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Original article

Electromagnetic Compatibility and Noise Mitigation in Modern Power Electronics

Ramzi Alriheebi

Electrical and Electronic Engineering Department, Faculty of Engineering and Technology, Aljafara University, Libya
Email. r.alriheebi@aju.edu.ly

Abstract
The rapid development of Power Electronic Technologies across a broad range of applications (including renewable energy systems, electric vehicles, industrial automation, aerospace platforms and smart grid solutions) has made significant improvements in energy conversion efficiency, power density and syste However, due to the high frequency and usage of switching devices as well as their miniaturization in converter topologies for EMI/EMC issues have become important more recently. Operation of power electronic converters gives rise to electromagnetic interference (EMI) with those propagating via conductive and radiative paths, which results in degradation of performance and reliability, or even safety issues for electronic circuits operating in parallel with them. Thus, EMC became an integral design consideration in today's power electronic systems. This paper reviews the important EMC issues and noise reduction methods relating to power electronics in detail. This paper summarizes the analysis of major sources of EMI, such as switching devices, passive integrated circuits (IC), gate driver circuits, and parasitic elements through studying conducted and radiated emissions mechanisms. Design Methodologies for EMC are Reviewed. In this section extent multiple design methodologies regarding filter techniques, shield handiness, grounding practices, and PCB floor optimization. It also provides an overview of international EMC standards and regulatory guidelines on electromagnetic emission and immunity tests. It also investigates the impact of EMC, operational safety, and reliability system performance. Finally, it discusses the recent developments on the new trend in wide-bandgap semiconductor technologies, multi-dimensional filtering methodology, and intelligent EMC optimization methodologies. Results emphasise the importance of EMC consideration in all phases of the design process for achieving high-performance, reliable, and compliant power electronic systems.
Keywords. Electromagnetic Compatibility, Power electronics, Conducted emissions, Radiated emissions.

Introduction

Power electronics enables the control and conversion of electric power for almost all applications competently while operating at a higher efficiency. As an ever-greater number of fields integrate power electronic converters into their systems—from renewable energy to electric transportation, industrial drives, telecommunications infrastructure, aerospace systems and smart grids—the need for compact, efficient and high-performance power conversion solutions has risen considerably. Advancing semiconductor technologies, particularly Silicon Carbide (SiC) to Gallium Nitride (GaN) devices, enable higher switching frequency operation over traditionally designed converters with improved efficiency, less loss, and increased power density.

But the universal use of fast switching devices has caused serious electromagnetic compatibility problems. Large dV/dt and dI/dt caused by fast switching transients both create a large electromagnetic interference (EMI). These disturbances can thus be transmitted through power distribution networks, signal lines and surrounding electromagnetic fields to interfere with neighbouring electronic systems. The electromagnetic radiation emitted may interfere with the operation of communication signals, destabilize sensors, cause sub-system oscillations and result in reduced reliability of important equipment.

Electromagnetic compatibility (EMC) is an attribute of any electrical or electronic device or system requiring it to perform satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to anything in that environment Intensively studied techniques for EMI generation, propagation path, and coupling mechanism will finally play roles in realizing EMC in any power electronic applications. As switching frequencies continue to increase, and system architectures cram into smaller volume, EMC has become a most important design objective.

Power electronic systems are becoming more and more compact, containing both larger parasitic elements in addition to subsystems interconnected to each other, producing many challenges concerning the EMC at higher frequencies. We will limit ourselves to this kind of electromagnetic radiation, which tends to propagate mostly within the frequency range from 150 kHz and 30 MHz (radiation that easily penetrates conductive pathways such as power lines and signal cables) Radiated emissions that are typically most significant above 30 MHz and are most effectively induced by current loops, switching nodes and parasitic or undesired antenna structures in electrical circuits The vital need to manage these emissions for the proper functioning of a ship and compliance with international regulation [8].

