

Gate-drive design guide for Infineon high-voltage CoolGaN™ Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

About this document

Scope and purpose

The fast-switching capability and superior figure of merit (FOM) of GaN transistors enable more significantly higher efficiency and power density compared with conventional silicon devices. However, these advantages also introduce new design challenges, particularly in gate driver architecture and PCB layout. As a result, GaN-based power stages require gate-drive concepts that differ fundamentally from those used for silicon MOSFETs.

This application note focuses on gate-driver design consideration for Infineon CoolGaN™ Transistors, which is an enhancement mode (E-mode) GaN device that require a gate holding current to maintain the formation of the two-dimensional electron gas (2DEG) channel during the on-state and to sustain conduction.

To support users and engineers in developing robust and practical gate-drive solutions, this application note:

- Explains the operating fundamentals of Infineon CoolGaN™ technology
- Discusses critical and realistic gate-drive design trade-offs
- Provides clear, step-by-step gate-drive design procedure tailored to Infineon CoolGaN™ Transistors

In addition, two practical design examples are studied and discussed in detail. These examples demonstrate how to design gate-drive circuits for CoolGaN™ Transistors, highlighting best practices to achieve superior performance while ensuring adequate safety margins and reliability.

Intended audience

Switched-mode power supplies (SMPS) and power electronics design engineers, technicians, and developers of electronic systems who are interested in achieving reliable and optimal system performance with HV CoolGaN™ Transistors.

Keypoints

- Develop a deep understanding of specifications, parameters, and characteristic curves from the CoolGaN™ Transistor datasheet to initiate a practical gate-drive design
- Comprehend design challenges and trade-offs with realistic considerations including parasitic components, thermal effects, and related factors
- Validate the gate-drive design and verify whether it meets overall system prospectives
- Address further considerations for optimizing performance and reliability from various perspectives

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

About this product family

About this product family

Product family

Infineon's high-voltage [CoolGaN™](#) product family offers advanced GaN power transistors, enabling a versatile and scalable solution for various applications, such as consumer electronics, industrial systems, enterprise equipment, and AI data center power supplies. CoolGaN™ offers diverse product specifications and packages to realize superior switching speed, high-power density, and reduced energy losses, resulting in smaller, lighter, and more compact systems with improved reliability and thermal conductivity. With CoolGaN™ technology, higher thermal conductivity and robust design, engineers can achieve a reliable, high-performance solutions, making these devices an ideal choice for designers seeking to create innovative, efficient, and compact power electronics systems.

Target applications

- [AI datacenter and server power supply units \(PSU\)](#)
- [Telecom PSU](#)
- [Switched-mode power supplies \(SMPS\)](#)
- [Adapters and chargers](#)
- [TV/monitor power supply](#)
- [Home appliances](#)
- [Energy storage systems \(ESS\)](#)
- [LED lighting system design](#)

Table of contents

About this document.....	1
About this product family	2
Table of contents	3
1 Introduction	4
2 Fundamentals of driving Infineon CoolGaN™ Transistors	5
3 Gate-drive design considerations for CoolGaN™ Transistors.....	7
3.1 Design example 1: Implementing CoolGaN™ gate-drive for high-power designs	8
3.2 Design example 2: Implementing CoolGaN™ gate-drive for low-power designs.....	11
4 Summary	13
5 Related resources	14
References.....	15
Revision history.....	16
Disclaimer.....	17

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Introduction

1 Introduction

Compared with conventional Si-based power devices, the advent of GaN marks a transformative phase in power semiconductors due to its fast-switching capability, low losses, and high-power density. GaN technology enables dramatic performance improvements across a wide range of power electronics applications by reducing passive component size, minimizing thermal overhead, and delivering higher efficiency and power density, even under stringent regulatory and performance demands. Among GaN devices available in market, Infineon CoolGaN™ offers best-in-class performance enabled by leading technology.

Achieving a robust and high-performance system relies heavily on the proper design of a gate-drive circuit for power devices, particularly those based on wide-bandgap technologies, as it plays a crucial role in determining overall system performance and reliability. This application note provides a comprehensive overview of the design principles, trade-offs, and methodologies for optimizing the performance of Infineon CoolGaN™ Transistors, offering detailed guidance to support effective and practical design implementation.

