



Vincotech

RECOMMENDED QUALIFICATION STEPS FOR OPTIMAL USAGE OF POWER MODULES

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Recommended qualification steps for optimal usage of power modules

1 Abstract

This document provides comprehensive guidance for customers on the proper use and integration of a power module in industrial applications. It outlines key considerations for mechanical mounting, thermal management and electrical interfacing requirements to ensure reliable and efficient operation under demanding conditions. The document details recommended verification tests that should be conducted on first samples during the initial qualification phase. These include electrical characterization, thermal performance validation, insulation and isolation testing and functional operation checks under representative load and switching conditions. By following these recommendations, customers can minimize integration risks, ensure compatibility with their system and establish a robust foundation for long-term, stable performance of the power module.

2 Introduction

In modern industrial applications, power modules play a critical role in delivering reliable and efficient energy conversion under often harsh electrical, thermal, and mechanical conditions. The increasing complexity and performance requirements of these systems make the proper integration of power modules more important than ever. A failure to correctly qualify or verify a power module in its intended environment can lead to degraded performance, reduced lifetime, or in worst-case scenarios, catastrophic failure of both the module and the surrounding system.

To mitigate such risks, it is essential that customers undertake a structured qualification and verification process when first implementing a power module into their design. This process not only helps confirm that the module operates within specified limits under real-world conditions but also uncovers any unexpected interactions with the surrounding components or system-level constraints. Early identification of issues allows for design adjustments and avoids costly failures during later stages of development or field operation.

This document serves as a culmination of our current best practices and knowledge related to power module usage and initial verification. It combines engineering insights gained from extensive application support, internal testing, and customer feedback across a wide range of



industrial environments. While we aim to provide comprehensive guidance, it is important to recognize that every application is unique. Variations in system architecture, cooling strategies, switching behaviour and safety requirements can significantly impact how the module behaves once integrated.

Therefore, while this document provides a solid foundation for correct usage and testing, it is ultimately the responsibility of the customer to assess the specific demands of their application and conduct any additional evaluations necessary to ensure long-term reliability and safety. We encourage all users to treat this guidance as a starting point and to apply it with engineering judgment, due diligence, and a thorough understanding of their end-use requirements.

3 Verification steps recommended by Vincotech

The below image outlines the recommended sequence of verification steps: starting with simulation, followed by electrical verification, assembly verification and finally thermal and lifetime verification. This structured flow ensures a comprehensive evaluation of the power module under various conditions and constraints. Each of these steps will be explored in detail in the following sub-chapters to support a reliable and efficient integration into your system.

