Boosting Reliability: A Comparative Study of Silicon Carbide (Sic) and Silicon (Si) in Boost Converter Design Using MIL-HDBK-217 Standards

Original Scientific Paper

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Abstract – *Reliability is very important in the world of electronic device design and production, particularly in applications where continuous and flawless performance is a necessity. This directs our attention to the boost converter, which forms the foundation of power electronics, renewable energy systems, and electric vehicles. However, as technology progresses, the choice of materials for these converters is a big challenge. For that, in this paper, the impact of using Silicon Carbide (SiC) devices, with their promising material properties, on the reliability of boost converters is presented. Because the results showed that more than 80% of boost converter failures are caused by semiconductors, the use of SiC materials is assessed by determining its reliability using MIL-HDBK-217 standard. In addition, a comparative study with the use of traditional Silicon (Si) is conducted. The results showed that the failure rate of boost converters based on SiC devices reduced from 8.335 failure/10-6h to 6.243 failure/10-6h. This notable shift in failure rates establishes SiC as a pivotal material in the evolution of boost converter technology, offering a compelling solution to address the persistent challenges associated with semiconductor-related failures.*

Keywords*:* *Boost converter, SiC devices, Schottky diode, Reliability prediction, MIL-HDBK 217*

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1. INTRODUCTION

In the dynamic landscape of electronic device design and manufacturing, the pursuit of reliability stands as an indispensable quest, especially in applications where unwavering performance is paramount. This pursuit leads us to boost converters, a very important element in modern technology which elevates modest input voltages to remarkable heights. This type of static converters form the backbone of power electronics, renewable energy systems, and the electric vehicles propelling us toward a sustainable future [1].

At its essence, the boost converter epitomizes the ingenuity of electronic engineering, orchestrating precise voltage transformations integral to powering a spectrum of electronic devices, ranging from portable gadgets to renewable energy sources. However, as technological progress persists, the material selection for these boost converters assumes heightened significance [2].

Silicon Carbide (SiC), characterized by its promising attributes, emerges as a substantial contender challenging the conventional dominance of traditional Silicon (Si). SiC presents a suite of superior material properties, encompassing a wide bandgap, outstanding thermal conductivity, and notable resistance to elevated temperatures [2]. These characteristics lay the groundwork for a prospective revolution in the design of boost converters, offering the prospect of improved efficiency and performance.

Researchers are actively pursuing investigations into the reliability of wide band gap semiconductors to assess their performance and stability under diverse operating conditions. This involves studying factors such as temperature fluctuations [2], electrical stress [3], and other environmental variables that can impact the long-term functionality of electronic devices based on these materials [4]. However, as the industry moves toward the use of SiC devices, it becomes imperative to comprehensively assess and predict their reliability in real-world applications. Reliability prediction is a critical aspect for designing and deploying power electronics systems, as it aids in understanding the potential failure modes, estimating component lifetimes, and ultimately ensuring the longevity of PV systems [5]. At 650V power conversion, various technologies, including SiC MOSFETs, GaN HEMTs, and silicon devices, offer distinct advantages, from high-speed GaN to SiC's temperature resilience and silicon's cost-effectiveness. In the paper [1] authors contrast MIL-HDBK-217 and FIDES methods, contributing to the collective understanding of electronic system dependability. In [6] authors examined their performance, body diodes, and reliability, shedding light on this competitive field. In Algeria, despite government support for PV system development, there is a notable absence of research labs focusing on PV system reliability. Authors in [4] studied the reliability of PV system MPPT and simulated the integration of a photovoltaic panel with a Disrupts & Regards-controlled DC/DC converter, considering various choppers and power level. The paper [2] investigated the reliability of driven design in power electronic circuits, with a specific emphasis on power loss in switches and diodes. It presents a reliability evaluation method for a buck converter using thermal analysis of an IGBT and a diode by switching frequency and duty cycle. The mean time to failure for the buck converter was calculated.

Yet, as with any technological leap, questions arise. What implications does the adoption of SiC in boost converters have on their reliability? How do we navigate this pivotal juncture in materials science and engineering to ensure that SiC-fortified boost converters stand as unwavering pillars of dependability?