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Fundamentals of driving Infineon CoolGaN™ Transistors

2 Fundamentals of driving Infineon CoolGaN™ Transistors

Infineon offers leading-edge enhancement-mode (E-mode) GaN high-electron-mobility transistors (HEMTs) built on its innovative high voltage CoolGaN™ platform, which utilizes gate injection transistor (GIT) technology to deliver exceptional high-performance and high-voltage capabilities. CoolGaN™ HEMTs feature a patented hybrid-drain architecture designed to deliver high current density, excellent robustness, and stable dynamic $R_{DS(on)}$ behavior, supporting high efficiency, reliability, and performance in demanding power-electronics applications.

Figure 1 and Figure 2 shows the equivalent circuits of CoolGaN™ Transistors and a comparable E-mode GaN HEMT that utilizes a Schottky gate transistor (SGT) structure. The gate structures of GIT and SGT exhibit subtle differences, leading to distinct requirements for their respective gate-drive circuit designs. SGT-based GaN HEMTs are typically considered voltage-driven devices, similar to MOSFETs, whereas GIT devices are regarded as current-driven devices, comparable to BJTs. A notable feature of CoolGaN™ devices is the presence of an equivalent diode between the gate and source, which imparts a unique characteristic in the form of a forward turn-on voltage (V_f) effect. This equivalent diode results in distinct gate-drive behavior, requiring a more careful gate-drive design approach to fully utilize the device benefits and ensure reliable operation. The following sections provide a detailed discussion of the key gate-drive design considerations.

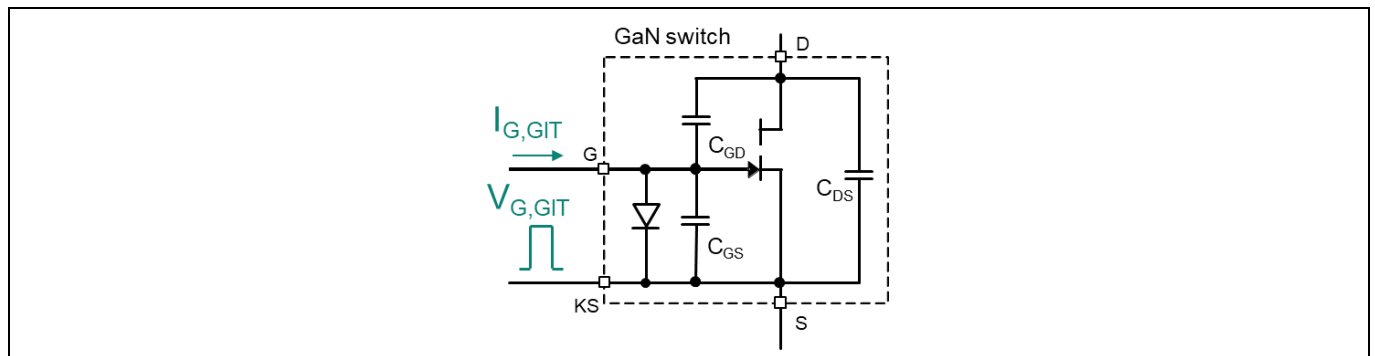


Figure 1 The equivalent circuit of GIT

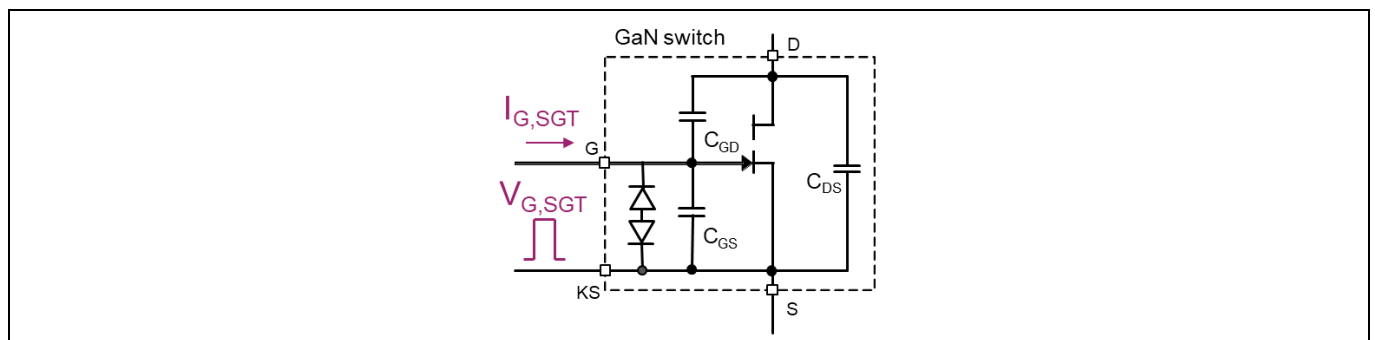


Figure 2 The equivalent circuit of SGT

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Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Fundamentals of driving Infineon CoolGaN™ Transistors

