Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 9, S. 37-44, 2, 2025

Araştırma Makalesi

https://as-proceeding.com/index.php/ijanser
ISSN:2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 9, pp. 37-44, 2, 2025

Research Article

Examination of Differential-Mode Characteristics in Single-Phase Induction Motors

Mohamed Miloudi [1,2*], Houcine Miloudi [2], Bendaoud Abdelber [2], Mohammed Hamza Bermaki [2], Abdelkader Gourbi [2,3], Mohammed El Amine Lahlaci [1,2], Yassine Hakmi [1]

[1]*GIDD Laboratory, Electrical Engineering and Automation Department, Relizane University, Relizane, Algeria*
[2]*APELEC Laboratory, Electrical Engineering Department, Djillali Liabes University, Sidi Bel Abbes, Algeria*
[3]*Institute of Science and Applied Techniques, Ahmed Ben Bella Oran 1 University, Oran, Algeria*

[*]*(mohamed.miloudi@univ-relizane.dz) Email of the corresponding author*

https://orcid.org/0000-0002-1283-4796.

(Received: 31 January 2025, Accepted: 03 February 2025)

(2nd International Conference on Pioneer and Innovative Studies ICPIS 2025, January 30-31, 2025)

ATIF/REFERENCE: Miloudi, M., Miloudi, H., Abdelber, B., Bermaki, M. H., Gourbi, A., Lahlaci, M. E. A. & Hakmi, Y. (2025). Examination of Differential-Mode Characteristics in Single-Phase Induction Motors. *International Journal of Advanced Natural Sciences and Engineering Researches*, 9(2), 37-44.

Abstract **–**This study explores the high-frequency impedance characteristics of four distinct types of single-phase induction motors: Split-Phase Induction Motor (SPIM), Permanent Split Capacitor Induction Motor (PCIM), Capacitor Start Induction Motor (CSIM), and Single-Phase Repulsion Motor (RIM). The focus is on analyzing differential-mode impedance and phase angle behavior across a broad frequency spectrum, with particular attention to resonance and anti-resonance points. Experimental results reveal unique impedance profiles for each motor type. Notably, the RIM consistently exhibits the highest impedance, while the CSIM shows lower impedance at lower frequencies. These impedance variations emphasize the significant role of motor design in Electromagnetic Compatibility (EMC). Motors with higher impedance, like the RIM, generally exhibit lower Electromagnetic Interference (EMI) emissions and better resistance to external electromagnetic disturbances, leading to superior EMC performance. Additionally, the resonance and anti-resonance frequencies differ across motor types, reflecting their varied electrical and structural designs. These findings highlight the crucial impact of motor design on electromagnetic characteristics. The insights gained from this study can guide the optimization of motor designs to enhance EMC compliance and ensure greater operational stability in applications where electromagnetic interference and compatibility are critical.

Keywords –Differential-Mode Impedance, Single-Phase Induction Motors, Electromagnetic Interference (EMI), Impedance Analysis, EMC Regulations, Resonant Frequency.

I. INTRODUCTION

Electromagnetic Interference (EMI) has become a critical issue in modern electrical engineering [1]–[8], especially with the growing adoption of Adjustable Speed Drives (ASDs) and electric motors across diverse industrial applications [9]–[14]. As these technologies evolve in complexity and application, managing EMI has become increasingly challenging.

This paper addresses a key aspect of this issue: Differential Mode (DM) behavior in motor systems. DM currents and voltages not only degrade system performance but also pose a risk to the surrounding electromagnetic environment, requiring special measures to mitigate such interference [15]. With international EMC standards becoming more stringent [16]–[18], understanding the mechanisms behind EMI, particularly in motor systems, is essential. It is equally important to manage DM interference not only to comply with EMC standards but also to maintain the reliability and safety of electrical systems. A thorough investigation of DM interference lays the foundation for developing effective EMI mitigation strategies, which are vital for the long-term performance and integrity of electrical systems in industrial settings [19]–[21]. Effective EMI management in motor systems goes beyond compliance and ensures the overall stability and efficiency of electrical infrastructure [22]–[24].