To answer these questions, in this paper, we delve into the ramifications of integrating Silicon Carbide (SiC) devices, renowned for their favorable material properties, on the reliability of boost converters. An in-depth analysis of the reliability of SiC materials is conducted, employing the MIL-HDBK-217 standard as the benchmark. Moreover, a comprehensive comparative study is executed, drawing distinctions between the application of SiC and the conventional Silicon (Si) within the context of boost converters. This investigation aims to provide insights into how SiC's distinctive material attributes impact the reliability landscape, particularly when juxtaposed with the established Silicon technology.

2. MATERIAL AND METHOD

2.1. BOOST CONVERTERS AND THEIR IMPORTANCE

Boost converters, although inconspicuous in their physical stature, occupy a paramount position in the world of modern electronics. Their significance lies in their ability to efficiently transform and regulate voltage levels, making them indispensable in a myriad of applications. These unassuming devices act as voltage elevators, taking a lower input voltage and elevating it to a higher output voltage. This fundamental function is pivotal in ensuring the smooth operation of numerous electronic systems and applications. From extending the lifespan of battery-powered devices by providing the required voltage boost to facilitating the integration of renewable energy sources into power grids, boost converters are the unsung heroes behind the scenes, ensuring that our electronic world operates with precision and reliability. In the context of power electronics, renewable energy systems, and electric vehicles, boost converters take center stage, making their reliability and performance critical factors that warrant meticulous examination [7].

Following bellow equations:

$$Vin = Vout(1 - D) \tag{1}$$

V_{in}= input voltage ; V_{out}= output voltage.

And the other component (Capacitor, Inductor) value we follow the equation [8]

$$L \geq V_{in} \frac{D}{\Delta I_L} f_S \tag{2}$$

While:

$$\Delta L \geq \frac{D \cdot V_{in-min}}{f_S \cdot L} \tag{3}$$

ΔI_L= estimate ripple current, $V_{in\text{-}min}$= minimum input voltage, f_s= switch frequency, D= duty cycle, L= inductor.

$$C = \frac{I_{out} \cdot D}{f_S \cdot \Delta V_{out}} \tag{4}$$

C= capacitor, I_{out}= output current, ΔV_{out} = estimate ripple voltage.

We have calculated parameters of the boost converter for 2kW and boosted the voltage from 120 V to 400 V, and switching frequency 25 kHz, the results are presented in the Table 1. For a ripple current of 30% and ripple voltage of 2%.

Using equations (1) to (4) for designing the parameters of boost converter which are presented in Table 1.

Table 1. Parameters of DC-DC boost converter

Parameter	Device specification
Inductor [mH]	0.67
Capacitor [μF]	17.42
Resistor [Ω]	160
Input voltage[V]	120
Output voltage[V]	400
Estimate ripple current [A]	5
Switch frequency[kHz]	25
Duty cycle	0.697
Estimate ripple voltage[V]	8

2.2. SILICON CARBIDE (SiC) VS. SILICON (Si): RESHAPING RELIABILITY IN ELECTRONIC DEVICES

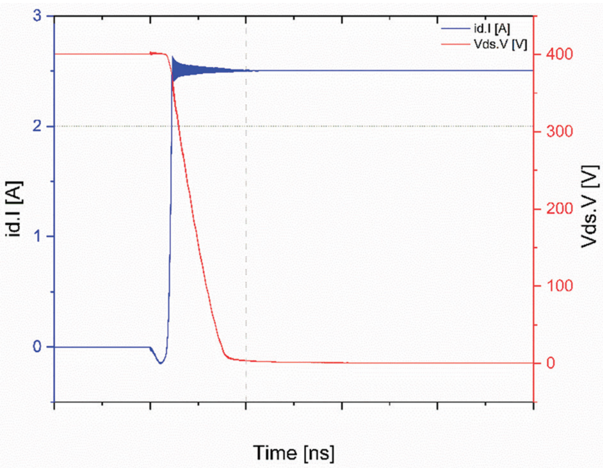
The ongoing comparison between Silicon Carbide (SiC) and Silicon (Si) as semiconductor materials represents a compelling juxtaposition of established incumbency versus emerging potential. Silicon, a longstanding cornerstone in the electronics industry, carries a legacy of reliability and widespread adoption. In contrast, Silicon Carbide, positioned as a nascent alternative, possesses distinctive properties and promising attributes that pose a challenge to the existing technological paradigm.