The theoretical gate driving voltage and current waveforms for GIT and SGT devices are shown in [Figure 3](#) and [Figure 4](#), respectively, highlighting the key differences in driving these two types of devices. As shown in [Figure 3](#), the GIT gate voltage ($V_{G,GIT}$) is clamped at the forward voltage (V_F), whereas the SGT gate voltage ($V_{G,SGT}$) closely follows the high level (V_H) of the gate-drive voltage. Furthermore, [Figure 4](#) shows that GIT requires a continuous turn-on current (I_{G,GIT_ON}) to maintain the 2DEG channel, highlighting a key difference in gate-drive currents behavior between GIT ($I_{G,GIT}$) and SGT ($I_{G,SGT}$) devices. These differences necessitate customized gate-drive circuit design approaches for Infineon CoolGaN™ Transistors. Detailed gate-drive design considerations are discussed in the following sections.

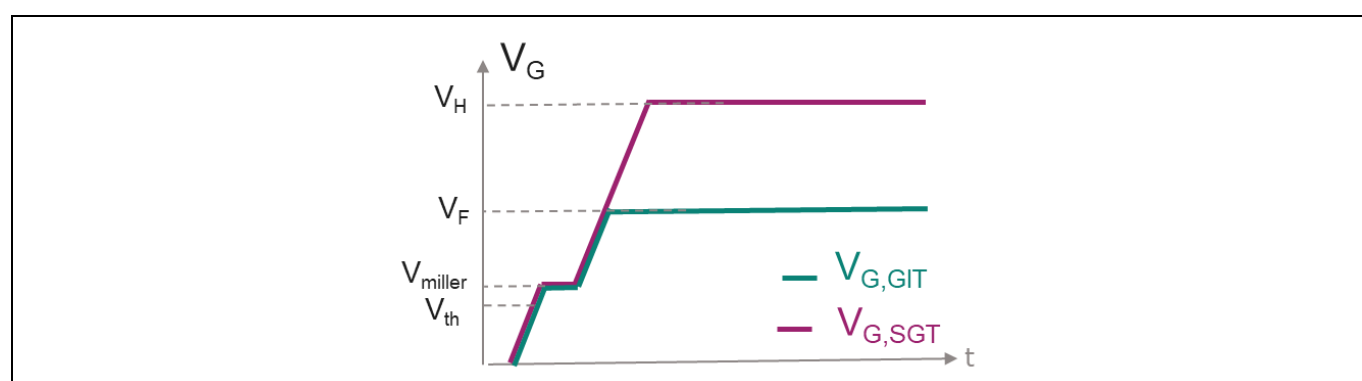


Figure 3 Theoretical VG waveforms of GIT and SGT

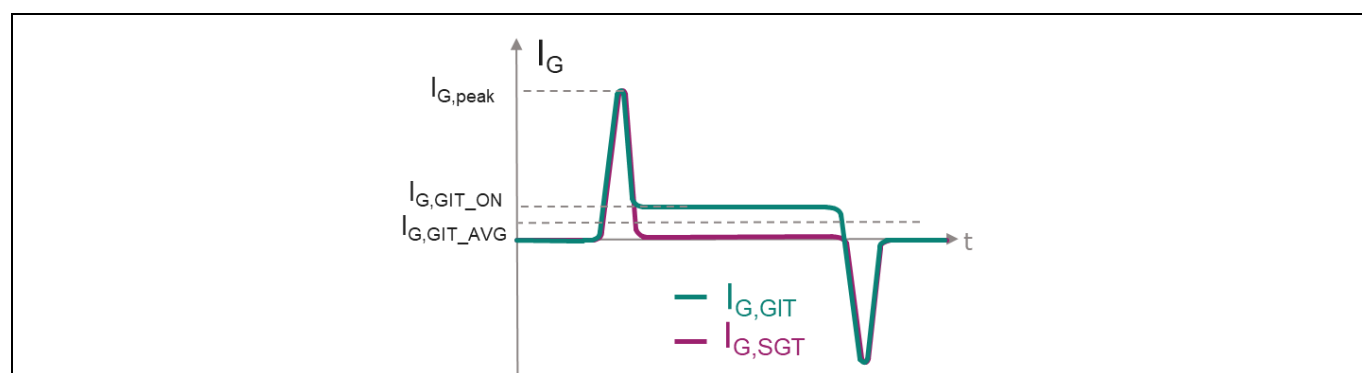


Figure 4 Theoretical IG waveforms of GIT and SGT

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Gate-drive design considerations for CoolGaN™ Transistors