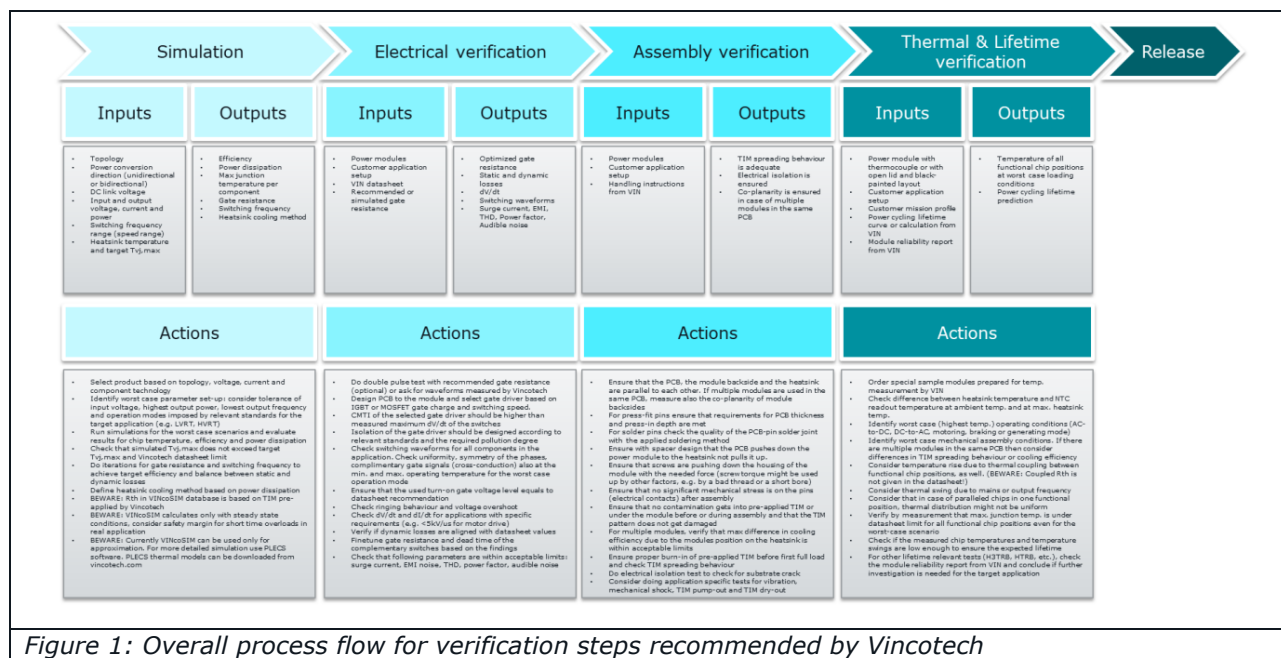
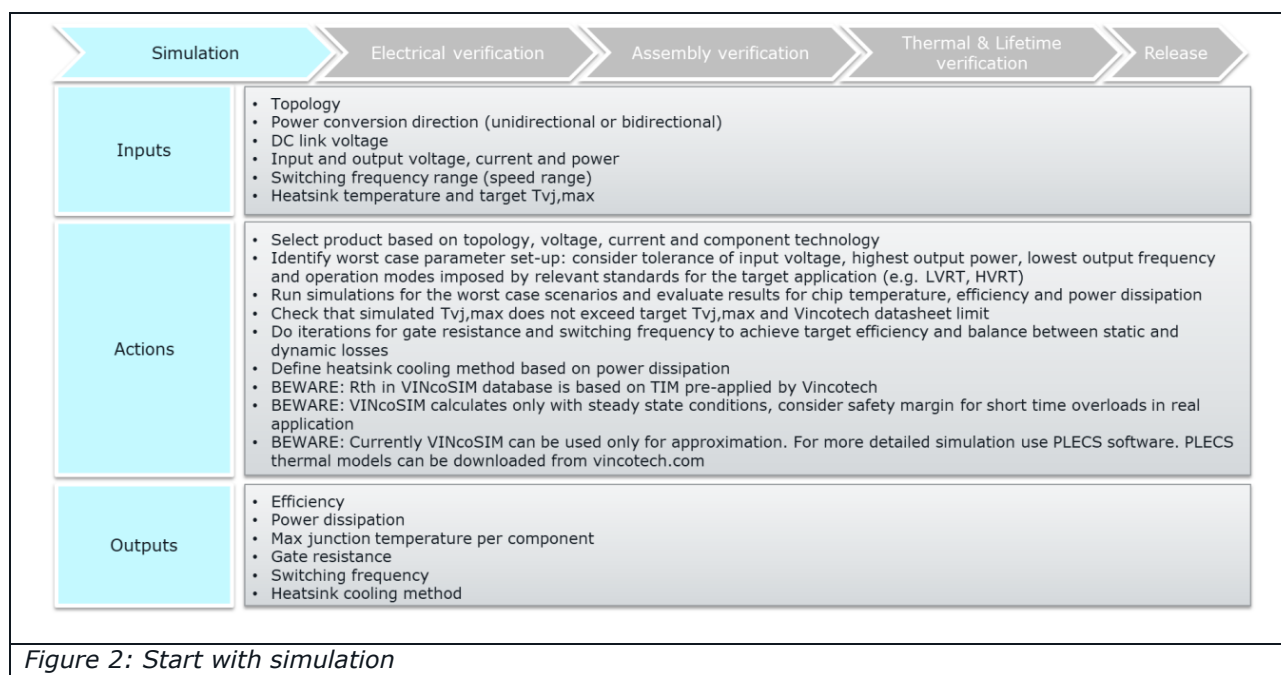