The importance of controlling EMI in motor systems is highlighted by numerous recent studies focused on energy efficiency and high-performance systems. For instance, Yashu Swami discusses the need for specialized design standards in low-power embedded systems to ensure both energy savings and robust electromagnetic performance [25]. Additionally, [26] analyze the performance of multilayer drivers in high-voltage applications regarding EMI issues, and [27] demonstrate the critical role of EMI control in sustaining the operation of smart production systems. These findings are directly applicable to single-phase induction motors, which are increasingly utilized in industrial applications where managing EMI is essential for maintaining reliable performance.

EMI management is crucial not only in low-power and medium-voltage systems but also in modern motor-driven industrial applications [28]. This highlights the need for a comprehensive approach to EMI control that considers a wide range of applications and ensures electrical systems meet stringent EMC requirements. By understanding DM EMI dynamics, engineers can design systems that address both current and future EMC challenges, protecting industrial processes and ensuring long-term operational stability.

Single-phase induction motors are widely used in applications ranging from household appliances like refrigerators, washing machines, and air conditioners to power tools and industrial machinery. These motors are in high demand due to their reliability and efficiency. However, they can face significant challenges with electromagnetic compatibility (EMC), particularly when the surrounding electromagnetic environment impacts their performance and reliability [11, 28].

One major form of EMC is differential-mode EMI, which occurs when noise travels through the phase and neutral conductors in an electrical system. Differential-mode EMI propagates along the power lines instead of the grounding conductor, significantly affecting the performance of electrical and electronic devices. This type of EMI can cause motor current and voltage waveforms to distort, leading to decreased efficiency, excess heat, and potential damage to the windings. It can also introduce electrical noise, increase vibrations, and produce audible sounds, all of which contribute to mechanical wear and early component failure [4, 11]. Moreover, EMI can interfere with motor control circuits, disrupting normal operations, including speed control and start/stop functions [24]. Additionally, it introduces harmonics into the power supply, reducing motor performance while increasing energy consumption and operational costs [23].

A motor's impedance, or its resistance to current flow, plays a key role in determining its DM behavior and impacts its EMC performance. Motors with higher impedance typically generate lower EMI emissions, and vice versa. Although single-phase induction motors are widely used, the issue of EMI in these motors has received less attention compared to three-phase motors, which are more commonly used in industrial settings where EMI is a significant concern [11, 28]. However, as single-phase motors are being used more frequently in environments where EMI management is crucial, there is a gap in research on their EMC performance.

This paper provides a comparative analysis of the differential-mode impedance across four different types of single-phase induction motors and explores their correlation with EMI emissions. The variations in impedance among these motors are analyzed to understand how impedance affects their EMI behavior. The findings of this study offer valuable insights for motor designers, helping to create motors that minimize the risk of EMI-related issues.

II. MATERIALS AND METHOD

The four motors examined in this study each have distinct configurations and wiring layouts, which result in different electromagnetic compatibility (EMC) behaviors. Since impedance is a key factor in determining a motor's EMC performance, this research aims to conduct a comparative analysis of the differential-mode impedance across these various electric induction motor types.

This section outlines the experimental methodology used to study the differential-mode impedance of four different induction motor types: Split-Phase Induction Motor (SPIM), Permanent Capacitor Induction Motor (PCIM), Capacitor Start Induction Motor (CSIM), and Single-Phase Repulsion Motor (RIM). To measure the impedance, we employed a Wayne Kerr 6500B spectrum analyzer, capable of detecting impedance and phase angles up to 120 MHz. This analyzer was chosen for its precision, particularly in the critical EMC frequency range from 150 kHz to 30 MHz. Prior to each testing cycle, the analyzer was calibrated to ensure accurate measurements and minimize drift.

Figure 1 demonstrates the experimental setup used for differential-mode impedance testing. All motor types were evaluated using this arrangement to ensure consistent and accurate measurements.