3 Gate-drive design considerations for CoolGaN™ Transistors

The distinctive features of Infineon CoolGaN™ Transistors necessitate tailored gate-drive design approaches, requiring careful consideration and planning of both gate-drive voltage and gate-drive current. The design concept is based on the unique V_G and I_G characteristics of Infineon CoolGaN™ technology and can be applied to various gate-drive circuits, including, but not limited to, the RC Interface. This section focusses specifically on the design considerations for the RC Interface, providing a detailed analysis and discussion. While this section addresses the RC Interface in detail, further research into other gate-drive circuit topologies is ongoing, and the results will be presented in future white papers and application notes.

Infineon's white paper "Gate drive configurations for GaN power transistors" [1] demonstrates that the RC interface (shown in Figure 5) can be designed to support both GIT and SGT technologies. Building on [1], the following sections develop a system-oriented RC-interface design for HV CoolGaN™ Transistors, detailing practical constraints and optimization for real implementations.

The RC interface comprises four external components, R_{on} , R_{off} , R_{ss} , and C_c . The turn-on and turn-off switching speed (dv/dt), and peak gate-drive currents, are determined by R_{on} and R_{off} , which are typically designed and fine-tuned based on overall system performance and signal-quality requirements. The capacitor C_c provides high-speed peak gate-drive current during turn-on and generates a negative gate-drive voltage during turns-off when the gate pulls low. The resistor R_{ss} supplies the continuous turn-on current ($I_{ss} = I_{G,GIT_ON}$) required to maintain the CoolGaN™ device in the on-state.

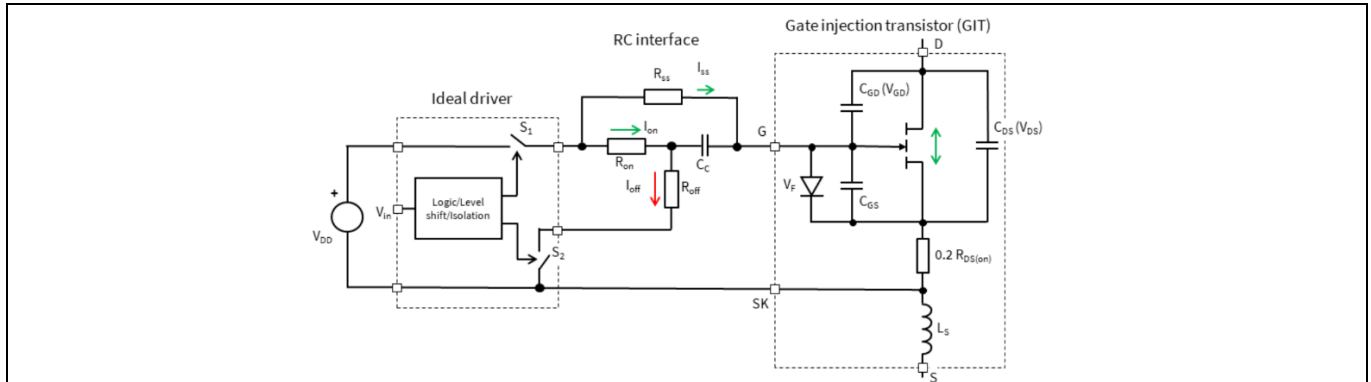


Figure 5 Equivalent circuit of CoolGaN™ and a standard gate-drive circuit with RC interface [1]

C_c and R_{ss} can be designed with the following equations:

$$C_c \geq k \times \frac{Q_g}{V_{DD} - V_F}$$

Equation 1 Unipolar supply

$$C_c \geq \frac{Q_g}{V_{DD} - V_F}$$

Equation 2 Bipolar supply

Gate-drive design guide for Infineon high-voltage CoolGaN™

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Gate-drive design considerations for CoolGaN™ Transistors

$$I_{SS} = \frac{V_{DD} - V_F}{R_{SS}}$$

Equation 3 Steady state driver current of GIT

Where, “k” is a constant, typically in the range of 2 to 4; Q_g is the gate charge; V_{DD} and V_F represent the high state voltage (V_H) or supply voltage of the gate-drive signal and the turn-on gate forward voltage (V_F) of GIT CoolGaN™ device, respectively. When a bipolar gate-drive supply voltage is used, a reduction of C_C is recommended to prevent excessive negative gate-drive voltage [1].

