



**Please note that GaN Systems is an Infineon Technologies Company**

The document following this cover page is marked as “GaN Systems” document as this is the company that originally developed the product. Please note that Infineon will continue to offer the product to new and existing customers as part of the Infineon product portfolio.

**Continuity of document content**

The fact that Infineon offers the following product as part of the Infineon product portfolio does not lead to any changes to this document. Future revisions will occur when appropriate, and any changes will be set out on the document history page.

**Continuity of ordering part numbers**

Infineon continues to support existing part numbers. Please continue to use the ordering part numbers listed in the datasheet for ordering.

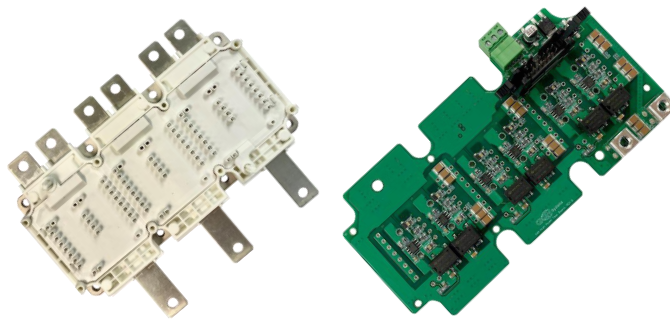
## GS-EVx-3PH-650V300A-SM1x

GS-EVM-3PH-650V300A-SM1

GS-EVB-3PH-650V300A-SM1A

### 650V 300A 3-Phase GaN Power Module with External Gate Driver Board

#### Technical Manual



Visit [www.gansystems.com](http://www.gansystems.com) for the latest version of this technical manual.



**WARNING:**

PCB surface can become hot. Contact may cause burns. Do not touch!



**CAUTION!**

This product contains parts that are susceptible to damage by electrostatic discharge (ESD). Always follow ESD prevention procedures when handling the product.

---

## Overview

The GS-EVM-3PH-650V300A-SM1 is 650V 300A 3-Phase GaN Power Module. This GS-EVM-3PH-650V300A-SM1 evaluation module is designed to meet high robustness, high power density, and low-cost requirements of the automotive and industrial markets. The GS-EVB-3PH-650V300A-SM1A is the external gate driver board for the 650V 300A 3-Phase GaN power module GS-EVM-3PH-650V300A-SM1. They are created in partnership with SilverMicro and intended for testing and evaluation purposes only.

## Features

- GS-EVM-3PH-650V300A-SM1
  - Includes 12 GS-065-150-1-D (650V 150A E-mode Die)
  - Industry standard form factor
  - High thermal conductivity base plate
  - External gate driver board
  - Ultra-low switching losses & Zero  $Q_{RR}$
  - Ultra-high dV/dt ruggedness
  - Adjustable  $T_{RISE}$  /  $T_{FALL}$  & reverse conduction capability
  - Press-Fit Pins for ease of assembly
  - ZTA substrates for superior reliability
  - Greater than 4 kV DC 1-second electrical Isolation
  
- GS-EVB-3PH-650V300A-SM1A
  - Optimized & isolated 3-phase gate drive
  - Single 5V input
  - Ultra-high dV/dt ruggedness 200V/ns

## Applications

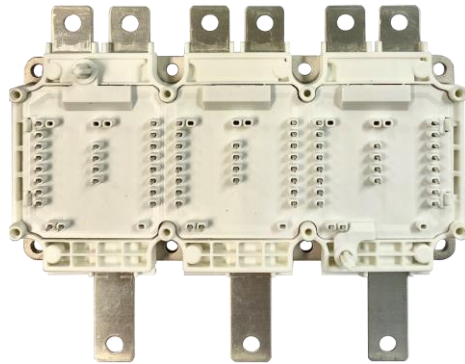
- High efficiency 75kW traction inverter drives
- Motor drives
- High efficiency high power density systems

**Contents**

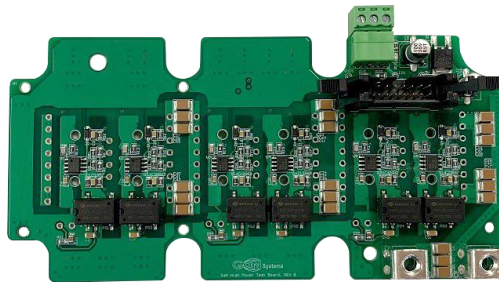
The GS-EVx-3PH-650V300A-SM1x includes the following hardware.

