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Research Article

Electromagnetic Conducted Interactions in the Inverter-Cable-Motor System: Differential Mode

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 [2]

[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.

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Abstract –We have developed a parameter identification method for a behavioral model of the common-mode impedance of unshielded power cables associated with an asynchronous machine, subjected to the high voltage gradients created by power electronic converters. In this paper, we apply the same method to obtain the differential-mode model of a 3-conductor unshielded cable connected to an asynchronous machine. To study the propagation paths of these currents and the level of conducted disturbances generated by the system, it is essential to use accurate models of the various components of the variable-speed drive. In this work, we have developed a parameter identification method for the load consisting of the asynchronous machine and its power supply cable. The obtained models are validated in the frequency domain. These models allow for the identification of propagation paths for common-mode and differential-mode currents and help predict the overvoltages caused by semiconductor power switches.

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

I. INTRODUCTION

Electromagnetic Interference (EMI) has emerged as a significant concern in contemporary electrical engineering [1]–[8], particularly with the increasing use of Adjustable Speed Drives (ASDs) and electric motors across various industrial sectors [9]–[14]. As these technologies continue to evolve in complexity and application, effectively managing EMI becomes an ever more pressing challenge. This paper delves into a critical component of this issue: Differential Mode (DM) behavior in motor systems. DM currents and voltages not only undermine system performance but also jeopardize the surrounding electromagnetic environment, necessitating targeted mitigation strategies [15]. With global EMC regulations becoming more stringent [16]–[18], understanding the underlying mechanisms of EMI, especially in motor systems, is crucial. Managing DM interference is not only necessary for regulatory compliance but also essential for safeguarding the reliability and safety of electrical systems. A comprehensive analysis of DM interference provides a foundation for developing effective EMI mitigation techniques, which are indispensable for maintaining the long-term performance and integrity of industrial electrical systems [19]–[21].

Proper EMI management in motor systems extends beyond mere compliance, contributing to the overall stability and efficiency of electrical infrastructures [22]–[24]. The importance of EMI control is underscored by recent studies that emphasize energy-efficient and high-performance systems. For example, Yashu Swami advocates for specialized design standards in low-power embedded systems to optimize energy savings while maintaining robust electromagnetic performance [25]. Similarly, [26] evaluates the impact of multilayer driver configurations on EMI in high-voltage applications, and [27] highlights the critical role of EMI control in ensuring the continuous operation of smart production systems. These findings are directly relevant to single-phase induction motors, which are increasingly utilized in industrial settings where EMI management is crucial for ensuring reliable performance.

The need for effective EMI management is not limited to low-power and medium-voltage systems but extends to modern, motor-driven industrial applications [28]. This underscores the importance of adopting a holistic approach to EMI control, addressing a broad spectrum of applications while ensuring that electrical systems meet increasingly stringent EMC standards. By understanding the dynamics of DM EMI, engineers can design systems capable of overcoming current and future EMC challenges, thus protecting industrial operations and ensuring long-term operational stability.

The importance of modeling the load, consisting of an asynchronous machine and its power cable, warranted a dedicated second section. We will demonstrate that this load constitutes one of the primary paths for the propagation of differential-mode disturbances. Using a simple frequency-based model, grounded in a rational description of the main parasitic couplings, we have developed a behavioral model that enables a more accurate representation of the machine's impedance. The cable connecting the variable-speed drive to the motor is also a key component in Electromagnetic Compatibility (EMC): issues such as voltage spikes at the motor terminals, which are related to cable length, exemplify this. This preferred path for the main common-mode currents thus serves as an excellent medium for radiated emissions. Although cable models are abundant and well-documented, we propose a different approach that allows for the estimation, with certain approximations, of conductor parameters while considering the geometry.

II. MATERIALS AND METHOD

Useful signals are typically transmitted in differential mode (DM), also known as series mode, normal mode, or symmetric mode. As shown in Figure 1, the differential-mode voltage is measured between the two conductors and can be captured using a differential probe. The input stage of electronic systems often includes a differential amplifier. Differential-mode current (DMC) circulates through both conductors in opposite directions, forming a loop between the two wires.