On the other hand, Silicon Carbide, with its wide bandgap and remarkable material properties, presents a tantalizing alternative. SiC exhibits superior thermal conductivity, enabling it to dissipate heat more efficiently, a quality that greatly enhances the reliability of electronic components operating at high temperatures. Additionally, SiC devices can handle higher voltages and power levels, reducing the stress on components and promising extended operational lifespans. These characteristics have propelled Silicon Carbide (SiC) into prominence as a contender challenging the dominance of Silicon.

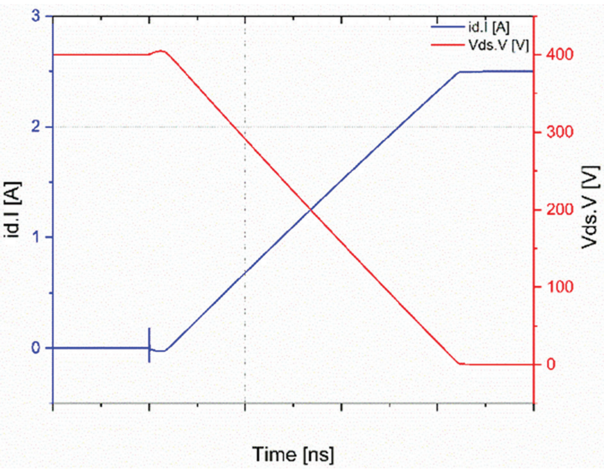
In the realm of boost converters and beyond, the SiC versus Si comparison stands as a testament to the continual pursuit of enhancement and reliability in electronic systems. As we navigate the ever-evolving landscape of technology, the choice between these two materials has the potential to reshape industries, redefine efficiency, and ultimately dictate the reliability of the electronic devices that underpin our modern world.

Table 2. Mosfets and diodes parameters [9-12]

Manufacture	ROHM	IXYS	CREE	APT
Part number	SCH2080KEC	IXFN 32N120	C4D20120D	APT60D120B
Breakdown rated voltage [V]	1200	1200	1200	1200
Rated current [Amp]	28A @ 100 °C	32A @ 25°C	33A @ 135 °C	60A @ 25 °C
Maximum junction temperature [°C]	175	150	175	150
Gate-source voltage [V]	-10/+20	-30/+30	/	/
Thermal resistance junction case θ_{jc} [°C]	0.44	0.16	0.43	0.66
Diode forward voltage Vf [V]	/	/	1.5	12
Static drain-source on-resistance RDS [Ω]	0.08 Ω	0.35 Ω	/	/

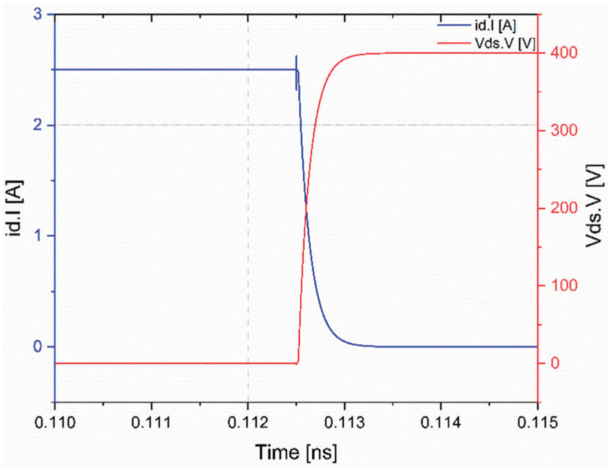


(a)

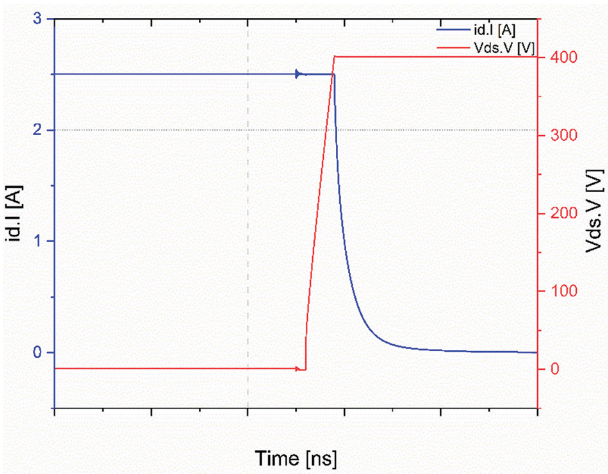


(b)