**Table 1 GS-EVx-3PH-650V300A-SM1x Evaluation Kit Contents**

Quantity	Description
1	GS-EVM-3PH-650V300A-SM1 650V 300A 3-Phase GaN Power Module
1	GS-EVB-3PH-650V300A-SM1A 650V 300A 3-Phase Driver Board



**Figure 1 650V 300A GaN 3 phase Power Module**



**Figure 2 External Gate Driver Board**

## Technical Specifications

### Block Diagram of Power Module

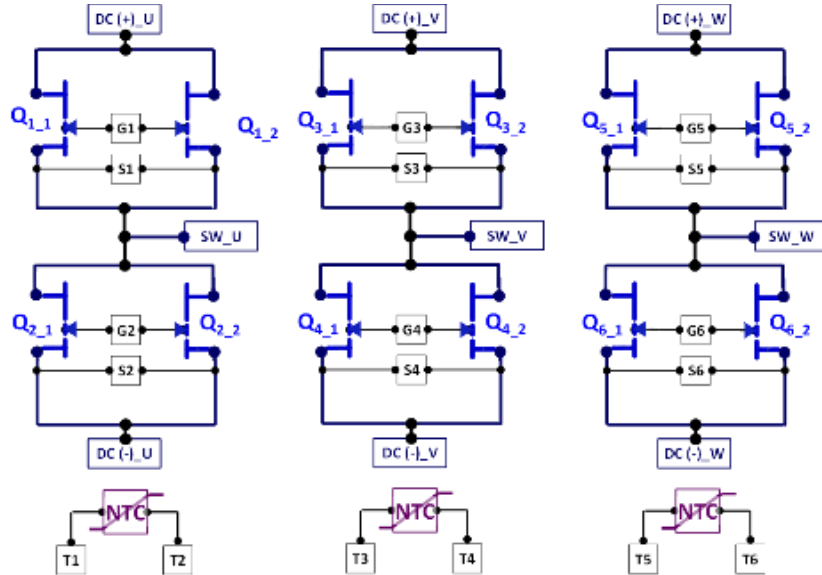


Figure 3 650V 300A GaN 3 phase Power Module Block Diagram

### Driver Board Pin Description

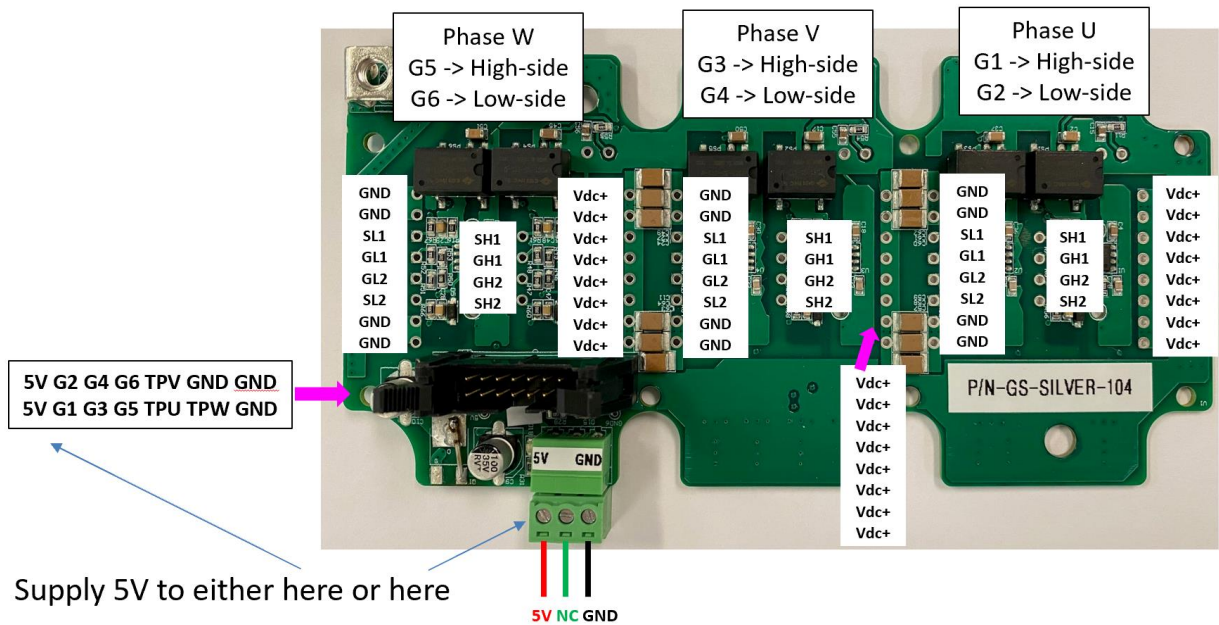
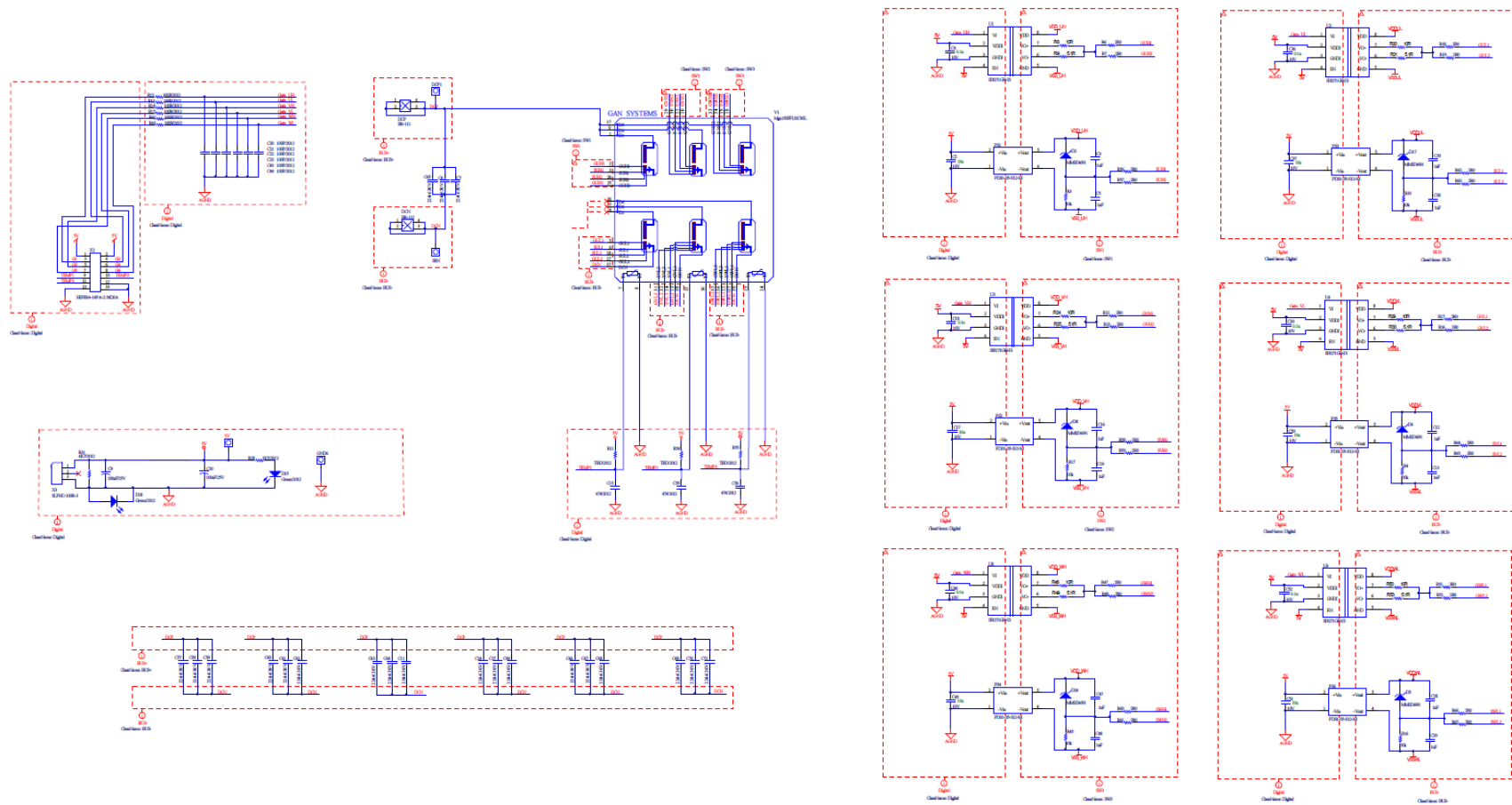