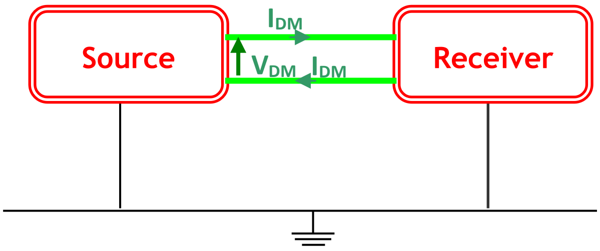

Fig. 1. Differential-mode

This current can be measured using a current probe that captures the flow through both conductors in opposite directions (Fig. 2) [1, 4].

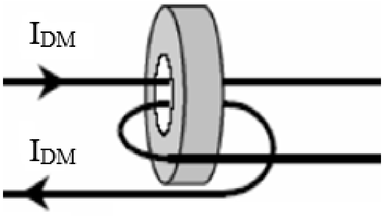

Fig. 2. Measurement of Differential Mode Current

Power components are considered the primary sources of electromagnetic pollution (EMI). In an inverter, it is the switching cell that generates EMI. Both current and voltage fluctuate with each switching event in the two components, IGBT and diode, and these electrical parameters contain significant high-frequency harmonics. The variation of these electrical parameters leads to electromagnetic pollution:

- The switching of current generates differential mode disturbances.
- The switching of voltage induces common mode high-frequency currents, which are present in parasitic components.
- The combined effects of differential mode and common mode pollution result in the total EMI generated by the device under test.

The propagation paths correspond to the electrical connections both upstream and downstream of the converter. The study of these propagation paths requires a thorough understanding of the high-frequency behavior of all components within the system being analyzed [13].

High-frequency models of asynchronous machines are typically composed of a limited number of components, such as the one used in previous work, which naturally explains their frequency limitations. However, the simplicity of these models provides the advantage of allowing the determination of the various components with a minimal set of measurements. The initial development of such models, like the one shown below (Fig. 3), is generally based on an interpretation of the physical phenomena occurring within the machine, specifically within a winding. In this case, the model is analogous to an inductance wound on a magnetic circuit, with additional parasitic couplings to the chassis.

The self-inductance and resistance of a winding are represented by Ld and Rs, respectively. The resistive element Rp is associated with the losses induced in the stator iron. Similar to the classical model of an inductance wound on a magnetic circuit, the element Cp represents parasitic inter-turn capacitive couplings. Common-mode capacitive couplings between a winding and the motor chassis are represented by the capacitances Cg_1 and Cg_2 [9].

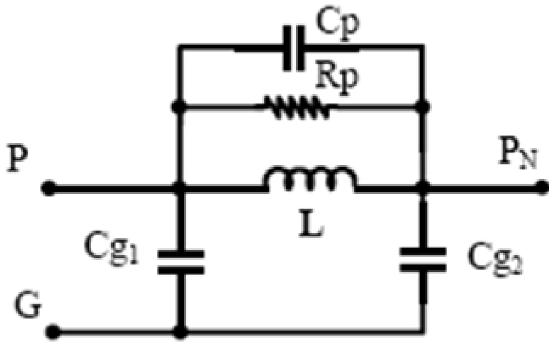

Fig. 3. Simplified Model of a Winding

Electromagnetic Interference (EMI) is classified into two types: Differential Mode (DM) and Common Mode (CM). The analysis of the motor's impedance is based on observing the impedance variation curves as a function of frequency in two configurations: one in Common Mode and the other in Differential Mode [1, 6, 7].

The model used in this section is defined based on an equivalent circuit by phase, where the inductance Ld does not precisely correspond to the intrinsic inductance of a winding.

The Differential Mode impedance model (Z_{DM}) is obtained by observing the variations in impedance Z_{AB} with frequency when the phase A and phase B windings are short-circuited, while phase C is disconnected (Fig. 4) [6].