Research Problem

Accelerated fashions leveraging ongoing improvements in power electronic systems (e.g., high-frequency switching devices, less volume converter topologies and high-power-density designs). While these advancements significantly improve the efficiency and performance, they also cause increased electromagnetic interference (EMI), which may disrupt a nearby electronic system or even compromise the reliability of an entire system. It is well-known that conducted and

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radiated electromagnetic emissions from modern power converters can easily exceed the [6] acceptable levels, if the design does not include any EMC measures.
EMI mitigation techniques is a broad subject — filters, shields & grounds and PCB layout improvement among others but determining the best EMC solutions for your system requires engineering experience; implementing these solutions is an even cut viewports old nail hammer. In addition to this fact that the EMC challenges are even amplified in newer technologies (like Silicon Carbide (SiC) and Gallium Nitride (GaN) devices) since of their touchy switching characteristics. Consequently, there is a growing need to have comprehensive understanding of the mechanisms that are responsible for EMI generation and propagation paths in order to ensure reliable, safe and standards-compliant operation of modern power electronic systems.

Research Objectives
This review aims to specifically explore the EM compatibility problems in updated PE systems and analyze reliable methods for the suppression of noise.

Specific Objectives
1. Objectives: To identify the main sources of electromagnetic interference in power electronic systems and perform an analysis.
2. Investigate the mechanisms for generation and conduction of EMI, including both conducted and radiated manners.
3. To assess the effects of the switching devices, parasitic components, and converter architectures on electromagnetic emanations.
4. To test the filtering expertise methods for conducted and radiated noise.
5. Experimental investigation of shielding and grounding against electromagnetic compatibility.
6. Research PCB layout optimization methods to reduce EMI emissions.
7. Peer-reviewed to identify international EMC standards and regulatory requirements for practical power electronic systems
8. To determine the impact of EMC performance on reliability, safety, and operational efficiency.
9. Detecting an emerging electromagnetic compatibility (EMC) challenge posed by wide-bandgap semiconductor technologies and future power electronic applications.

Research Contributions
The research presents the following contributions to power electronics and electromagnetic compatibility.

Contribution 1
An approachable overview of electromagnetic interference sources in modern power electronic systems, including switching devices, passive components, and parasitic elements.

Contribution 2
A comprehensive survey of both conducted and radiated EMI mechanisms and their impact on electronic systems' performance.

Contribution 3
A comparison of different EMI mitigation techniques, such as filtering, shielding, ground strategies, and PCB optimization methods.

Contribution 4
A systemic framework to support implementing EMC design principles in the early design stages of power electronic converters.

Contribution 5
Review of World EMC standards and their effect on converter design and compliance tests.

Contribution 6
Forecasting new EMC problems and approaches to solving them for high-frequency wide-bandgap power semiconductor devices and advanced power conversion techniques.

Contribution 7
Design guidelines that assist engineers in building reliable, safe, and standards-compliant power electronic systems.

Research Gaps
ECM has already seen much work on the power electronic side, much of which is still too under-explored:

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Gap 1
Most existing studies are based on single EMI mitigation approaches without a thorough side-by-side assessment of their performance under various operating conditions.

Gap 2
Despite the overall importance of this topic, limited work integrates filtering, shielding, grounding, and PCB design into a holistic EMC design process.

Gap 3
This has significant EMC implications as the new switching technologies based on SiC and GaN have both very high speeds at which they are being commutated (on/off), as well as increased levels of emission [11].

Gap 4
There are currently few useful design frameworks that can effectively equate EMC performance to system efficiency, cost, and/or power density.

Gap 5
Most of the studies in the literature are directed towards conducted emissions analyses, whereas not enough attention is given to radiated emission mechanisms and interactions with converter structures.

Gap 6
Existing literature only provides limited insight into the relationship between EMC performance and long-term system reliability.