Fig. 1. Turn-ON of Mosfet – SiC (a) vs Si (b)



(a)



(b)

Fig. 2. Turn-OFF of Mosfet – SiC (a) vs Si (b)

The simulation of the switches is made using Ansys simplorer to define the power losses and response time. Silicon Carbide (SiC) Mosfets offer advantages such as quicker turn-on switching, reduced switching losses, and enhanced efficiency due to their rapid switching properties (Fig. 1.a). However, they necessitate gate drivers capable of supplying higher voltage levels. In contrast, Silicon (Si) Mosfets (Fig. 1.b) have slower turn-on speeds, increased switching losses, and lower threshold voltages, rendering them better suited for specific low- to medium-power applications. Choosing between SiC and Si Mosfets hinges on precise application requirements, considering factors like speed, efficiency, and gate driver capabilities.

Regarding turn-off (Fig. 2.a) characteristics, SiC Mosfets exhibit swift switching speeds, enabling rapid deactivation, and they experience lower turn-off losses, which enhances overall efficiency during turn-off transitions. Nonetheless, SiC Mosfets demand gate drivers with the capability for quick switching and precise control. Conversely, Si Mosfets (Fig. 2.b) feature slower turn-off speeds and tend to incur higher turn-off losses, potentially affecting overall efficiency. They typically have lower gate drive requirements in terms of voltage and current. The decision between Silicon Carbide (SiC) and Silicon (Si) MOSFETs for turn-off is a pivotal choice that hinges on the specific requirements of the application. Several critical factors must be carefully considered to optimize performance, efficiency, and overall reliability.

2.3. RELIABILITY PREDICTION USING MIL-HDBK-217 STANDARDS

Reliability prediction using the MIL-HDBK-217 standards represents a cornerstone in the field of electronic engineering. This venerable set of guidelines and methodologies provides a structured approach to assessing and forecasting the reliability of electronic components and systems, ensuring they meet the rigorous demands of various applications.

In the context of boost converters and the comparison between Silicon Carbide (SiC) and Silicon (Si) as semiconductor materials, MIL-HDBK-217 offers a robust framework to navigate this critical juncture. It takes into account an array of factors, including temperature, voltage, and environmental conditions, to estimate the failure rate of electronic components [13].

For boost converters, these standards become a compass, guiding engineers and designers through the labyrinth of material choices. By leveraging MIL-HDBK-217, one can scrutinize how SiC and Si-based boost converters fare under the relentless forces of time and environmental stressors. It enables us to make data-driven decisions, shedding light on which material SiC or Si ultimately yields the highest reliability.

By adopting this time-tested methodology, we initiate an exploration into the intricate synergy among material science, electronic engineering, and reliability. This endeavor holds the potential not only to yield insights but also to provide a systematic framework for fortifying our boost converters against the rigors of the most demanding operational challenges. Continuing to drive innovation and progress across the electronic landscape [14].

Temperature and Stress Levels

Operating temperature is a pivotal factor. SiC's superior thermal conductivity allows it to handle higher temperatures without degradation, potentially extending the operational life of the converter. Si-based devices may experience more significant stress due to elevated temperatures.

Voltage Ratings

The voltage ratings of semiconductor materials impact their reliability. SiC devices are known for their ability to handle higher voltage levels without breakdown, making them more suitable for high-voltage applications.

Environmental Conditions

MIL-HDBK-217 takes into account environmental factors such as humidity, vibration, and thermal cycling. These conditions can affect the reliability of electronic components and SiC's resistance to harsh environments may confer an advantage.

Redundancy and Mitigation Strategies

Reliability predictions should consider the deployment of redundancy and mitigation strategies. This can involve redundancy in critical components or systems and the use of protective features like overcurrent or overvoltage protection.

Testing and Validation

Real-world testing and validation data should complement reliability predictions. Actual performance in the field can provide valuable insights into the reliability of SiC and Si-based boost converters.