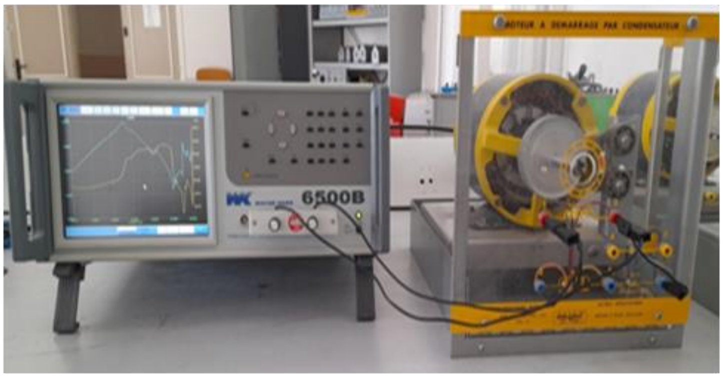

Fig. 1 Experimental Configuration for Measuring Differential-Mode Impedance in Relation to EMC and EMI Performance

The impedance measurement process followed a structured approach to capture the differential-mode EMC characteristics:

1. Environmental Control: A controlled testing environment, free of external electromagnetic interference, was established to ensure precise measurements.
2. Terminal Component Fixture (TCF): Each motor type was connected to a TCF, ensuring stable connections and proper impedance matching, which are essential for reliable measurements.
3. Calibration: The Wayne Kerr 6500B analyzer was recalibrated between tests to guarantee measurement consistency. Calibration data were stored and compared across tests to verify repeatability.
4. Frequency Sweep: A frequency sweep was conducted, ranging from 150 kHz to 30 MHz, in line with EMC standards. This enabled a thorough examination of impedance variations across the relevant operational frequencies.
5. Stability: Each frequency point was allowed to stabilize before recording measurements, preventing transient responses from influencing results. Multiple sweeps were conducted to ensure reliability and repeatability.
6. Data Collection: Impedance magnitude and phase angles were recorded at specific frequency points within the sweep range.
7. Data Analysis: The impedance data for each motor type were plotted to visualize their frequency-dependent behavior. This analysis helped identify resonant frequencies, indicated by impedance peaks, and highlighted critical impedance values that could potentially affect differential-mode EMC performance. By comparing the impedance profiles of different motors, we gained insights into how design differences influence their EMC characteristics.

III. RESULTS

In this section, we present a detailed analysis of the experimental results, focusing on the differential-mode impedance behavior of four types of electric induction motors: Split-Phase Induction Motor (SPIM), Permanent Split Capacitor Induction Motor (PCIM), Capacitor Start Induction Motor (CSIM), and Single-phase Repulsion Motor (RIM). Figures 2 and 3 illustrate the impedance and phase angle profiles of each motor across a frequency range of 150 kHz to 30 MHz. This analysis reveals both similarities and differences in the electromagnetic compatibility (EMC) characteristics of each motor.

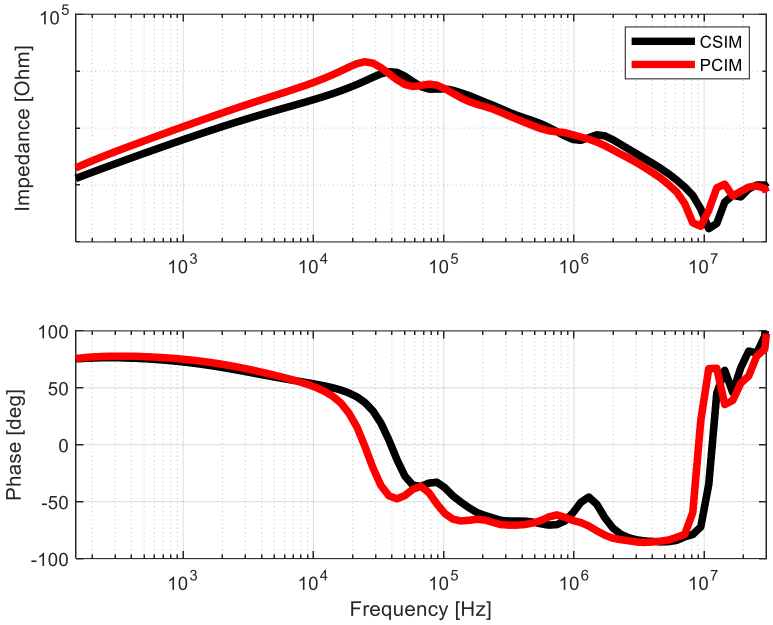

Fig. 2 DM Impedance and Phase Angle Analysis of CSIM and PCIM Motors in EMC and EMI Contexts