Figure 4 Driver Board Pin Description

**Driver Board Schematics**



**Figure 5 Driver Board Schematics**

## Electrical Characteristics

Test Conditions, unless otherwise noted:  $T_{JUNC} = 25^{\circ}C$ ,  $V_{GS} = 6.0V$

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Drain-to-Source Blocking Voltage	$V_{(BL)DSS}$	650	-	-	V	$V_{GS} = 0V$ , $I_{DS} < 560 \mu A$
Module ON Resistance $T_{JUNC} = 25^{\circ}C$	$R_{ON}$	-	6	7.5	$m\Omega$	$V_{GS} = 6.0V$ , $I_{DS} = 100A$ $T_{JUNC} = 25^{\circ}C$
Module ON Resistance $T_{JUNC} = 150^{\circ}C$ (Note 4)	$R_{ON}$	-	14	-	$m\Omega$	$V_{GS} = 6.0V$ , $I_{DS} = 100A$ $T_{JUNC} = 150^{\circ}C$
Drain-to-Source Leakage $T_{JUNC} = 25^{\circ}C$	$I_{DSS}$	-	22	550	$\mu A$	$V_{GS} = 0V$ , $V_{DS} = 650V$ $T_{JUNC} = 25^{\circ}C$
Drain-to-Source Leakage $T_{JUNC} = 150^{\circ}C$ (Note 4)	$I_{DSS}$	-	4400	-	$\mu A$	$V_{GS} = 0V$ , $V_{DS} = 650V$ $T_{JUNC} = 150^{\circ}C$
Gate-to-Source Threshold	$V_{GS(TH)}$	1.1	1.7	2.6	V	$V_{GS} = V_{DS}$ , $I_{DS} = 40mA$
Gate-to-Source Leakage	$I_{GSS}$	-	1822	-	$\mu A$	$V_{GS} = 6.0V$ , $V_{DS} = 0V$
Input Capacitance	$C_{ISS}$	-	2962	-	pF	$V_{GS} = 0V$ $V_{DS} = 400V$ $f = 100kHz$
Output Capacitance	$C_{OSS}$	-	740	-	pF	
Reverse Transfer Capacitance	$C_{RSS}$	-	22	-	pF	
Total Gate Charge	$Q_G$	-	66	-	nC	$V_{GS} = -3V$ to $6V$ $V_{DS} = 400V$
Gate-to-Source Charge	$Q_{GS}$	-	26	-	nC	
Gate-to-Drain Charge	$Q_{GD}$	-	20	-	nC	
Output Charge	$Q_{OSS}$	-	650	-	nC	$V_{GS} = 0V$ , $V_{DS} = 400V$
Reverse Recovery Charge	$Q_{RR}$		Zero		nC	N/A

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Turn-On Delay Time	$t_{D(ON)}$	-	<i>tbd</i>	-	ns	$V_{GS} = -3V$ to $6V$ , $V_{DS} = 400V$ , $I_{DS} = 160A$ , $R_{G(ON)} = 5\Omega$ , $T_{JUNC} = 25\text{ }^{\circ}C$ (Note 5)
Rise Time	$t_{RISE}$	-	<i>tbd</i>	-	ns	
Turn-Off Delay Time	$t_{D(OFF)}$	-	<i>tbd</i>	-	ns	
Fall Time	$t_{FALL}$	-	<i>tbd</i>	-	ns	
Turn-On Switching Energy	$E_{ON}$	-	715	-	$\mu J$	$V_{GS} = -3V$ to $6V$ , $V_{DS} = 400V$ , $I_{DS} = 150A$ , $R_{G(ON)} = 10\Omega$ , $R_{G(OFF)} = 1\Omega$ , $L = 40\mu H$ (Note6)
Turn-Off Switching Energy	$E_{OFF}$	-	115	-	$\mu J$	

(Note 4) No manufacturing test (specified by design)

(Notes 5, 6) See diagrams in applications section for switching tests methodology

### Thermal Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit
Junction Temperature Range	$T_{JUNC}$	-	-	-55 to +150	$^{\circ}C$
Thermal Resistance, Junction-to-Cold Plate	$R_{\theta\_JUNCTION-COLD\ PLATE}$	-	0.20	-	$^{\circ}C/W$
Storage Temperature Range	$T_{STOR}$	-	-	-40 to +125	$^{\circ}C$