Research Questions
The research attempts to help answer the following questions.
Main Research Question
So, how to improve EMC in the power electronic systems of today without sacrificing efficiency and reliability, or notwithstanding worldwide regulations?
Sub-Research Questions
RQ1: What are the main sources of EMI in modern power electronic systems?
RQ2: What is the propagation of conducted and radiated electromagnetic emissions in power electronic converters and circuits (if any)?
RQ3: What is the influence of switching frequency, converter topology, and semiconductor technology on EMI generation?
RQ4: Which filtering techniques are the most efficient in reducing conducted and radiated emissions?
RQ5: Impact of Shielding and Grounding Strategies on Overall EMC Performance
RQ6: What PCB layout considerations most significantly reduce EMI?
RQ7:International EMC thinking for power electronic systems, how to comply with IEC 61000 and CISPR requirements?
RQ8: What is the impact of EMC performance on system reliability, operational safety, and long operability?
RQ9: Which new EMC challenges will be raised in the future by, e.g., some emerging wide-bandgap semiconductor-based technologies (e.g., SiC and GaN devices)?
RQ 10: Research direction for improving future electromagnetic compatibility of next-gen power electronic systems

Literature Review
Recent literature from 2020 to 2026 shows
Which makes electromagnet compatibility (EMC) one of the major design challenges in modern power electronic systems. The fast penetration of high frequency converters and very compact PCB layouts with wide-bandgap semiconductor devices namely SiC, GaN are the main background. However, these technologies require high switching speed, i.e., dv/dtdv/dtdv/dt or di/dtdi/dtdi/dt, leading to parasitic coupling and increased high frequency electromagnetic emissions. All of these studies show that particularly with new power converters in the modern era using WBG devices conducted EMI and radiated EMI have become much more complex [82; 83].
More recently, starting from 2020, research works have focused on understanding the physical mechanisms leading to electromagnetic interference (EMI) in power electronic converters. The EMC studies historically were mostly conducted by treating EMI like a compliance problem, and as EMI research starts addressing EMI as a design constraint (for example during topology selection, switching control, packaging and PCB layout), much more recent work. Li et al. The paper reviewed about on EMI mitigation from "Common Conductive and Radiated EMI Reduction Techniques in Power Electronics" states that EMIs can also be influenced by layout, parasitic, switching behaviour, system-level coupling paths cannot only filter.
In the more recent literature, one of the most notable trends is the growing concern regarding wide-bandgap devices. The SiC MOSFETs and GaN transistors have faster switching transitions than the conventional silicon so that the basic power frequency is highly required. However, this benefit also increases common-mode and differential-mode noise. It has

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already been proved in various articles that a meticulous gate-drive design along with parasitic inductance control, shielding and grounding along with broadband EMI Analysis ought to be more focused for the WBG-based converters. Mitsuo et al.,

This is because it has a large effect on compliance tests and power-line interferences, which warrants recent investigations of EMI margins without testing already. 2023-2025 Passive EMI Filters for Power Electronics, Active EMI Filters and Common-mode Choke Modeling Papers Lai et al. presented EMI filter modeling and emissions in power electronics applications with a special focus on the contributions of the filter passive components which can also introduce parasitic effects, resulting in degraded high-frequency attenuation performance. In a 2025 review, the authors categorized EMI filters into passive, active and composite structure aligning with the current trend in order to miniaturization, optimization and from mere attenuation design to system integration (Kim et al., 2025).

One of the research areas was radiated EMI, which received special focus after 2020. When the switching frequency is high enough and mechanical layouts compact, PCB traces, cable structures, magnetic components and switching loops can radiate as unintentional antennas. However, for converters using WBG device, we need to look at both near-field and far-field radiation mechanisms in the power electronics systems [1], based on sequential report of radiated EMI specification. This represents a paradigm shift because the majority of past studies were limited to conducted emissions and there is only recent literature that recognizes radiated EMI impact on communications systems, sensors, control circuits and surrounding electronics.