Figure 1: Overall process flow for verification steps recommended by Vincotech



3.1 First step: simulation

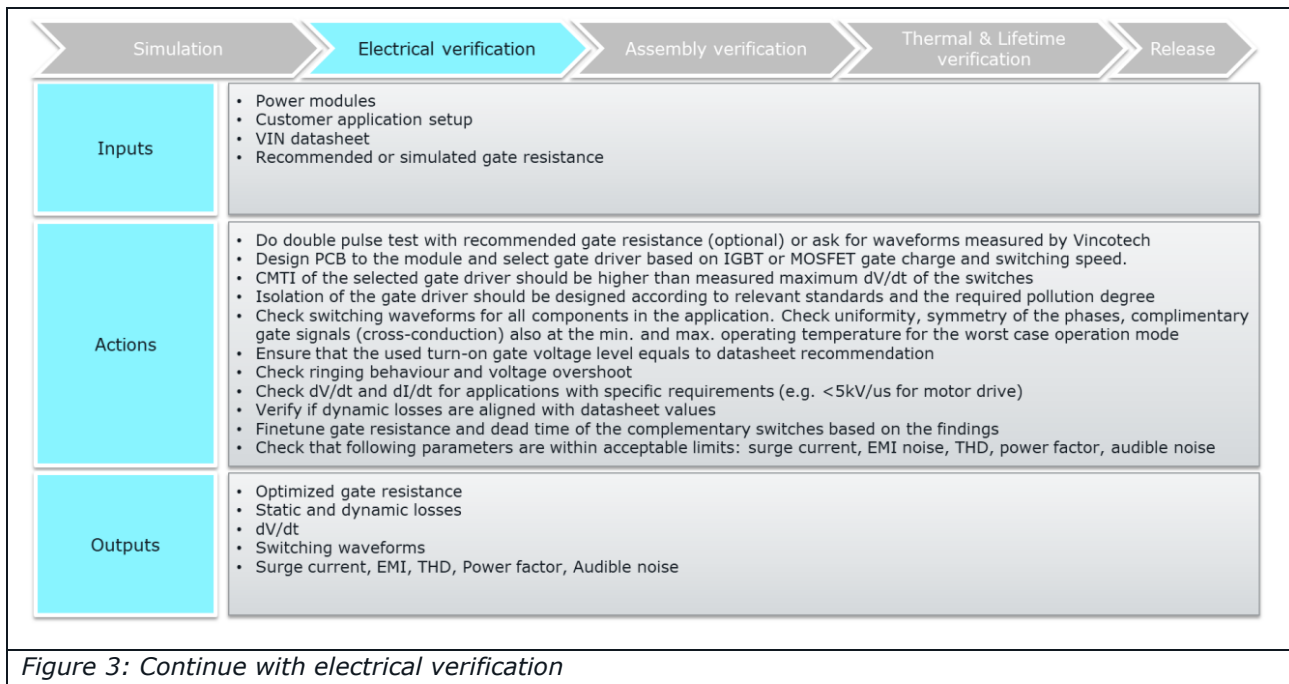
Starting with basic calculations and simulation is a critical first step in the design-in process. It allows engineers to predict the behaviour of the power module under different operating conditions without the need for physical prototypes, saving both time and cost. Early simulations help identify potential issues such as thermal stress, electrical overstress or inefficiencies in the design. By validating key parameters and performance expectations upfront, simulation lays a solid foundation for the subsequent verification steps and helps streamline the overall development process. *Figure 2* summarizes the most important sub-steps of this phase.



Vincotech provides supporting tools for this phase. For further information, please check the References section.

3.2 Second step: electrical verification

Electrical verification is essential to confirm that the power module performs as expected under real operating conditions. This step involves measuring key parameters such as switching behaviour, losses, and voltage/current waveforms to ensure they align with simulation results and datasheet specifications. It also helps detect issues like parasitic oscillations, improper gate drive settings or unexpected voltage spikes. By thoroughly testing the electrical characteristics, engineers can validate the design’s reliability and performance before moving on to mechanical and thermal assessments.



3.3 Second step: electrical verification

Assembly verification focuses on ensuring that the power module is correctly and reliably integrated into the application's mechanical and electrical system. This step includes checking mounting methods, soldering quality, connector alignment, and proper application of thermal interface materials. Verifying the assembly helps prevent common issues such as poor thermal contact, mechanical stress on the module or electrical connection failures. A thorough assembly verification ensures long-term reliability and performance by confirming that the module is physically and electrically well-implemented in the final system.