Application-Specific Considerations:

The intended application of the boost converter plays a significant role. Different applications may have varying demands and stress factors that influence reliability requirements.

In the subsequent sections, we delve into the results of these reliability predictions, conducting a comprehensive analysis of the SiC-based and Si-based converters' performance and reliability under various conditions and scenarios.

On the other hand, the parts count approach is more conservative and can be used in the early stages of design when limited information is available. The reliability expression R is

$$R(t) = e^{-\lambda.t} R(t) = e^{-\lambda t} \tag{5}$$

λ presents the failure rate and its value is constant, at t the average of $R(t)$ is determined while:

$$t = \frac{1}{\lambda} \quad (6)$$

In this context, λ represents the unchanging rate at which failures occur, and 't' denotes the time at which the initial failure happens. The Mean Time to Failure (MTTF) can be found by calculating the average of R(t), while the Mean Time Between Failure (MTBF) can be computed using the MTTF in conjunction with the Mean Time to Repair (MTTR), according to the following formula:

$$MTBF = MTTR + MTTF = \frac{1}{\lambda} \quad (7)$$

When it comes to particular components like Mosfets, diodes, inductors, and capacitors, determining their failure rates involves considering a range of factors. These factors encompass the construction factor, application factor, environment factor, quality factor, stress factor, and temperature factor, all of which contribute to the overall reliability assessment of these components. (λ_{system}) for the part stress method is:

$$\lambda_{system} = \sum_{i=1}^{N} (\lambda_{part})i \quad (8)$$

Failure rate of Mosfet is calculated by:

$$\lambda_{P(S)} = \lambda_{(b(S)} \cdot \pi_Q . \pi_A . \pi_E . \pi_T) \quad (9)$$

For the diode failure rate:

$$\lambda_{P(D)} = \lambda_{b(D)} \cdot \pi_Q . \pi_C . \pi_E . \pi_T . \pi_S \quad (10)$$

The Inductor failure rate is

$$\lambda_{P(L)} = \lambda_{b(L)} \cdot \pi_Q . \pi_C . \pi_E \quad (11)$$

For the capacitor failure rate:

$$\lambda_{P(D)} = \lambda_{b(C)} \cdot \pi_Q . \pi_{CV} . \pi_E \quad (12)$$

In summary, comprehending the reliability of electronic components holds immense importance in the design and operation of electronic systems. To assess this reliability, we employ methods such as part stress and parts count, which allow us to calculate failure rates accurately. These calculations involve various factors, including the contact construction factor (π_C), application factor (π_A), environment factor (π_E), quality factor (π_Q), stress factor (π_S), and temperature factor (π_T).

Equations (13) and (15) are instrumental in determining the thermal conductivity values of the inductor (λb) and capacitor ($\lambda_{P(C)}$), respectively. Equation (14) aids in finding the hot spot temperature of the inductor (T_{HS}), a critical parameter needed for equation (13). This equation relies on two essential inputs: the ambient operating temperature (T_A) and the temperature rise above ambient (ΔT). Furthermore, equation (15) hinges on the ratio of operating voltage to rated voltage (S) and the capacitance value (C). By leveraging these equations and factors, we can pinpoint the reliability of electronic components, identify key factors impacting system reliability, and propose strategies to enhance reliability while minimizing maintenance costs.

$$\lambda_b = 0.00035 \cdot e^{\left(\frac{T_{HS} + 273}{329}\right)^{15.6}} \quad (13)$$

$$T_{HS} = T_A + 1.1 \times \Delta T \quad (14)$$

$$\lambda_b = 0.00254 \left(\left(\frac{S}{0.5} \right)^3 + 1 \right) \exp \left(5.09 \times \left(\frac{(TA + 273)}{378} \right)^5 \right) \quad (15)$$

Equations (16) and (17) come into play when calculating the temperature factor (π_T) for both the switch and diode components. To apply these equations, we first need to ascertain the junction temperature (T_j), a parameter essential for these calculations. Equation (11) assists in determining the junction temperature, requiring inputs such as the heat sink temperature (T_C), the thermal resistance of the switch or diode (θ_{jc}), and the total power loss experienced by the switch or diode (P_{loss}). It's worth noting that the junction temperature is typically established through simulation results, allowing for an accurate assessment of component temperature and, by extension, the temperature factor crucial for reliability calculations.

