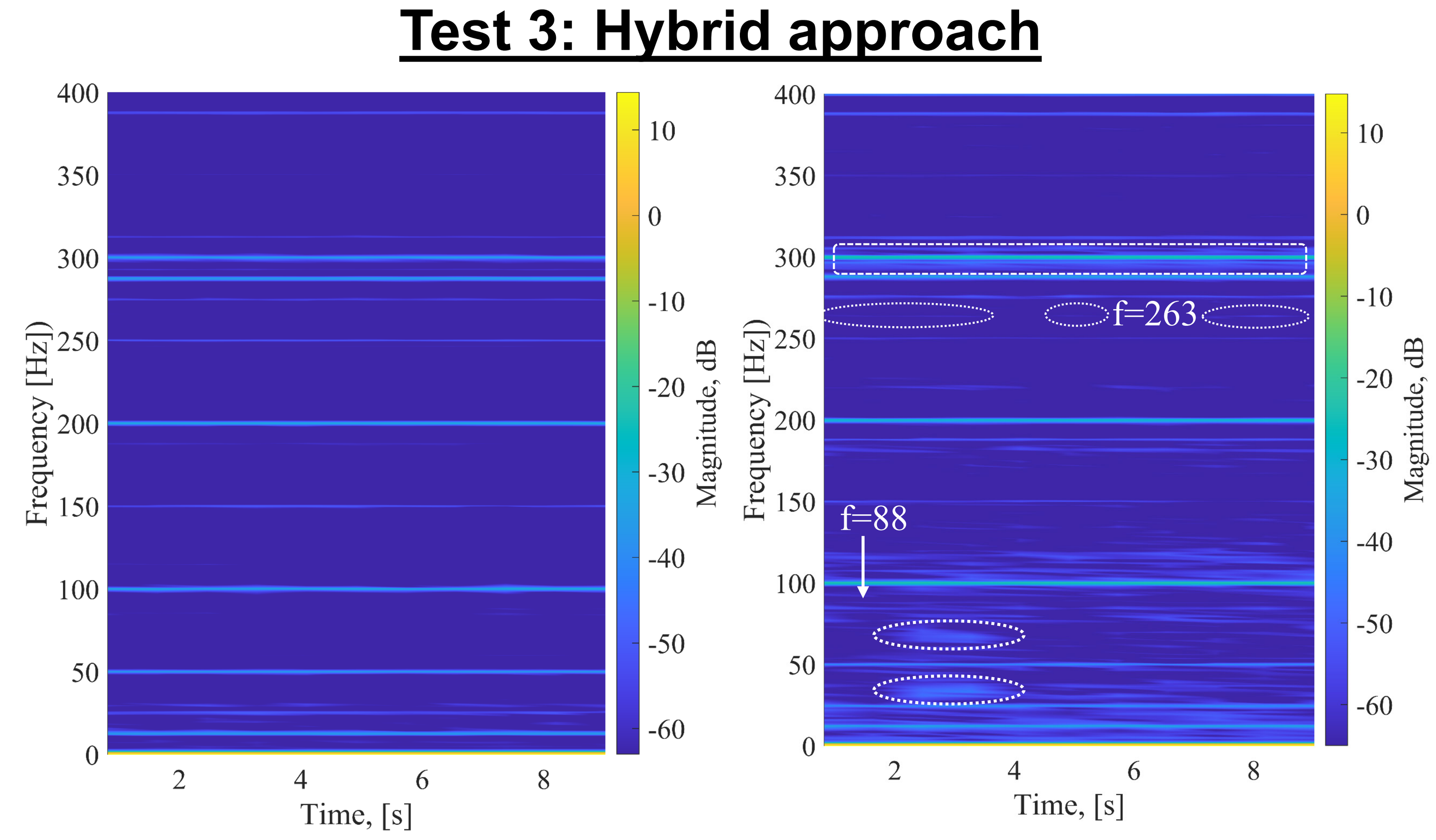

Figure 5 - Hybrid approach: healthy condition (left) and fault condition (right), at half load.