PCB layout optimization is also an essential research direction. Newer research highlights the important need to minimize large high-frequency loop areas, eliminate parasitic inductance requirements, control return-current paths, separate power and signal sections, and provide effective optimization of ground planes [22]. This aspect is especially critical in compact converters with high-frequency switching nodes located next to sensitive control circuits. Books and papers are treating the pecisi PCB layout as an EMC mitigation technique with the same importance of external filtering and shielding

Shielding and grounding continue to be important mitigation techniques; however, the latest literature states that they should not be applied as late-stage correction factors but rather as part of an integrated EMC design process. In high-frequency converters, a poor ground can create common-mode current paths, and inadequate shielding of regions can allow for the coupling of magnetic and electric fields into adjacent circuits. Training materials in research and industry suggest that PCB design should not be studied as an isolated subject, but rather along with passive and active component parasitics, shielding, near-field coupling reduction to make the overall EMC design effective.

International EMC standards still serve as a basis for research and industrial designs. IEC 61000-6-3:2020 is a standard that specifies emission limits for residential, commercial, and light-industrial environments and addresses conducted and radiated emissions up to 400 GHz. CISPR 11:2024, in the frequency range of 9 kHz to 400 GHz, describes requirements for RF disturbance emission from industrial, scientific and medical (ISM) equipment. IEC 61800-3:2022 defines EMC requirements for adjustable-speed electrical power drive systems, ie those that contain electronic converters, for use in industry (link is external). Being in full compliance with these standards is extremely important, given the wide variety of power electronic systems (e.g., motor drives, EV converters, renewable-energy inverters and industrial converters) that must comply to emissions as well as immunity.

The scope of this literature is also limited and the gaps identified have been highlighted. Firstly, most of the studies focus on isolated EMI mitigation methodologies (like filters or shielding) without coupling them entirely in an EMC-oriented design toolbox. Second, filter-design studies are mostly based on conducted EMI, while predicting radiated EMI is more complex. Field coupling and layout dependency make it difficult. Third, the converters based on WBG still needs more studies because at very high switching speeds, standard EMC techniques may not be enough. Lastly, the overall body of work linking EMC responsing performance directly to long-term system reliability, safety and operational stability tend-status is still a sore point.

To sum up, the literature from 2020 to 2026 strongly suggests that EMC is far more than a regulatory deal but rather one of the main goals in power electronics through a cycle of design. To mitigate EMI today requires cooperation between experts in semiconductor selection, converter topology, modulation strategy, filter design and PCB layout, shielding and ground design and compliance test. We expect that future works will investigate the use of AI to assist with EMI prediction, as well as the concept of a digital twin for EMC modeling, monolithic filter structures designs in next to or integrated with the converters and optimization by conducting suppression conductor (for SiC- and GaN-based converters).

Table 1. Summary of Recent Literature on EMC and EMI Mitigation in Power Electronics (2020–2026)

Ref.	Year	Author(s)	Research Focus	Methodology	Key Findings	Limitations
[1]	2020	IEC 61000-6-3	EMC emission requirements	International standard development	Established emission limits and testing procedures for residential and industrial environments	Focuses on compliance requirements rather than mitigation techniques
[2]	2022	IEC 61800-3	EMC requirements for adjustable speed	Standardization framework	Defined EMC requirements for converter-fed motor	Does not provide implementation methodologies