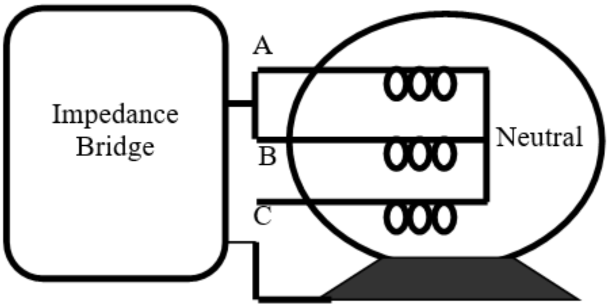

Fig. 4. Differential Mode Motor Configurations

The equivalent circuit of the impedance of a phase in differential mode becomes as shown in Figure 5.

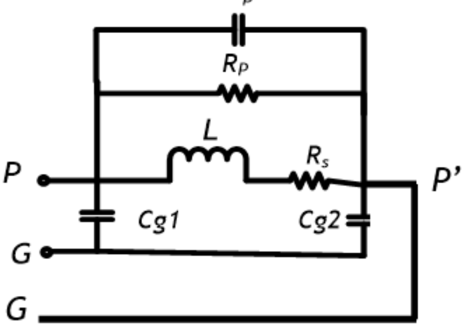

Fig. 5. Equivalent circuit of the impedance of a phase (Differential Mode)

Based on the equivalent circuit of Differential Mode, the impedance Z_{DM} can be expressed as the ratio of the Differential Mode current to the Differential Mode voltage in the Laplace domain.

$$Z = \frac{V_{DM}(p)}{I_{DM}(p)} \qquad (1)$$

$$Z_{pp'} = \frac{1}{3} \cdot \frac{L.p}{L_d(C_p + \frac{C_{g1} C_{g2}}{C_{g1} + C_{g2}}) p^2 + \frac{L_d}{R_p} p + 1} \qquad (2)$$

With this model, the impedance exhibits only a single resonance frequency defined by Ld and the equivalent capacitance Ceq.

$$F_{N(PG)} = \frac{1}{2\pi\sqrt{L_d \cdot C_{éq}}} \qquad (3)$$

$$C_{éq} = (C_p + \frac{C_{g1} C_{g2}}{C_{g1} + C_{g2}}) \qquad (4)$$

At high frequencies, the skin effect becomes significant, causing the current distribution to no longer be uniform. As a result, the calculation of resistance and inductance becomes more complex than in the case of direct current (DC).

In this section, the proposed cable modeling method is based on the use of a distributed-constant model, where the linear parameters vary with frequency. These models enable the identification of propagation paths for both common mode and differential mode currents. At high frequencies, the resistance increases due to the skin effect, and it can be expressed as follows [1, 13]:

$$R = \frac{l}{\sigma S} = \frac{l}{\sigma\pi\left(2a\delta - \delta^2\right)} \qquad (5)$$

Theoretically, the alternating current (AC) resistance of a round copper wire, as shown in Fig. 7, can be expressed by equation (5).

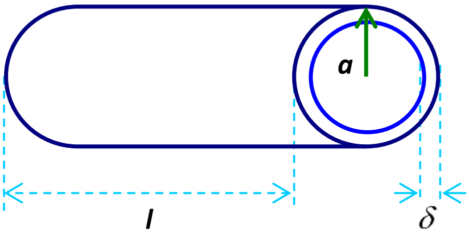

Fig. 7. Parameters of a Copper Conductor

For a conductor with radius *a*, the ratio of AC resistance to direct current (DC) resistance is generally defined by equation (6).

$$\frac{R_{AC}}{R_{DC}} = \frac{\frac{l}{\sigma S_{AC}}}{\frac{l}{\sigma S_{DC}}} = \frac{a}{2\delta} \qquad (6)$$

Therefore, modeling the cable resistance is a crucial part of studying the propagation paths of disturbances, as most common-mode impedance couplings are resistive. This study highlights the importance of additional parameters such as cable diameter, length, and the frequency at which the problem is resolved.