$$\pi_{T(S)} = \exp \left(-1925 \times \left(\frac{1}{(T_j + 273)} - \frac{1}{298} \right) \right) \quad (16)$$

$$\pi_{T(D)} = \exp \left(-1925 \times \left(\frac{1}{(T_j + 273)} - \frac{1}{293} \right) \right) \quad (17)$$

$$T_j = T_C + \theta_{jc} \times P_{loss} \quad (18)$$

The Equation (19) and (20) present, respectively, the ratio of operating voltage to rated voltage, VS, and the factor π_{CV} for a Capacitance C.

$$\pi_S = V^{2.43} \quad (19)$$

$$\pi_{CV} = 0.34 \times C^{0.18} \quad (20)$$

3. RESULTS AND DISCUSSION

The MIL HDBK-217F standard, in its traditional form, lays the foundation for conducting reliability analysis and predictions. This process entails the incorporation of adjustment factors, with a primary focus on the base failure rate, which acts as a fundamental parameter for modifying the component's failure rate.

Critical data concerning both average and effective power values hold pivotal importance as they serve as the building blocks for calculating losses and subsequently determining the junction temperature of the MOSFET component. Leveraging the Arrhenius model, the temperature factor is fine-tuned, leading to the ultimate calculation of the failure rate for the MOSFET.

For the purpose of this analysis, it is assumed that the ambient temperature remains constant at 27°C.

Caculation of failure rate for main Switch

For SiC Mosfet

$P_{losss} = P_{M\text{-}Con} + P_{M\text{-}SW}$

$P_{M\text{-}Con} = R_{DS} R \cdot I^2_{RMS}$ =0.08 . (16.66) ^{2} =22.2 W

$P_{M\text{-}SW}$=$(E_{off}$+$E_{on})\,f_{sw}$
=(87.2+31.7)10^{-6} . 25.103=2.97

$P_{loss\text{-}s}$=25.17W

T_c=27°c

T_j=T_c+$\theta_{jc}\cdot P_{loss}$
=38.4

$$\pi_{T(S)} = \exp\left(-1925 \times \left(\frac{1}{(T_j + 273)} - \frac{1}{298}\right)\right)$$

π_T=1.311

π_Q=5.5, π_E=6, π_A=10, λ_b=0.012

λ_P-(S) =5.191

For Si Mosfet

$P_{loss\text{-}s}$= $P_{M\text{-}Con}$+$P_{M\text{-}SW}$

$P_{M\text{-}Con}$ Rds*I^2RMS=0.35*$(16.66)^2$ =97.14 W

$P_{M\text{-}SW}$=$(E_{off}$+$E_{on})f_{sw}$=(55.2+168.4) 10^{-6} *25.103=5.59 W

$P_{loss\text{-}s}$=102.73 W

T_c=27°c

T_j= T_c+ θ_{jc}*$P_{loss\text{-}s}$=53.52

$$\pi_{T(S)} = \exp\left(-1925 \times \left(\frac{1}{(T_j + 273)} - \frac{1}{298}\right)\right)$$

π_T=1.758

π_Q=5.5, π_E=6, π_A=10, λ_b=0.012

λ_P-(S)=6.962

Calculation of failure rate for output Diode:

Schottky Diode

$P_{loss\text{-}D}$=$P_{con\text{-}d}$+$P_{sw\text{-}d}$

$P_{con\text{-}d}$ =V_{fd}*I_{RMS}=1.8*16.66=29.98 W

$P_{sw\text{-}d}$=Q_c.V_{fsw}=8.10^{-8}.400.25.10^3=0.8 W

T_c=27°c

T_j= T_c+ θ_{jc}*P_{loss}=40.23°C

$$\pi_{T(S)} = \exp\left(-1925 \times \left(\frac{1}{(T_j + 273)} - \frac{1}{298}\right)\right)$$