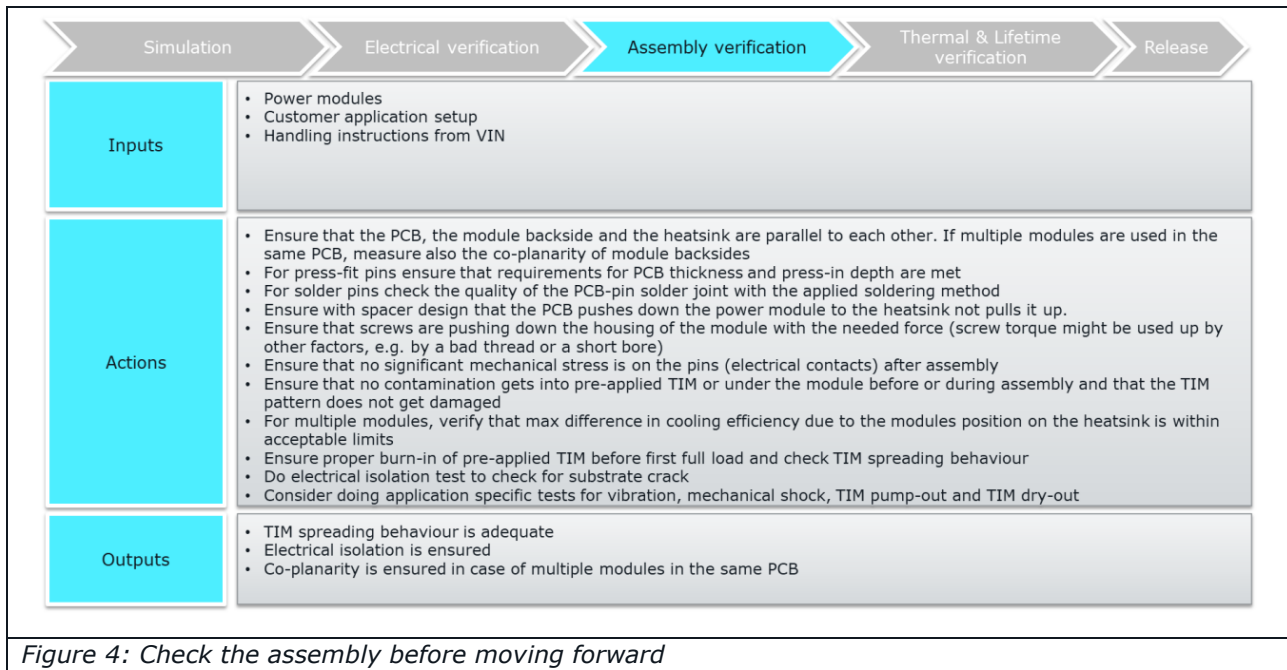
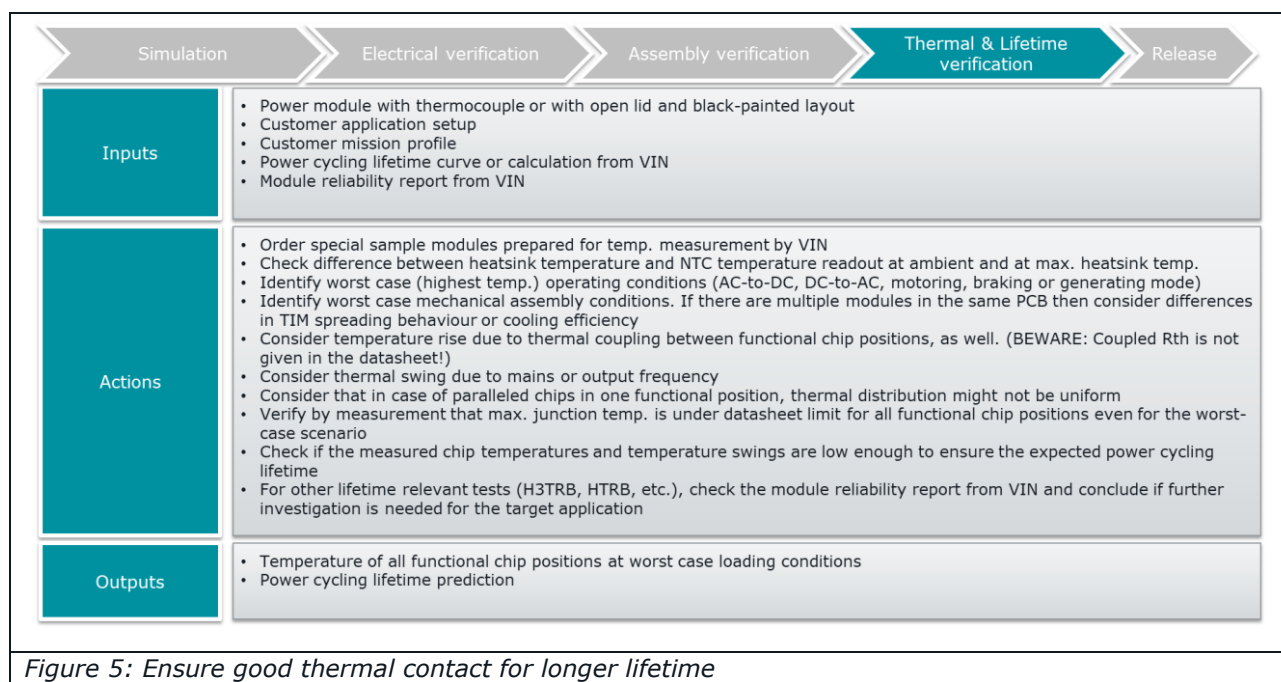