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			drives		drive systems	
[3]	2023	Li et al.	Conducted and radiated EMI reduction techniques	Comprehensive review	Identified filtering, grounding, shielding, and layout optimization as key mitigation strategies	Limited quantitative comparison between techniques
[4]	2023	Lai et al.	EMI filter modeling and emissions	Analytical and review-based study	Demonstrated the influence of parasitic components on filter effectiveness	Focused mainly on conducted EMI
[5]	2023	Aalborg University EMC Research Group	EMI/EMC challenges in power electronics	Experimental and industrial applications	Highlighted PCB layout, shielding, and parasitic effects as dominant EMC factors	Limited discussion of compliance testing
[6]	2024	Ma et al.	Radiated EMI in power electronic systems	Comprehensive review	Examined radiation mechanisms, antenna effects, and coupling paths in converters	Limited practical mitigation guidelines
[7]	2024	CISPR 11	RF disturbance limits and measurement methods	International EMC standard	Updated emission limits and testing procedures for industrial equipment	Regulatory focus rather than engineering solutions
[8]	2025	Gu et al.	High-frequency EMI in modern power systems	Review of WBG-based systems	Identified SiC and GaN devices as major contributors to high-frequency EMI	Limited experimental validation
[9]	2025	Review of Conducted EMI Filters	EMI suppression filters for converters	Comparative review	Compared passive, active, and integrated filter technologies	Focused mainly on filter performance
[10]	2026	Recent EMC Studies on WBG Devices	EMC challenges in SiC and GaN converters	Experimental and simulation studies	Demonstrated increased common-mode noise due to fast switching speeds	Lack of unified EMC design framework

Table 2. Comparison of EMI Mitigation Techniques Reported in Literature

Technique	EMI Type	Advantages	Limitations	Recent Research Trend
Passive EMI Filters	Conducted	Simple, low cost, reliable	Large size at low frequencies	Integrated filter structures
Active EMI Filters	Conducted	High attenuation, compact design	Increased complexity and cost	Adaptive control-based filters
Shielding	Radiated	Effective field suppression	Increased weight and cost	Lightweight composite shielding
Grounding	Conducted & Radiated	Reduces common-mode currents	Ground loops may occur	Hybrid grounding schemes
PCB Layout Optimization	Both	No additional hardware cost	Requires early-stage design planning	AI-assisted layout optimization
Soft Switching	Both	Reduced switching noise	Increased circuit complexity	Wide-bandgap converter applications
Spread Spectrum Modulation	Conducted & Radiated	Reduces emission peaks	May affect control performance	Digital implementation techniques

Table 3. Identified Research Gaps from Literature (2020–2026)

Gap ID	Research Gap	Evidence from Literature
G1	Lack of unified EMC design methodology	Most studies focus on a single mitigation technique
G2	Limited integration of filtering, grounding, shielding, and PCB optimization	Research typically evaluates techniques independently

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G3	Insufficient EMC studies for SiC and GaN converters	High-frequency effects remain difficult to predict
G4	Limited radiated EMI modeling accuracy	Most publications focus on conducted emissions
G5	Few studies link EMC performance with system reliability	Reliability impacts are often discussed qualitatively
G6	Limited use of AI and optimization methods in EMC design	Emerging area with significant research potential
G7	Lack of real-time EMI prediction methods	Digital twin and AI approaches are still developing

Research Methodology

This study presents a holistic analytical and review-based approach to analyze the electromagnetic compatibility (EMC) issues and electromagnetic interference (EMI) minimization methods in modern power electronic systems. This study integrates a systematic review of current database literature, comparative introduction of EMI mitigation methods, and assessment of global EMC approaches to provide a structured approach on how EMC generation occurs and effective noise reduction strategies in an ascending hierarchical manner.

It covers the identification of major EMI sources, mechanisms of conducted and radiated emissions, mitigation methods for both types of emission as well as related practices to demonstrate improvements in EMC characteristics through modeling and simulations in modern power electronic converters.

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Phase 1: Literature Review Collection

Between 2020 and 2026, a literature review was conducted on peer-reviewed journal articles, conference papers, international standards basis and technical reports.

Literature was collected from key scientific databases, as follows:

IEEE Xplore
ScienceDirect
Springer
MDPI
IET Digital Library

The selected studies focused on:

EMI generation mechanisms
Conducted emissions
Radiated emissions
EMC design methodologies
EMI mitigation techniques
Wide-bandgap semiconductor technologies
EMC standards and compliance requirements

Phase 2: EMI Source Identification

Phase II—Identify major sources of electromagnetic noise in the power electronic systems.