Equation 1 to Equation 3 form the foundation of the GIT gate-drive circuit design and serve as the basis for the design examples presented in the following section. These examples show the practical application of the equations and design methodology.

A gate pull-down resistor R_{GS} is recommended for high-voltage CoolGaN™ switches to prevent unintended turn-on during faults like open drivers or solder issues. Due to GaN’s low threshold voltage, leakage or Miller-induced currents can trigger the device. The resistor R_{GS} clamps the gate-source voltage below this threshold, especially during unpowered states. While traditional silicon uses 10 kΩ, GaN’s low leakage allows higher values (approximately 50 kΩ to 100 kΩ) to balance clamping efficiency and power loss. The exact choice depends on the specific gate driver and startup requirements. An external resistor is unnecessary if the driver is pre-powered or includes an internal pull-down.

To demonstrate the design concepts in real-world scenarios, two design examples covering different applications and power levels are discussed, providing insights into the design process and practical implementation considerations.

3.1 Design example 1: Implementing CoolGaN™ gate-drive for high-power designs

This section provides a step-by-step walkthrough of a high-power design process, examining each stage in detail to illustrate the design methodology and considerations. The design objective focuses on a high-power full-bridge LLC converter application with a specified maximum operating current of 20 A. The Infineon CoolGaN™ IGT65R055D2 device is selected for this design example.

To properly design the gate-drive circuit, it is essential to thoroughly review the datasheet of the CoolGaN™ IGT65R055D2 device [2], which provides key parameters and characteristics required for the design process. To maximize performance and ensure optimal utilization of CoolGaN™ technology, a careful balance must be achieved between minimizing gate-drive power consumption, optimizing $R_{DS(on)}$ performance, and achieving the desired pulse drain current capability ($I_{D,pulse}$).

Figure 6 and Figure 7 provide essential information for gate-drive circuit design, illustrating the typical output characteristics (I_D vs. I_{G,GIT_ON}) and the drain-source on-state resistance ($R_{DS(on)}$ vs. I_{G,GIT_ON}) of the CoolGaN™ IGT65R055D2 device under high-temperature operating conditions. In addition, the maximum pulsed drain current rating ($I_{D,pulse}$) is specified as 36 A in Table 2 of the CoolGaN™ IGT65R055D2 datasheet, which corresponds to a gate current of $I_{G,GIT_ON} = 26$ mA at a junction temperature of $T_j = 125^\circ\text{C}$ [2].

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Gate-drive design considerations for CoolGaN™ Transistors

In general, appropriate derating is applied to the maximum operating current to ensure sufficient safety margin and reliability, which expects the $I_{D,pulse}$ to be larger than 25 A (80% derating is applied to the maximum operating current 20 A). Based on the characteristics shown in Figure 6 and Figure 8, this requirement corresponds to a minimum gate current of approximately 13 mA for I_G .