Figure 4: Check the assembly before moving forward

3.4 Fourth step: thermal and lifetime verification

Thermal verification is essential for assessing the long-term reliability and durability of the power module under real-world operating conditions. This step includes measuring temperature distribution, evaluating cooling efficiency, and ensuring that the module remains within its thermal limits across all load scenarios. Thorough validation of thermal performance ensures safe and efficient operation throughout the module’s intended service life.

For lifetime verification, including accelerated aging tests and thermal cycling to evaluate the effects of temperature fluctuations and mechanical stress, Vincotech provides comprehensive test reports. These tests help identify potential failure modes such as solder fatigue, delamination, and material degradation. However, customers are strongly encouraged to evaluate the final application environment. In harsh conditions - such as exposure to corrosive gases, humidity condensation, or intense vibration - additional risk assessment and tailored verification tests may be necessary to ensure reliable long-term performance.



3.5 About iterations

Iteration is a vital part of the development and verification process. While the described 4-step structure provides a logical flow, in practice, it's rarely a one-pass journey. Insights gained during electrical, assembly, or thermal verification often reveal areas that need adjustment - whether it's refining simulation models, improving layout or optimizing cooling strategies. Each iteration helps to fine-tune the design, address unexpected issues and close gaps between theoretical performance and real-world behaviour.

This iterative approach not only improves the robustness and reliability of the power module integration but also builds confidence in the final product. By continuously validating and refining each aspect of the system, the development team ensures that the module will meet performance, safety and lifetime expectations. Ultimately, this process leads to a smoother and more successful product release, reducing the risk of field failures and minimizing costly late-stage changes.

4 Conclusion

Successfully integrating a power module into an application requires a structured and thorough verification process. By following the four-step approach - starting with simulation, then performing electrical, assembly, and thermal & lifetime verification - engineers can ensure that the module operates reliably, efficiently, and safely under real-world conditions. Each step



serves as a critical checkpoint to identify and resolve potential issues early, reducing development time and long-term costs.

Equally important is recognizing that this process is inherently iterative. Re-evaluating and refining the design based on test results leads to a more robust solution and minimizes the risk of failure in the field. Combined with the technical support and test data offered by Vincotech, this methodology lays a solid foundation for successful product development and deployment. By investing in careful verification and continuous improvement, engineers can confidently move from concept to a reliable, high-performance final product.

5 References

Further details on specific topics covered in this document - such as simulation methods, electrical testing procedures, thermal management techniques, and reliability evaluation - can be found in the referenced literature listed in the table below. These sources provide in-depth technical information and industry best practices that complement and expand upon the content discussed in this paper.

No.	Phase	Description
1	Simulation	Simulation software VINcoSIM and PLECS
2	Simulation	VINcoSIM - The next generation power module simulation environment from Vincotech
3	Simulation	A step-by-step tutorial - Mastering VINcoSIM PLECS model generation
4	Electrical	Power module datasheet explanation
5	Electrical	Current carrying capability of solder and press-fit pins
6	Electrical	Power modules in low power drive applications
7	Electrical	The challenges of using SiC MOSFET-based power modules for solar inverters
8	Assembly	Handling instructions per housing type
9	Assembly	Advantages of pre-applied TIM for power modules



10	Assembly	Handling of power modules with phase-change material
11	Assembly	Thickness and pattern of thermal interface material per housing type
12	Thermal and lifetime	Chip temperature sensing methods for power modules
13	Thermal and lifetime	Thermal measurement with an integrated NTC thermistor
14	Thermal and lifetime	Thermal resistance, thermal spreading and temperature measurement
15	Thermal and lifetime	Influence of thermal cross coupling at power modules
16	Thermal and lifetime	Effects of Oxidation on the Thermal Performance of DCB Power Modules



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