The internal inductance due to the skin effect, or the penetration of field lines into a conductor, will be developed in this section. We will use the energy method to calculate the internal inductance.

$$L = \frac{\mu}{2} \times \frac{1}{\sqrt{\pi f \mu \sigma}} \qquad (7)$$

From the inductive and resistive elements, it is possible to calculate the values of capacitances and conductances. The conductance is determined based on the conductivity of the conductors and the permittivity previously provided, as follows:

$$C = \frac{\mu \cdot \varepsilon}{L_e} \quad (8)$$

$$G = \frac{\sigma_{CU}}{\varepsilon} \cdot C \quad (9)$$

III. RESULTS

In this section, we present a detailed analysis of the results, focusing on the differential-mode impedance behavior of four types of electric induction motors. In this configuration, the variation of Differential Mode impedance with respect to frequency is depicted in Figure 6.

The cable lengths between the converter and the machine can become quite significant (several tens of meters), which implies that propagation effects can no longer be neglected. Beyond the impact on the conducted disturbance spectrum, these propagation phenomena can lead to much more serious issues. These effects manifest as overvoltages at the machine terminals, which in the worst-case scenario could lead to its destruction [9]. The longer the cable lengths, the more intense these phenomena become, and appropriate filters are then required at the output of the drive and/or at the motor terminals. Electromagnetic disturbances on cables couple very weakly directly in differential mode. The impedance significantly decreases for long lengths (Fig. 9). When the forward and return conductors are close and reasonably distant from the disturbance sources, differential mode (DM) disturbances can generally be neglected. In practice, the problem arises from the conversion of common mode to differential mode due to input asymmetry.

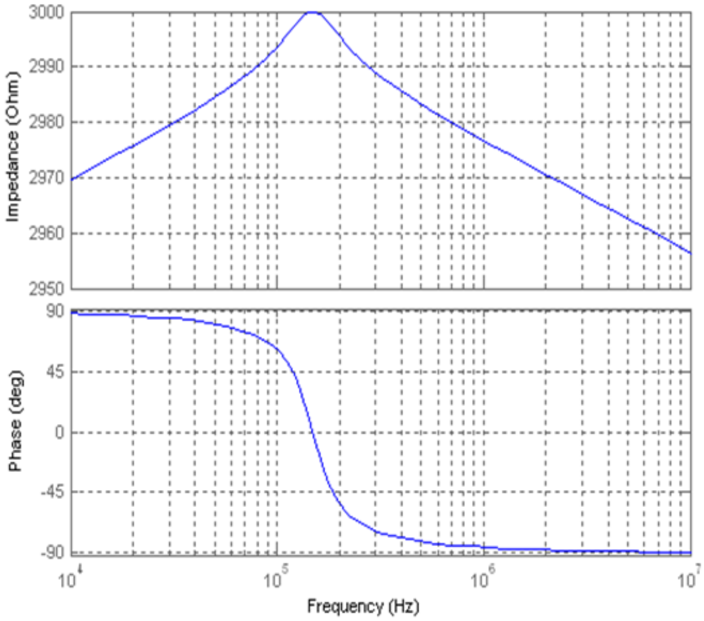

Fig. 6. Motor Impedance (Differential Mode Impedance)