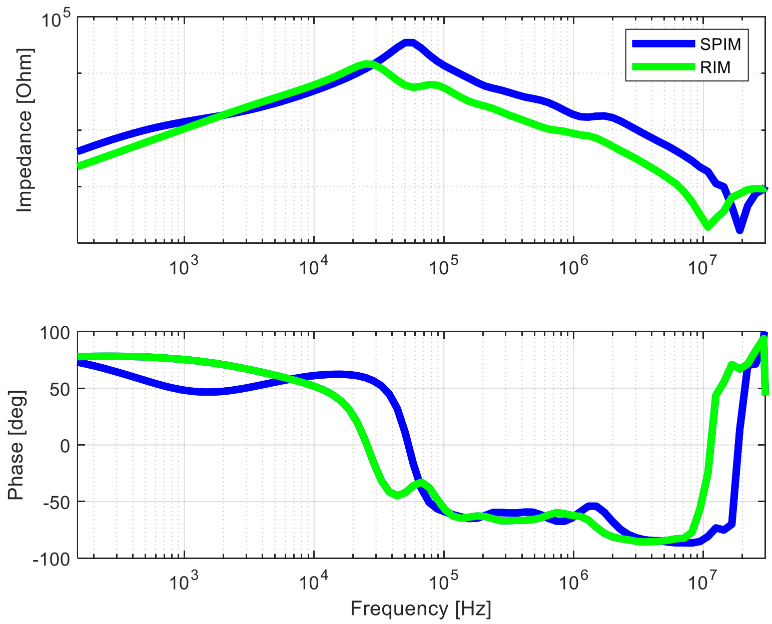

Fig. 3 DM Impedance and Phase Angle Analysis of SPIM and RIM Motors in EMC and EMI Contexts

As we examine the impedance characteristics, we observe that all four motor types exhibit an increase in impedance with frequency up to the resonance frequency (f_1). At f1, each motor shows a peak in impedance, indicating resonance. The resonance frequencies for each motor are as follows: 37.936 kHz for CSIM, 24.822 kHz for both PCIM and SPIM, and 50.334 kHz for RIM. Corresponding impedance values at f1 are 9.76 kΩ for CSIM, 14.61 kΩ for PCIM, 14.66 kΩ for SPIM, and 34.88 kΩ for RIM. The phase angles at f1 differ, with CSIM at 4.10°, PCIM at -1.50°, SPIM at 3.74°, and RIM at 10.87°.

After f_1, the impedance decreases until reaching its minimum value at the antiresonance frequency (f_2). The antiresonance frequencies are 10.846 MHz for CSIM, 9.416 MHz for PCIM, 10.846 MHz for SPIM, and 19.094 MHz for RIM. The impedance values at f2 are 17.10 Ω for CSIM, 18.87 Ω for PCIM, 19.26 Ω for SPIM, and 16.83 Ω for RIM. Despite the impedance being at its minimum, the phase angles at f_2 remain non-zero, with values of -34.79° for CSIM, 21.17° for PCIM, -24.94° for SPIM, and 13.86° for RIM.

Figures 2 and 3 provide a comparative overview of the impedance and phase angles for all four motor types, summarizing the key similarities and differences.

- From 100 Hz to f_1, all motor types show an increase in impedance as frequency rises. This is characteristic of inductive behavior, as the inductance of the motor windings becomes more significant at higher frequencies. The phase angles are positive, indicating that voltage leads current.
- At f_1, all motor types exhibit a peak in impedance, marking resonance. The phase angle is positive for CSIM and SPIM, suggesting a leading nature, while PCIM shows a slight negative phase angle, likely due to its capacitor. RIM exhibits a significantly positive phase angle.
- After f_1, the impedance decreases and reaches its minimum at the antiresonance frequency f_2. In this range, the phase angle turns negative, indicating capacitive behavior.
- At f_2, the impedance is at its minimum, but the phase angle remains non-zero, highlighting the ongoing influence of reactive components.
- Beyond f_2, the impedance increases, and the phase angle becomes positive again, reflecting a return to inductive behavior at high frequencies.