The investigated EMI sources include:

Table 4. Major sources of electromagnetic noise

Source	EMI Mechanism
MOSFETs and IGBTs	High dv/dt switching
SiC MOSFETs	Ultra-fast switching transitions
GaN Devices	High-frequency switching
Gate Drivers	Switching transients
Transformers	Leakage magnetic fields
Inductors	Current ripple generation
PCB Traces	Antenna effects
Parasitic Components	Noise coupling

Phase 3: Mechanisms of EMI Propagation

Phase three looks at the propagation of electromagnetic disturbances over power electronic systems. The analysis examined 2 major EMI categories:

Conducted EMI

Conducted EMI propagates through:

Power cables
Ground conductors

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Signal lines
Converter interconnections
Frequency range:
150 kHz – 30 MHz
Radiated EMI
Radiated electromagnetic interference (EMI) propagates through the electromagnetic fields produced by:
Switching loops
PCB traces
Power cables
Magnetic components
Frequency range:
30 MHz – 1 GHz and above
Comparative studies were conducted to identify the leading propagation mechanisms under various working conditions.

Data Analysis Procedure
We analyzed the literature gathered according to these broad steps:
Types of studies by EMI type.

- Categorization of mitigation techniques.
- Comparison of reported performance outcomes.
- Identification of common challenges.
- Identification of research gaps.
- Development of EMC design recommendations.

Results were compiled to find the optimal types of EMC practices for modern Power Electronic Solutions.
4.5 Methodology Expected Outcome
The proposed methodology enables:
Knowledge of the conduction and radiation emission mechanism
EMC Mitigation Techniques – Analysis and Comparison
Evaluation of conformity with global EMC requirements.
Areas of Future EMC Challenges Related to SiC and GaN Technologies
Practical EMC Design Guidelines for the Reliable and Standards-Compliant Development of Power Electronic Systems.

Results and Discussion
5.1 Effectiveness of EMI Mitigation Methods
The literature assessed shows that it is not sufficient for modern power electronic systems if only one EMI mitigation technique can be used individually for achieving the full EMC compliance. In fact, good EMC performance is achieved through the combination of multiple mitigation techniques: filtering, shielding, grounding and PCB layout.
Table 5.1: Relative effectiveness of the widely-used techniques for EMI mitigation (Based on literature review.)

Table 5. EMI mitigations methods comparison Table

Technique	Conducted EMI Reduction	Radiated EMI Reduction	Cost	Complexity	Overall Effectiveness
Passive EMI Filter	High	Medium	Low	Low	High
Active EMI Filter	Very High	Medium	High	High	Very High
Shielding	Low	Very High	Medium	Medium	High
Grounding Optimization	Medium	High	Low	Low	High
PCB Layout Optimization	High	High	Low	Medium	Very High
Soft-Switching Techniques	Medium	Medium	High	High	Medium

PCB layout optimization and active EMI filters offer the greatest overall improvement in EMC, as determined by the analysis. Passive filters a simple and cost-effective solution, while shielding techniques are especially effective at reducing radiated emissions, as they can help to confine the EMI.

5.2 EMI Sources Contribution Analysis
Literature findings indicate that switching devices are the dominant contributors to EMI generation in modern converters.