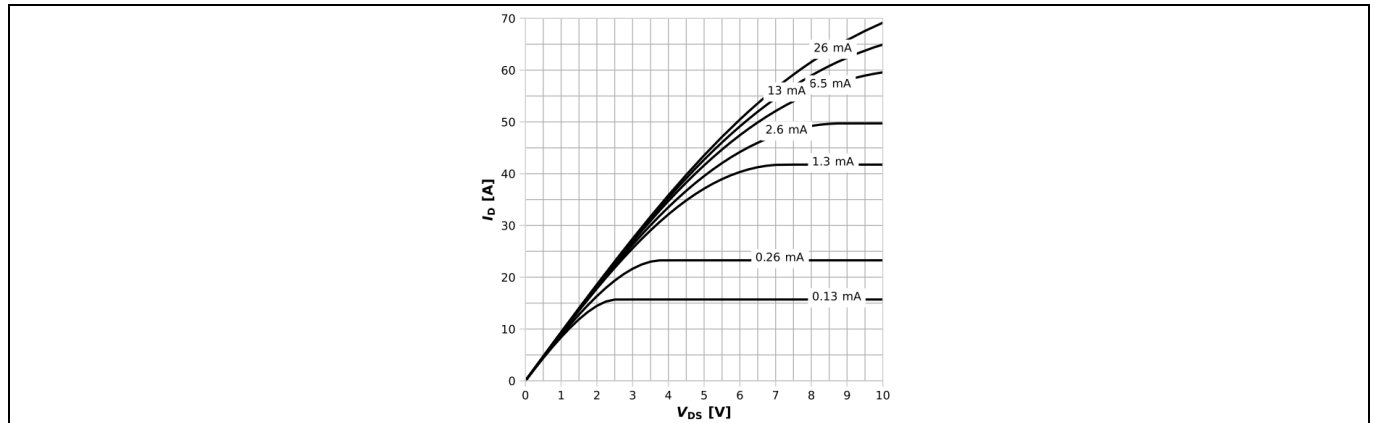


Figure 6 CoolGaN™ IGT65R055D2 typical I_D vs. I_{G,GIT_ON}

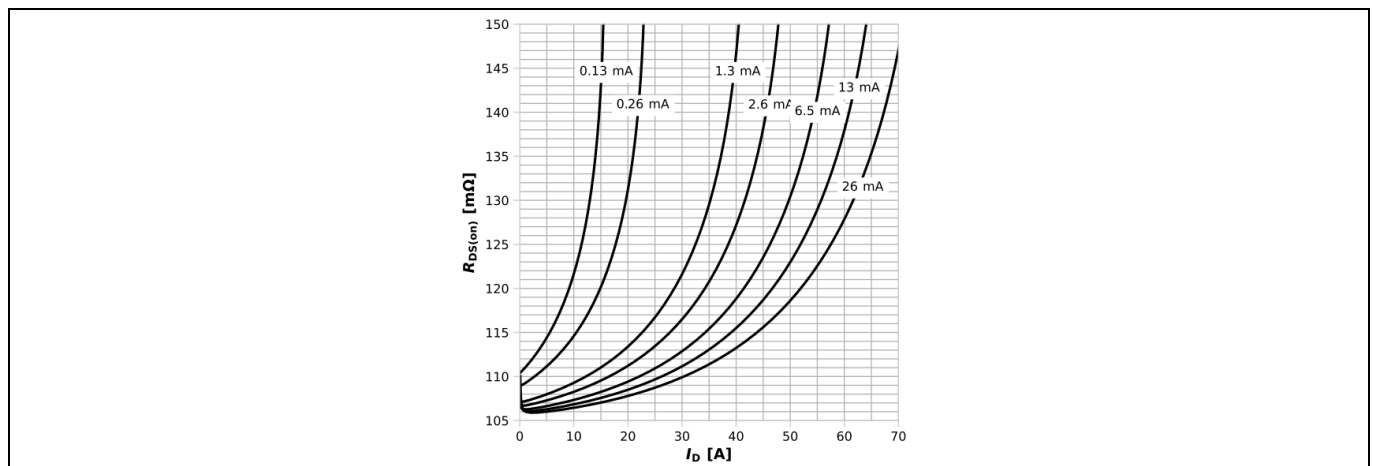


Figure 7 CoolGaN™ IGT65R055D2 typical $R_{DS(on)}$ vs. I_{G,GIT_ON}

Additionally, a ratio ($k_{ID,pulse/ID,peak}$) can be used to rapidly estimate the $I_{D,pulse}$ value for different I_{G,GIT_ON} currents (assuming under ideal and without thermal accumulating conditions), providing a convenient method to approximate the $I_{D,pulse}$ value under various operating conditions. This $k_{ID,pulse/ID,peak}$ ratio can be calculated as:

$$k_{ID,pulse/ID,peak} = \frac{I_{D,pulse_max}}{I_{D,peak_max}}$$

Equation 4 The ratio between $I_{D,pulse}$ and $I_{D,peak}$

Where, the values of $I_{D,pulse_max}$ and $I_{D,peak_max}$ can be obtained from Figure 6 and the maximum rating table in the datasheet. For the CoolGaN™ IGT65R055D2 device, these values are specified as 36 A and 68 A [2], resulting in $k_{ID,pulse/ID,peak} \approx 0.529$. The $I_{D,pulse}$ value can be estimated for different I_{G,GIT_ON} currents based on the ratio of $k_{ID,pulse/ID,peak}$ and Figure 6. For example, when $I_{G,GIT_ON} = 13$ mA, the ideal $I_{D,pulse}$ value is approximately 34 A.