Characteristic frequencies [4]

$$f_{bor} = \frac{N_{cr}.n}{2} * \left(1 - \frac{D_{cr}}{D_p} * cos\beta\right)$$

$$f_{bir} = \frac{N_{cr}.n}{2} * \left(1 + \frac{D_{cr}}{D_p} * cos\beta\right)$$

$$f_{bs} = \frac{D_p.n}{2 * D_{cr}} * \left(1 - \left(\frac{D_{cr}}{D_p} * cos\beta\right)^2\right)$$

$$f_{ft} = \frac{n}{2} * \left(1 - \frac{D_{cr}}{D_p} * cos\beta\right)$$

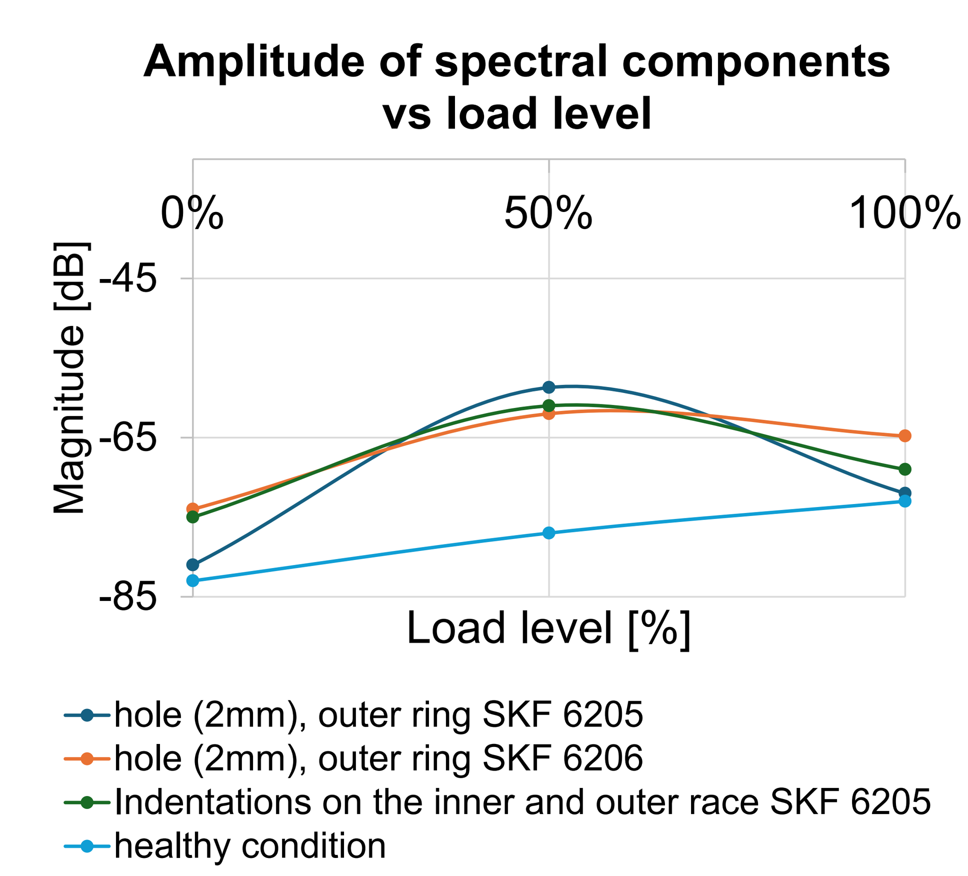

Figure 6 - Energy increase, for the f_{bor} with respect to the load level through hybrid analysis.

CONCLUSIONS

In the STFT analysis, an increase in energy at the characteristic frequency of 88 Hz was observed, with wide bands and increased energy in the low frequencies and around the harmonics of 250 Hz and 350 Hz. The EPVA showed small frequency peaks at 88 Hz, but they were not very perceptible. The hybrid method succeeds as long as the EPVA provides good results, distinguishing the resulting frequencies in the EPVA, as well as the increases in bandwidth and energy in the low frequencies and the harmonic of 300 Hz.

REFERENCES

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