- The RIM consistently exhibits higher impedance than the other motor types, likely due to its unique winding configuration or mechanical design.
- The CSIM shows lower impedance at low frequencies, a result of its start capacitor design.
- Beyond the first resonance frequency f_1, impedance behavior diverges. PCIM generally exhibits the lowest impedance, while RIM retains the highest value.
- The resonance frequency f_1 varies across motor types, with SPIM having the lowest value, followed by CSIM and RIM. The antiresonance frequency f_2 is lowest for PCIM, followed by CSIM and SPIM with similar values, while RIM shows the highest value.

IV. DISCUSSION

The impedance characteristics of electric motors play a crucial role in determining their electromagnetic compatibility (EMC) performance. Higher impedance typically results in better EMC, as it minimizes electromagnetic interference (EMI) emissions and reduces susceptibility to external EMI sources. Engineers with a strong understanding of the impact of differential-mode impedance on EMI behavior can design motors that meet the stringent EMC requirements in applications such as electric vehicles, industrial automation, and smart power grids.

Across the frequency spectrum, the Single-phase Repulsion Motor (RIM) consistently shows higher impedance values, making it highly suitable for EMC compliance. Increased impedance helps reduce the flow of currents induced by external electromagnetic fields, thereby making the motor less vulnerable to EMI. This characteristic is essential for ensuring the motor's performance in power grids, where operational stability and reliability are paramount. Motors like RIM can reduce harmonic distortions and electromagnetic disturbances that interfere with critical electrical equipment, such as power transformers and inverters. Therefore, RIMs are well-suited for environments where strict EMC compliance is necessary, particularly in urban and industrial areas prone to electrical disturbances.

On the other hand, the Capacitor Start Induction Motor (CSIM) has lower impedance at low frequencies, making it more susceptible to EMI. This lower impedance may lead to higher EMI emissions, especially in applications requiring high-precision signal transmission, such as sensor networks. In such cases, the low impedance of the CSIM can lead to data transmission errors, communication failures, or disruptions in network performance. However, the start capacitor within the CSIM plays a role in managing phase angles during startup, which may help mitigate some of the EMI challenges. For enhanced EMC performance in CSIMs, additional measures, such as improved shielding or filtering, may be necessary, particularly in applications requiring low-frequency EMI control.

Motors like the Permanent Split Capacitor Induction Motor (PCIM) and Split-Phase Induction Motor (SPIM) exhibit similar impedance characteristics up to the resonance frequency (f_1), suggesting that their EMC performances are comparable in low-frequency operations. These motors are ideal for applications that do not require strict EMI control, such as consumer electronics and small industrial machinery. However, above the resonance frequency, the impedance profiles of PCIM and SPIM diverge, with PCIM displaying lower impedance. This necessitates customized EMC mitigation strategies for high-frequency operations, particularly in sensitive applications like automated manufacturing systems, where EMI can disrupt complex processes.

At high frequencies, the impedance profiles of motors become even more significant for EMC performance. In environments with high electromagnetic radiation, such as smart grids or sensor networks, motors like the RIM, with higher impedance at high frequencies, will be less susceptible to external EMI. This makes RIMs ideal for applications requiring continuous monitoring and control, such as sensor-based industrial networks or distributed energy management. In contrast, motors like the CSIM, with lower impedance at high frequencies, may require additional EMC measures to maintain reliability in these environments.

To achieve optimal EMC compliance in motor design, it is essential to understand impedance behavior across a wide frequency range. Motors like RIM, designed for high impedance, offer advantages in minimizing both EMI emissions and susceptibility, making them suitable for power grids and industrial automation. Meanwhile, motors with lower impedance, such as CSIMs, can benefit from additional components like capacitors, shielding, and filtering to enhance their EMC performance in applications like sensor networks or consumer electronics. The choice of motor should therefore align with specific application requirements and the surrounding electromagnetic environment to ensure the best possible EMC compliance and system performance.