π_T=1.4511

π_Q=5.5, π_E=6, π_S=0.07, π_C=1, λ_b=0.003

λ_P-(D)=0.01005

For Si Diode

$P_{losss\text{-}D}$=$P_{Con\text{-}D}$+$P_{SW\text{-}D}$

$P_{con\text{-}d}$=V_{fd}+$I_{out\text{-}RMS}$=2.15 .16.66=35.81 W

$P_{sw\text{-}d}$=$Q_c\cdot V_{out}\cdot f_{sw}$=1.88.$10^{-6}$.400.25.103
=18.8 W

T_c=27°c

T_j=T_c+$\theta_{jc}\cdot P_{loss}$=63.04

$$\pi_{T(S)} = \exp\left(-1925 \times \left(\frac{1}{(T_j + 273)} - \frac{1}{298}\right)\right)$$

π_T=2.077

π_T=2.077

π_Q=5.5, π_E=6, π_S=0.07, π_C=1, λ_b=0.069

$\lambda_{P\text{-}(D)}$=0.3310

Calculation of failure rate for each of output capacitor

π_{CV} = 0.34 · $C^{0.18}$=0.34 $(17.42)^{0.18}$=0.5687

S=400/600=0.667, T_A= 27°C

$$\lambda_b = 0.00254\left(\left(\frac{S}{0.5}\right)^3 + 1\right)\exp\left(5.09 \times \left(\frac{(TA + 273)}{378}\right)^5\right)$$

λ_b =0.043

π_Q=10, π_E=4

$\lambda_{P\text{-}(C)}$=0.043.4.10.0.5687=0.9781

Calculation of failure rate for each of input inductor

T_{HS} = T_A + 1.1 × ΔT

$$\lambda_b = 0.00035 \times \exp\left(\frac{(T_{HS} + 273)}{329}\right)^{15.6} = 0.00162$$

π_Q=20, π_E=2. π_C=1.

$\lambda_{P\text{-}(L)}$==0.00162.2.20.1=0.0648

Table 3. Adjustment factors (MIL HDBK-217F standard)

	π_Q	π_E	π_S	π_T	π_A	π_C	π_{CV}	λ_b
SiC Transistor FET	5.5	6	/	2	10		/	0.012
Schottky Diode	5.5	6	0.07	3	10	1	/	0.003
Si Transistor	5.5	6	/	2	10		/	0.012
Diode	5.5	6	0.07	3	10	1	/	0.069
Inductor	20	2	/	/		1	/	0.00162
Capacitor	10	4	/	/	/	/	0.56	0.043

Table 4. Reliability of the boost converter based on different semiconductors generation

	Element	Failure rate λpart [failure/10^{-6}]	System failure rate
Boost converter based on SiC device	Inductor	0.0648	$\lambda_{system} = \sum_{i=1}^{N} \lambda_{i-part}$ 6.243 failure/10-6h
	Capacitor	0.9781	
	SiC Mosfet	5.191	
	Schottky diode	0.01005	
Boost converter based on Si device	Iductor	0.0648	$\lambda_{system} = \sum_{i=1}^{N} \lambda_{i-part}$ 8.335 failure/10-6h
	Capacitor	0.9781	
	Si Mosfet	6.962	
	Diode	0.3310	

Table.4 provides insights into the expected reliability results, rigorously evaluated in accordance with the well-established Military Handbook (MIL-HDBK-217) standard. This analysis takes various factors into account, including thermal stress, voltage fluctuations, and current variations, delivering valuable insights into the Mean Time Between Failures (MTBF) of the converter. The forecasted reliability once again confirms the resilience of the SiC-based system in enduring demanding conditions, assuring steadfast performance across the converter's entire operational spectrum.