Gate-drive design guide for Infineon high-voltage CoolGaN™

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Gate-drive design considerations for CoolGaN™ Transistors

Additionally, to account for non-ideal components and guarantee reliable and optimal performance, it is recommended to add an extra 15% margin to the previously calculated I_g value, resulting in a suggested minimum gate current (I_g) of about 15 mA. Consequently, the required C_c and R_{SS} can be determined using [Equation 1](#) and [Equation 3](#), as shown below:

(Assuming $k = 4$, $V_{DD} = 9\text{ V}$, $V_F = 3.5\text{ V}$, while IGT65R055D2 $Q_g = 4.7\text{ nC}$ [\[2\]](#))

$$C_c \geq 4 \times \frac{4.7\text{ nC}}{9\text{ V} - 3.5\text{ V}} \approx 3.42\text{ nF}; \quad R_{SS} = \frac{V_{DD} - V_F}{I_{SS}} = \frac{9\text{ V} - 3.5\text{ V}}{15\text{ mA}} \approx 367\ \Omega$$

Equation 5 Coupling capacitance and resistor

3.2 Design example 2: Implementing CoolGaN™ gate-drive for low-power designs

For this design example, a low-power flyback converter application is selected with a maximum operating current of 4.5 A, and CoolGaN™ IGD70R200D2S is chosen as the device to be used in this specific design. The characteristics of CoolGaN™ IGD70R200D2S are shown in [Figure 9](#) and [Figure 10](#), which depict the typical output curves (I_D vs. I_{G,GIT_ON}) and drain-source on-state resistance ($R_{DS(on)}$ vs. I_{G,GIT_ON}) under high-temperature ($T_j = 125^\circ\text{C}$) conditions. Furthermore, according to the CoolGaN™ IGD70R200D2S datasheet [\[3\]](#), the maximum pulse current rating ($I_{D,pulse}$) is listed in Table 2 as 9.7 A, corresponding to a gate current (I_{G,GIT_ON}) of 7.1 mA at $T_j = 125^\circ\text{C}$.

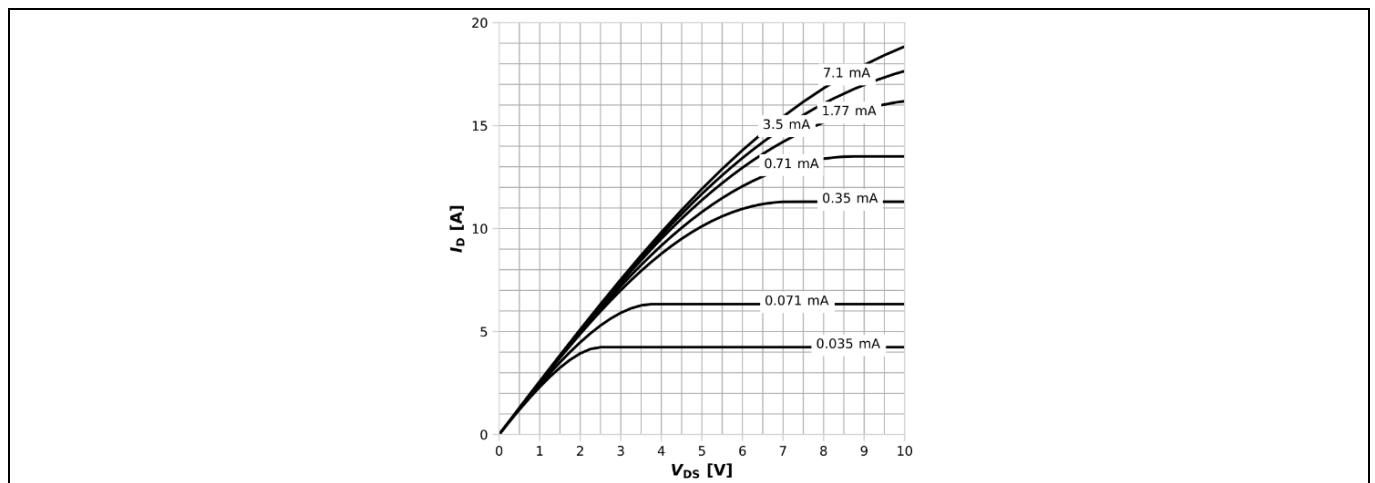


Figure 9 CoolGaN™ IGD70R200D2S typical I_D vs. I_{G,GIT_ON}

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Gate-drive design considerations for CoolGaN™ Transistors