The consistency of the results was ensured through repeated testing using precise instruments, such as the Wayne Kerr 6500B analyzer. These reliable impedance profiles, obtained across multiple tests and frequency ranges, reflect the fundamental electrical characteristics of the motors. Consequently, further studies into numerical modeling techniques to optimize motor designs for better EMC performance are well-justified.

V. CONCLUSION

This study examines the differential-mode impedance characteristics of four types of single-phase induction motors: Split-Phase Induction Motor (SPIM), Permanent Split Capacitor Induction Motor (PCIM), Capacitor Start Induction Motor (CSIM), and Single-Phase Repulsion Motor (RIM) over a frequency range of 150 kHz to 30 MHz. The results revealed distinct impedance and phase angle profiles, highlighting their impact on electromagnetic compatibility (EMC) and electromagnetic interference (EMI) performance.

The RIM exhibited higher impedance, making it suitable for applications in industrial automation systems and power grids, where stringent EMC compliance is necessary. The CSIM, with its lower impedance at low frequencies due to its start capacitor, is more susceptible to EMI, requiring additional mitigation strategies in environments like sensor networks. The PCIM demonstrated lower impedance beyond its first resonance frequency, indicating a need for high-frequency EMI mitigation strategies, making it ideal for low-EMI applications such as consumer electronics.

The SPIM and PCIM showed similar impedance profiles at lower frequencies, suggesting interchangeable solutions with comparable EMC behavior. The study also revealed significant phase angle variations at resonance and anti-resonance frequencies, offering insights into the motors' electromagnetic behavior.

The findings emphasize the role of impedance in determining a motor's EMC performance and contribute to optimizing motor design for compliance with EMC regulations. Future work will include numerical simulations to further explore how motor design influences EMC performance under different conditions.

ACKNOWLEDGMENT

This research was conducted with the support of the APELEC Laboratory at Djillali LIABES University, Sidi Bel Abbes, Algeria.

REFERENCES

[1] Mohamed Miloudi, Abdelber Bendaoud, Houcine Miloudi, "*Common and Differential Modes of Conducted Electromagnetic Interference in Switching Power Converters*", Revue Roum. Sci. Techn. (RRST), ISSN: 0035–4066, Vol.62 (3): pp.246–251, 2017.

[2] Mohammed Elamine Lahlaci, Mohamed Miloudi, Houcine Miloudi, "*Experimental electromagnetic compatibility of conducted electromagnetic interferences from an IGBT and a MOSFET in the power supply*", Electrical Engineering & Electromechanics Journal, ISSN: 2074-272X, Vol.3, pp.3–7, 2024. DOI: 10.20998/2074-272X.2024.3.05.

[3] Benhadda Nassireddine, Abdelber Bendaoud, Mohamed Miloudi, Benazza Baghdadi, Belhenini Soufyane, "*Conducted Differential-Mode Emission from Buck Converter*", International Journal of Electronics and Electrical Engineering Systems, ISSN: 2602–7437, Vol.4 (1), pp.24–28, 2021.

[4] Abdelkader Gourbi, Mohamed Miloudi, Mostefa Brahami. *Analysis of Hybrid Photovoltaic System Performanc*e. Advances in Green Energies and Materials Technology: Selected Articles from the Algerian Symposium on Renewable Energy and Materials, 2021.

[5] Mohamed Miloudi, Abdelber Bendaoud, Houcine Miloudi, "*Characterization of Differential–Mode and Common–Mode EMI Noise in a Flyback Switched–Mode Power Supply (SMPS)*", 20th Telecommunications Forum TELFOR'2012, 20–22 November 2012, Belgrade, Serbia. DOI: 10.1109/TELFOR.2012.6419398

[6] Benhadda Nassireddine, Abdelber Bendaoud, Mohamed Miloudi, Benazza Baghdadi, Belhenini Soufyane, "*Buck Converter Common-Mode Emission with the Frequency Approach*", International Journal of Electronics and Electrical Engineering Systems, ISSN: 2602–7437, Vol.3 (1), pp.24–28, 2020.