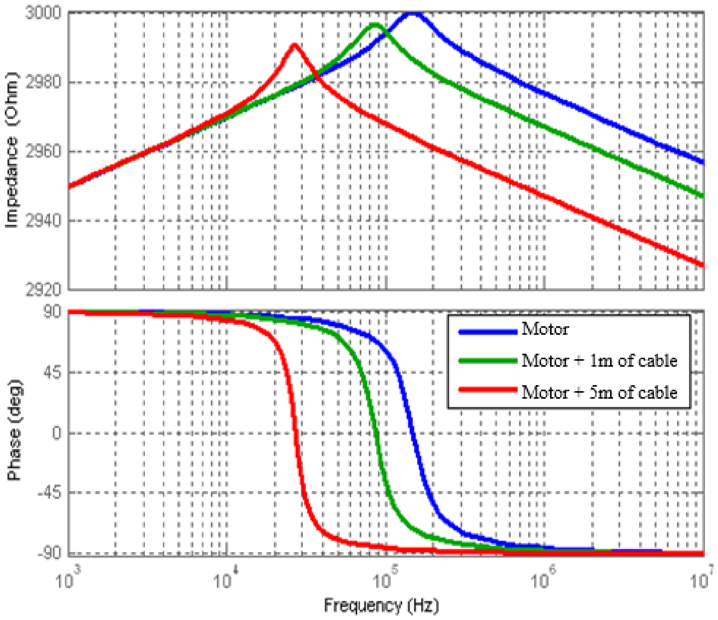

Fig. 9. Total Differential Mode Impedance for Two Cable Lengths (Cable-Motor Configuration)

The motor impedance curve shifts, and the resonance peaks are moved to lower frequencies. The resonances induced by the cable elements become clearly noticeable for cable lengths greater than 1 meter. In practical terms, cable length affects the installation in two ways: one relates to voltage drop, which can be compensated by increasing the cable cross-section (i.e., reducing resistance), and the other affects the electromagnetic compatibility (EMC) of the installation, either in common mode or differential mode.

IV. DISCUSSION

The results discussed in this context highlight the significant impact of cable lengths on the electromagnetic compatibility (EMC) and performance of electrical systems, especially in the context of variable speed drives (VSD) and asynchronous machines. Several key observations and implications emerge from this analysis, which can guide future work and practical design considerations for minimizing electromagnetic interference (EMI).

1) 1. Influence of Cable Length on EMI and Propagation Effects

Longer cables between the converter and the motor can lead to amplified propagation effects, particularly in terms of both common mode and differential mode disturbances. These disturbances are typically more pronounced in systems with longer cable runs, as the interaction between the cables and electromagnetic fields becomes more significant. The study reveals that, beyond a certain length (e.g., 1 meter), resonances induced by the cable elements are clearly observed, contributing to an overall increase in the EMI generated by the system.

The analysis underscores the importance of considering cable length as a critical factor in EMI management. Long cables effectively serve as antennas that can radiate or conduct electromagnetic disturbances. As cables increase in length, their impedance decreases, which may lead to unwanted high-frequency currents being coupled into the system. These disturbances can propagate through the system and potentially cause malfunction or degradation in performance.

2) 2. Overvoltages and Damage to the Machine

A crucial point raised in the results is the occurrence of overvoltages at the motor terminals, which can result from these propagation effects. In the most severe cases, such overvoltages could lead to permanent damage to the motor or other critical components in the system. The phenomenon of overvoltage is closely tied to the interaction between the converter, the motor, and the cable, all of which act as conduits for the electromagnetic disturbances.

Overvoltages are particularly problematic in systems with significant cable lengths, as the impedance of the cable becomes more influential at higher frequencies. The results point out that the longer the cable, the more intense the disturbances become, which makes overvoltage issues more likely. This highlights the importance of using protective measures, such as surge suppressors or filters, to mitigate the risk of damage.

3) 3. Impact on Impedance and Mode Conversion

The results reveal that the motor impedance curve shifts and that the resonance peaks are displaced toward lower frequencies as the cable length increases. This behavior is significant because it suggests that the cable’s characteristics affect the motor's electrical behavior, particularly in terms of its impedance. The coupling of electromagnetic disturbances within the cable can lead to the conversion of common mode (CM) disturbances into differential mode (DM) disturbances. This mode conversion is problematic because DM currents are typically more difficult to control and mitigate.

When the forward and return conductors of the cable are placed near each other and sufficiently distanced from the disturbance sources, the common mode interference is less pronounced, and differential mode interference becomes more dominant. This conversion can introduce additional complexity to the system, as the differential mode currents are typically harder to suppress compared to common mode currents. This effect underscores the importance of both proper cable placement and the use of techniques such as shielding and grounding to reduce mode conversion.