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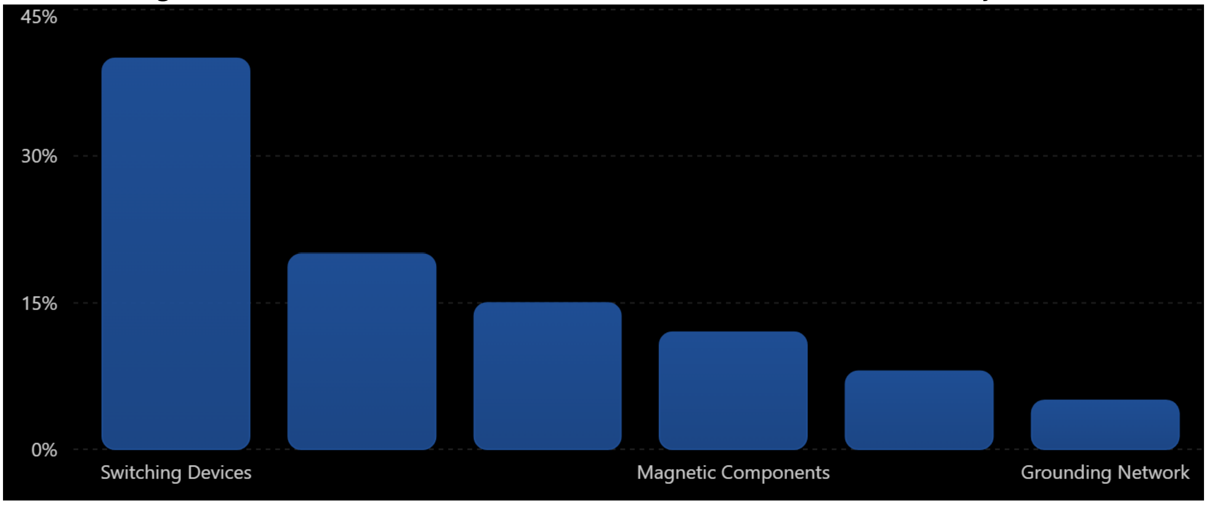
Table 6 .Relative Contribution of EMI Sources

EMI Source	Relative Contribution (%)
Switching Devices (MOSFET/IGBT/SiC/GaN)	40
PCB Parasitics	20
Gate Drivers	15
Transformers & Inductors	12
Power Cables	8
Grounding Network	5

EMI Source of Contribution Relativity

Figure 1 .Relative Contribution of EMI Sources in Power Electronic Systems



Since high-frequency switching transitions create large voltage and current transients, switch device protective EMI generation occupies the biggest share of EMI generation. In fact, with incredible switching speeds in excess of 10 kHz, wide-bandgap devices amplify this effect again.

5.3 EMI Impact of Wide-Bandgap Devices

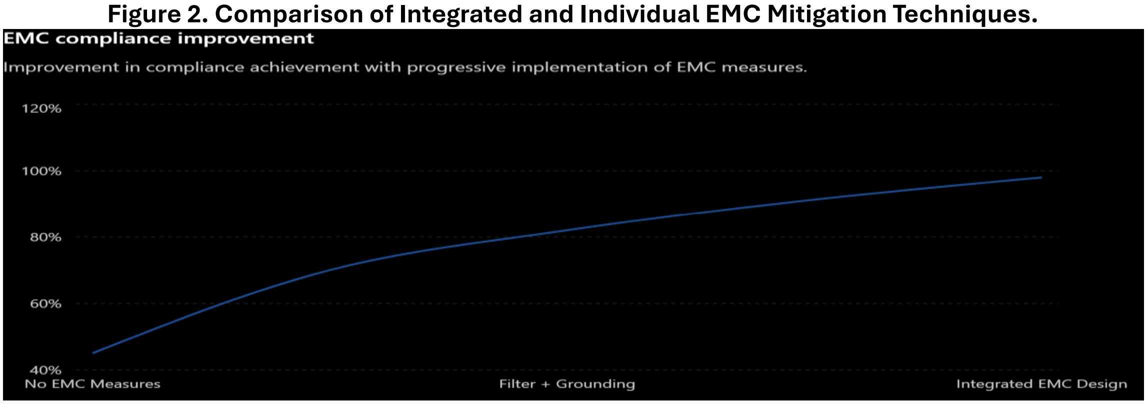
Studies made on SiC and GaN devices, most recently, as you would expect, show even more improvements in the efficiencies that can be obtained, but increased EMI is becoming a concern.