[7] Abdelkader Gourbi, Mohamed Miloudi, Houcine Miloudi, "*An investigation and analysis of a hybrid photovoltaic system for power supply*", Ingeniería Energética Journal, ISSN: 1815-5901, Vol.43 (3), pp.1–11, 2022.

[8] Mohamed Miloudi, Abdelber Bendaoud, Houcine Miloudi, Said Nemmich, M. Okli, "*Characterization of Conducted Electromagnetic Interference (EMI) Generayed by Switch Mode Power Supply (SMPS)*", The 7th International Conference on Electrical Engineering: 08–10 Novembre 2012, Batna, Algeria.

[9] H. Miloudi, A. Bendaoud, M. Miloudi, S. Dickmann; S. Schenke, "*Common Mode and Differential Mode Characteristics of AC Motor for EMC Analysis*", International Symposium on Electromagnetic Compatibility – EMC EUROPE 2016, September 5–9, 2016, Wroclaw, Poland. DOI: 10.1109/EMCEurope.2016.7739260

[10] Houcine Miloudi, Mohamed Miloudi, Abdelber Bendaoud, "*A Method for Modeling a Common–Mode Impedance for the AC Motor*", Journal of Electrical Engineering and Computer Science (JEECS), ISSN: 0013–5852, Vol.84 (5): pp.241–246, 2017.

[11] Houcine Miloudi, Mohamed Miloudi, Sid Ahmed El Mehdi Ardjoun, Mohamed Metwally Mahmoud, Ahmad A. Telba, Mouloud Denaï, Usama Khaled, and Ahmed M. Ewias, "*Electromagnetic Compatibility Characterization of Start-Capacitor Single-Phase Induction Motor*", IEEE Access Journal, ISSN: 2169-3536, Vol.12, pp.2313–2316, 2024. DOI: 10.1109/ACCESS.2023.3349018

[12] Mohamed Miloudi, Houcine Miloudi, Abdelber Bendaoud, Mohammed Adnan Salhi, Ahmad N. Al–Omari, "*Experimental Characterization of the High–Frequency Isolating Power Transformer*", Journal of Electrical Engineering and Computer Science (JEECS) ISSN: 0013–5852, Vol.86 (4), pp.211–218, 2019.

[13] H. Miloudi, A. Bendaoud, M. Miloudi, A. Gourbi, H. Slimani, "*Common Mode Conducted Electromagnetic Interference in Inverter – Fed – AC – Motor*", Electrical and Electronics Engineers Review (EEER), ISSN: 0033–2097, pp.271–275, 2010.

[14] H. Miloudi, A. Bendaoud, M. Miloudi, S. Dickmann, S. Schenke, "*A Novel Method of Transfer–Function Identification for Modeling DM Impedance of AC Motor*", International Symposium on Electromagnetic Compatibility – EMC EUROPE 2017, September 4–8, 2017, Angers, France. DOI: 10.1109/EMCEurope.2017.8094770

[15] H Miloudi, A Bendaoud, M Miloudi. *Réduction des perturbation électromagnétique conduites dans la machine asynchrone.* Mediterranean Journal of Modeling and Simulation 2 (1), 8-15. 2014.

[16] Houcine Miloudi, Mohamed Miloudi, Abdelkader Gourbi, Mohamed Hamza Bermaki, Abdelber Bendaoud, Abdelhakim Zeghoudi, "*A high-frequency modeling of AC motor in a frequency range from 40 Hz to 110 MHz*", Electrical Engineering & Electromechanics Journal, ISSN: 2074-272X, Vol.6, pp.3–7, 2022. DOI: 10.20998/2074-272X.2022.6.01.