4) 4. Practical Implications for System Design and EMC Management

The practical implications of these results are far-reaching for engineers designing electrical systems with variable speed drives and asynchronous motors. Several design strategies can be inferred from the findings:

- **Cable Sizing and Length Control**: To reduce the impact of EMI, it is critical to limit the cable lengths between the converter and the motor. When long cables are unavoidable, engineers should consider using larger cable cross-sections to reduce impedance and minimize voltage drop. Additionally, ensuring proper cable routing and shielding can help mitigate the risk of overvoltage and mode conversion.
- **Filter Implementation**: The need for effective filtering is emphasized, especially in systems where long cables are used. Filters should be strategically placed both at the output of the drive and at the motor terminals to attenuate high-frequency disturbances. These filters can play a crucial role in reducing the levels of EMI and protecting sensitive equipment.
- **Resonance and Impedance Matching**: The resonance behavior observed in the system should be taken into account when designing the electrical system. Engineers should aim to prevent resonant frequencies that could lead to excessive disturbances, particularly in the frequency range where the system operates. Proper impedance matching between the converter, cable, and motor can help minimize these effects.
- **Electromagnetic Shielding and Grounding**: The conversion of common mode to differential mode highlights the need for effective shielding and grounding techniques. Shielding can prevent

the propagation of unwanted EMI, while proper grounding can help dissipate unwanted currents and prevent them from affecting the motor or other components.

5) 5. Limitations and Further Research

While the study provides valuable insights, it is essential to note that real-world applications may involve more complex scenarios than those modeled in the analysis. For example, factors such as cable type, insulation materials, and environmental conditions can influence the propagation of EMI. Furthermore, the use of different types of power converters, motor configurations, and cable designs can introduce variations in the impedance and EMI characteristics.

Future research should focus on developing more sophisticated models that incorporate these additional factors and provide more accurate predictions of EMI behavior in real-world systems. Moreover, experimental validation of the proposed models would be crucial to confirm their accuracy and applicability in different industrial environments.

V. CONCLUSION

The prediction of high-frequency disruptive currents circulating within a variable speed drive system requires the use of accurate models for the various components that make up the system. In this study, we have developed high-frequency models for unshielded power cables and provided high-frequency characterization of an asynchronous machine. The models derived are validated in the frequency domain, ensuring their reliability and accuracy for practical applications.

The study has shown that electromagnetic disturbances on cables exhibit minimal coupling directly in differential mode. This result indicates that, while differential mode interference can still occur, the predominant coupling tends to occur in common mode, particularly in systems with long cables or when the cable layout and impedance characteristics contribute to mode conversion. This insight underscores the need for precise modeling and understanding of both common mode and differential mode interference mechanisms in order to effectively manage EMI in variable speed drive systems. Furthermore, this work demonstrates the importance of considering both the high-frequency impedance characteristics of cables and the electromagnetic behavior of connected machines when analyzing the impact of EMI. The ability to predict and mitigate these disturbances is crucial for ensuring the long-term reliability and EMC compliance of industrial electrical systems. By applying the models and insights developed in this study, engineers can make informed design decisions that optimize the performance and minimize the interference in variable speed drive applications.

Additionally, this research highlights the need for continued efforts in refining and expanding these models, incorporating additional factors such as cable shielding, motor-specific characteristics, and environmental conditions, in order to more accurately predict and manage EMI in real-world industrial settings. The ultimate goal is to create more robust and efficient systems that can operate within the stringent electromagnetic compatibility standards required by modern industrial applications.

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REFERENCES

[1] 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.

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

[3] 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.

[4] 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.

[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] 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.

[9] 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.

[10] 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

[11] 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.

[12] 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

[13] 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.

[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, 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.

[16] 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

[17] 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

[18] 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.

[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] 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.

[21] 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.

[22] 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.

[23] 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.

[24] 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

[25] 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

[26] 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

[27] 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.

[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