Table 7. Performance Comparison of Silicon, SiC MOSFET, and GaN HEMT Technologies.

Parameter	Silicon IGBT	Si MOSFET	SiC MOSFET	GaN HEMT
Switching Speed	Low	Medium	High	Very High
Efficiency	Medium	High	Very High	Very High
EMI Generation	Low	Medium	High	Very High
Power Density	Medium	High	Very High	Very High
EMC Design Difficulty	Low	Medium	High	Very High

The use of SiC and GaN devices allows considerably higher efficiency but comes with increased levels of both common-mode, as well as differential-mode noise because of the bigger dv/dtdv/dtdv/dt and di/di/di/ddi currents [1], [2]. This is where more sophisticated EMC mitigation techniques come into play.

Figure 2. Comparison of Integrated and Individual EMC Mitigation Techniques.



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Results show that integrated EMC design approaches outperform individual mitigation alternatives. The systems with combined filtering, grounding, shielding, and PCB optimization have the highest probability of complying with EMC regulatory standards.

Discussion and Conclusion

The research focused on addressing issues of electromagnetic compatibility (EMC) and mitigating electromagnetic interference (EMI) in contemporary power electronic devices and systems. With the rapid adoption of high-frequency switching converters, compact layouts, as well as wide-bandgap semiconductor devices like SiC and GaN among electronic applications, the research results demonstrate that EMC has turned into a vital design consideration. While these technologies contribute to improvements in efficiency, power density and dynamic response, they likewise exacerbate switching transients, parasitic coupling, conducted emissions and radiated noise.

The study verifies that in power electronic systems EMI is mainly caused by fast-switching semiconductor devices, PCB parasitics, gate-driver circuits, magnetic parts design, grounding structures and cables. Conducted EMI passes mostly through the power line, signal lines, and earth return path while radiated EMI is generated by high-frequency current loops, switching nodes, and parasitic structures that behave as antennae. Hence, successful EMC design relies on a comprehensive understanding of the means by which noise are generated and how they propagate.

Review of the existing literature shows that no one mitigation method can assure EMC compliance. Conducted emissions can be counteracted with passive and active EMI filters while radiated emissions, as well as common-mode noise, are best controlled through shielding and grounding. The most vital and cost-effective solution is PCB layout optimization since its directly lowers loop area, parasitic inductance, noise coupling and undesirable radiation. They enhance the EMC performance of your designs when they are integrated directly into the design stages across passive elements, PCB layout, shielding, grounding and switching-control strategies.

It is interesting to note that international EMC standards such as IEC 61000, CISPR 11 and IEC 61800-3 are key elements for the emission limits, immunity specifications and testing of power electronic systems [6]. Adherence to these standards is necessary not just to get selling approval in the market, but also for reliability of the system of operation and electromagnetic compatibility with adjacent equipment as well. IEC 61000-6-3:2020 General emissions standard * Part 6-3: Generic standards *Emission standard for residential, commercial and light-industrial environments IEC 61800-3:2022 Adjustable speed electrical power drive systems-part 3: EMC requirements threat or disclosure

In summary, EMC should not be considered a last-stage correction but as an integral part of modern power electronics design. Future research efforts will be directed towards integrated EMC design frameworks, AI-assisted EMI prediction, digital-twin-based EMC analysis, compact active EMI filters and advanced mitigation methods for SiC- as well as GaN-converter applications. These directions are needed to enable the next generation of high-performance, high-density, resilient and standards-compliant power electronic systems. This trend is also substantiated from recent reviews in the literature with regard to WBG converters [4], EMI filters [5], radiated EMI modeling for power electronics modules and systems under consideration of high-frequency interference coupling mechanisms in converter-dominated power systems.

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