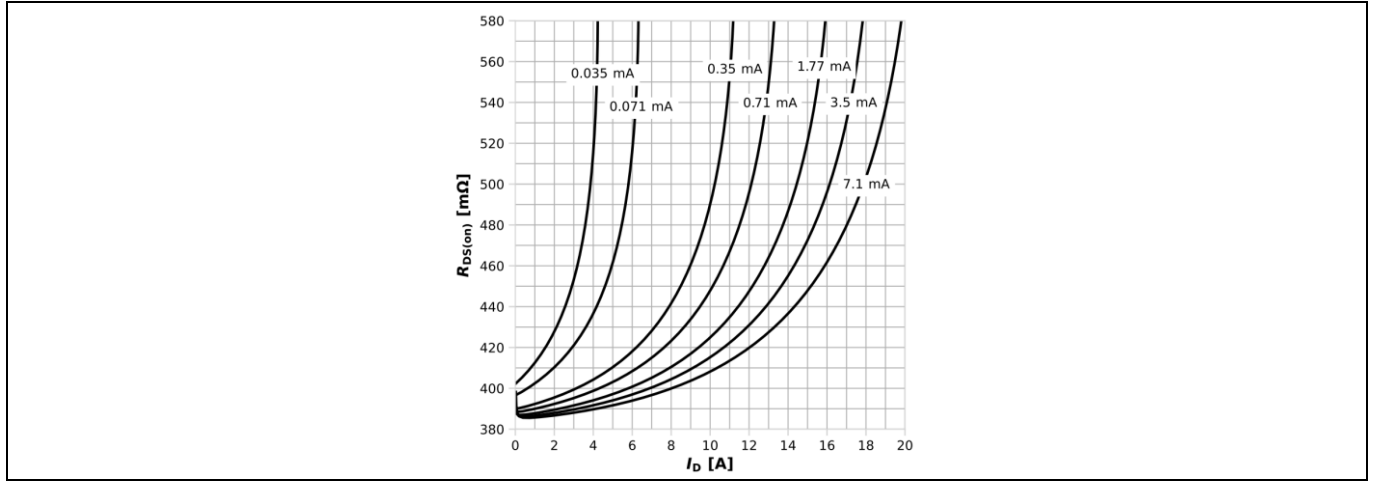


Figure 10 CoolGaN™ IGD70R200D2S typical $R_{DS(on)}$ vs. I_{G,GIT_ON}

Assuming an 80% derating is applied to the maximum operating current of 4.5 A, the required $I_{D,pulse}$ must be greater than 6 A. The $k_{ID,pulse/ID,peak}$ ratio is derived from [Figure 9](#), and the data from the CoolGaN™ IGD70R200D2S datasheet [\[3\]](#), a minimum gate current of approximately 1.77 mA is required when an additional 20% production variation is considered.

To further consider the non-ideal components and ensure reliable and optimal performance, an additional margin of 10% to 20% is recommended. Applying this margin to the calculated value results in a suggested minimum gate current I_G of approximately 2 mA for this design. Based on this selected gate current, the required values of C_C and R_{SS} can be calculated using [Equation 1](#) and [Equation 3](#), as shown below:

(Assuming $k = 4$, $V_{DD} = 12$ V, $V_F = 3.5$ V, while CoolGaN™ IGD70R200D2S $Q_g = 1$ nC [\[3\]](#))

$$C_C \geq 4 \times \frac{1 \text{ nC}}{12 \text{ V} - 3.5 \text{ V}} \approx 0.47 \text{ nF}; \quad R_{SS} = \frac{V_{DD} - V_F}{I_{SS}} = \frac{12 \text{ V} - 3.5 \text{ V}}{2 \text{ mA}} = 4.25 \text{ k}\Omega$$

Equation 6 Coupling capacitance and resistor

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Summary

4 Summary

This application note provides a detailed theoretical discussion of the key considerations and design methodology for RC-interface-based gate driving circuits tailored to Infineon's CoolGaN™ devices. The design approach is supported by two detailed design examples addressing different power-level applications, effectively demonstrating the practical application of the design principles.

In addition, the note highlights the importance of evaluating gate drive designs under real-world conditions, including the influence of non-ideal components and parasitic effects on overall performance. While the presented methodology offers a clear and accessible foundation for initiating an RC-based gate driver design, further refinement and application-specific optimization may be required to achieve optimal efficiency, robustness, and reliability.

For further technical guidance or design-specific discussions, please consult [Infineon technical support](#).

Transistors

Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Related resources

5 Related resources

- [GaN transistors \(GaN HEMTs\)](#)
- [Developer Community](#)

References

- [1] Infineon Technologies AG: *Gate drive configurations for GaN power transistors*; [Available online](#)
- [2] Infineon Technologies AG: *CoolGaN™ IGT65R055D2 Final datasheet*; [Available online](#)
- [3] Infineon Technologies AG: *CoolGaN™ IGD70R200D2S Final datasheet*; [Available online](#)

Gate-drive design guide for Infineon high-voltage CoolGaN™ Transistors



Practical guidelines for optimizing performance and reliability in SMPS using HV CoolGaN™

Revision history

Revision history

Document revision	Date	Description of changes
V 1.0	2026-08-31	Initial release

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