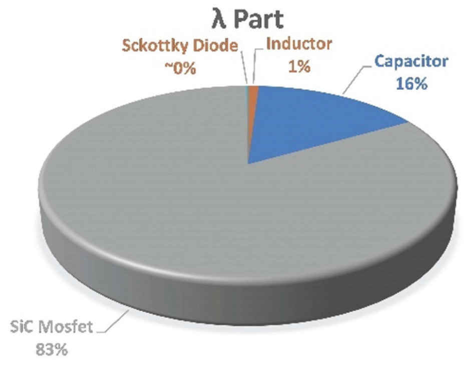


Fig. 3. λ part of boost converter based on SiC device

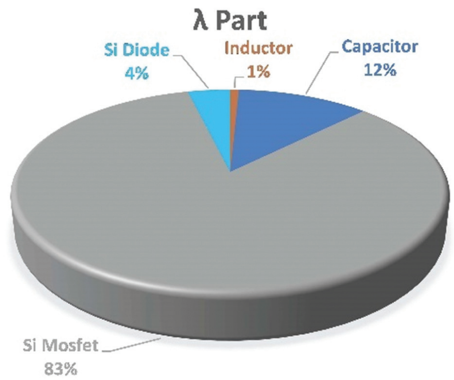


Fig. 4. λ part of boost converter based on Si device

Figs. 3 and 4 present the λ part of boost converter based on SiC and Si devices, respectively. The results show that more than 83% of boost converter failures are caused by semiconductors. This justifies the importance of improving the reliability of these devices.

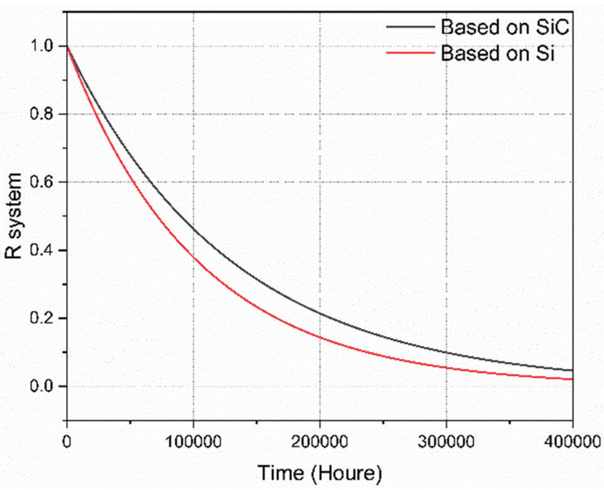


Fig. 5. Comparative Reliability Analysis - Si vs SiC

The comparison of reliability predictions between SiC-based and Si-based boost converters, as shown in Fig. 5, tells a compelling story of transformation. In this narrative, the SiC-based system emerges as a symbol of robustness and trustworthiness. Its superior thermal stability, coupled with the intrinsic durability of SiC devices, positions it for a prolonged operational life, surpassing its Si-based counterpart in terms of sustained reliability.

In this intersection of data, our analysis resonates with the potential of SiC-based boost converters to redefine the reliability landscape. They not only exhibit qualities such as higher efficiency, superior voltage and current handling but also emphasize their capacity for enduring and dependable performance. This reliability prediction further bolsters our confidence in the SiC-based boost converter's ability to gracefully navigate the challenges posed by real-world applications, seamlessly aligning with the exacting demands of contemporary power electronics systems.

4. CONCLUSION

In conclusion, our study delved into the intricate interplay between Silicon Carbide (SiC) and traditional Silicon (Si) in the realm of boost converters' reliability, guided by the MIL-HDBK-217 standard. The primary focus was on assessing the impact of SiC devices, with their promising material properties, on the failure rates of these essential electronic components.

The results of our analysis revealed a substantial decrease in the failure rate of boost converters when utilizing SiC devices, dropping from one failures on 13.7 year to one failures 18.3 year. This significant reduction underscores the heightened reliability achieved with SiC technology, aligning with the expectations outlined in the MIL-HDBK-217 standard. The standard's comprehensive guidelines facilitated a meticulous evaluation, ensuring the robustness and consistency of our reliability assessment.

Our findings not only corroborate the efficacy of SiC in enhancing reliability but also provide valuable insights for practitioners and researchers in the field of electronic engineering. The MIL-HDBK-217 standard played a pivotal role in guiding our study, offering a reliable framework for comparison and assessment.

In the broader context of boost converter technology, our results suggest that Silicon Carbide emerges as a material that holds great promise in elevating the reliability standards of electronic systems. The visual representation of our results, presented graphically, will further enhance the accessibility and clarity of our findings.

As we move forward, this study contributes to the ongoing discourse on material selection in electronic design, providing a foundation for future advancements in boost converter technology. The promising outcomes with SiC materials underscore their potential role as key enablers for achieving robust and dependable electronic systems in the pursuit of technological progress.

This study can be improved using others recent and updated benchmarks, as well as it can be extended by including other methods of reliability evaluation.

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