[17] A Zeghoudi, A Bendaoud, H Slimani, M Miloudi, H Miloudi, L Canale. *Experimental measurements of near magnetic field by different probe for AC/DC LED driver*. IEEE International Conference on Environment and Electrical Engineering 2022. Prague, Czech Republic. DOI: 10.1109/EEEIC/ICPSEurope54979.2022.9854788

[18] Mohammed Hamza Bermaki, Houcine Miloudi, Mohamed Miloudi, Abdelkader Gourbi, Abdelber Bendaoud, "*High-frequency differential mode modeling of universal motor's windings*", International Journal of Electrical and Electronics Research (IJEER); ISSN: 2347- 470X, Vol.11, pp.1057–1064, 2023.

[19] A Zeghoudi, A Bendaoud, H Miloudi, S Bechkir, H Slimani, M Miloudi. *Effectiveness of Shielding on the Magnetic Emissions Emitted by a Toroidal Inductor*. 2nd International Conference on Advanced Electrical Engineering (ICAEE). 2022, Constantine, Algeria. DOI: 10.1109/ICAEE53772.2022.9962063

[20] Abdelhakim Zeghoudi, Abdelber Bendaoud, Amar Tilmatine, Mohamed Miloudi, Houcine Miloudi, Laurent Canale. *Experimental Measurement of Harmonic Distortion and Electromagnetic Interferences For LED Lamps*. IEEE Industry Applications Society Annual Meeting (IAS). 2022, Detroit, MI, USA. DOI: 10.1109/IAS54023.2022.9940136

[21] Abdelhakim Zeghoudi, Abdelber Bendaoud, Helima Slimani, Houcine Miloudi, Mohame Miloudi, Nawel Chikhi. *Experimental Measurement of Common and Differential Modes for Variable Speed Drive DC Motor*. 19th International Multi-Conference on Systems, Signals & Devices (SSD), 2022, Sétif, Algeria. DOI: 10.1109/SSD54932.2022.9955933

[22] Houcine Miloudi, Mohamed Miloudi, Mohammed Hamza Bermaki, Abdelkader Gourbi, Abdelber Bendaoud. *Optimization of EMC Filter for a Variable Speed Drive System in Electric Aircraft*. The Eurasia Proceedings of Science Technology Engineering and Mathematics. 2023.

[23] Houcine Miloudi, Mohamed Miloudi, Sid Ahmed El Mehdi Ardjoun, Amro A Nour, Ibrahim Mahariq. *Experimental investigation of conducted electromagnetic interference differential-mode performance in various split-phase induction motors designs.* Results in Engineering. 2025. https://doi.org/10.1016/j.rineng.2025.103963

[24] Y Hakmi, H Miloudi, M Miloudi, A Bendaoud, K Mendaz, MH Bermaki. *A Novel Experimental Approach for Predictive High-Frequency Modeling of Differential-Mode Impedance in Three-Phase Induction Motors*. 3rd International Conference on Advanced Electrical Engineering (ICAEE). Sidi-Bel-Abbes, Algeria, 2024. DOI: 10.1109/ICAEE61760.2024.10783247

[25] Yacine Hakmi, Houcine Miloudi, Mohamed Miloudi, Abdelkader Gourbi, Mohammed Hamza Bermaki, "*Frequency experimental identification approach for single-phase induction motor common-mode parameters*", Electrical Engineering & Electromechanics Journal, ISSN: 2074-272X, Vol.4, pp.3–7, 2024. DOI: 10.20998/2074-272X.2024.6.01.

[26] Mohammed Hamza Bermaki, Houcine Miloudi, Mohamed Miloudi, Abdelkader Gourbi, Abdelber Bendaoud. *Transfer function method for EMC high-frequency modeling of electrical machines*. The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2024.

[27] Sara Ghalem, Abdelber Bendaoud, Houcine Mıloudı, Mohamed Hamza Bermakı, Mohamed Mıloudı, Abdelhakim Zeghoudı. *Prediction of Conducted Disturbances Generated by a DC/DC Converter*. The Eurasia Proceedings of Science Technology Engineering and Mathematics, 2023.

[28] Abdelkader Gourbi, Mohamed Miloudi, Houcine Miloudi, Mohammed Hamza Bermak. *Comparative Analysis of Differential-Mode Impedance in Single-Phase Induction Motors*. WSEAS Transactions on Circuits and Systems. 23, 261-273. 2024. DOI: 10.37394/23201.2024.23.26