### NTC Characteristics

Parameter	Conditions / Equation	Typical Value	Units
$R_{25}$	$T_C = 25\text{ }^{\circ}C$	5	$k\Omega$
$\Delta R/R$	$T_C = 100\text{ }^{\circ}C$ , $R_{100} = 481\Omega$	$\pm 5$	%
$P_{25}$	$T_C = 25\text{ }^{\circ}C$	50	mW
$B_{25/50}$	$R_2 = R_{25} \exp[B_{25/50}(1/T_2 - 1/(298.15K))]$	3380	KW
$B_{25/80}$	$R_2 = R_{25} \exp[B_{25/80}(1/T_2 - 1/(298.15K))]$	3440	K



### Module Characteristics

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Isolation Voltage	V <sub>ISO</sub>	4.2	-	-	kV	RMS, f = 0Hz, t = 1s
Terminal RMS Current	I <sub>TRMS</sub>	-	500	-	A	T <sub>F</sub> = 85 °C, T <sub>Cl</sub> = 105 °C
Terminal Creepage	d <sub>CREEPAGE</sub>	-	9.0	-	mm	To Heatsink/Terminal
Terminal Clearance	d <sub>CLEARANCE</sub>	-	4.5	-	mm	To Heatsink/Terminal
Comparative Tracking Index	CTI	200	-	-		
Terminal Screw:M5	M	3.0	-	5.0	N•m	
Mounting Screw:M4	M	1.80	-	2.20	N•m	
Screw PCB to frame	M	0.45	0.50	0.55	N•m	
Weight	G	-	305	-	g	

---

## Application Characteristics

### GaN Gate Drive

- GaN E-mode Gate Drive Voltage ( $V_{GS}$ ) is nominally -3V to +6.0V for high-power systems, to achieve optimal  $R_{DS(on)}$  performance and lifetime reliability. Absolute maximum  $V_{GS}$  rating is +7.0V (DC voltage), but GaN E-modes are rated for transients up to +10V and -20V, for pulses up to 1 $\mu$ s.
- Gate and commutation loop inductances are minimized in the module design (i.e., DBC layout and Pin configuration), however, wire-bonded case-type power modules will have higher loop inductances than embedded power modules with integrated gate drive. Therefore, careful gate driver board design must be implemented.

### GaN Reverse Conduction

- GaN E-modes do not have a parasitic body diode or a parasitic Bi-polar in their substrate, therefore the GaN E-mode has zero  $Q_{RR}$  and extremely high  $dV/dt$  ruggedness. But despite not having a body diode, the GaN E-mode will *inherently* conduct in reverse current flow (source-to-drain) through the 2DEG channel, when source-to-drain potential ( $V_{SD}$ ) is greater than  $V_{TH}$  (*approximately* 1.7V).
- During reverse conduction,  $V_{GS}$  can be zero volts (no gate bias is required for reverse conduction operation), and anti-parallel diodes are **not** required for reverse conduction.
- For optimal efficiency, dead time should be minimized and synchronous rectification should be implemented in the system design.

### GaN Blocking Voltage

- GaN E-mode blocking voltage ( $V_{(BL)DSS}$ ) is defined by the value of drain leakage Current ( $I_{DSS}$ ). Hard breakdown (unrecoverable) will occur well above the rated  $V_{(BL)DSS}$  value, similar to hard breakdown in a Si MOSFET or IGBT. As a general practice, the applied drain voltage should be de-rated in a similar manner as Si MOSFET or IGBT.
- All GaN power transistors do not avalanche and thus do not have an avalanche breakdown rating.
- The maximum drain-to-source rating does not change if negative gate voltage is applied.

### HybridPACK™ module case modification

- Additional pins were added along the centerline of each half-bridge portion, to connect to gate and source sense nodes for each GaN device in the half-bridge. Two 150A GaN transistors are paralleled for high-side and low-side switches, providing 300A current. The additional gate and source sense pins allow a symmetric DBC Layout and GaN device placement.

## Test Results

### Double Pulse Test (GS-EVx-3PH-650V300A-SM1x)

- Test Condition:  $V_{DS} = 400V$ ,  $I_D = 300A$ ,  $R_{g-ON} = 12\Omega$ ,  $R_{g-OFF} = 7\Omega$

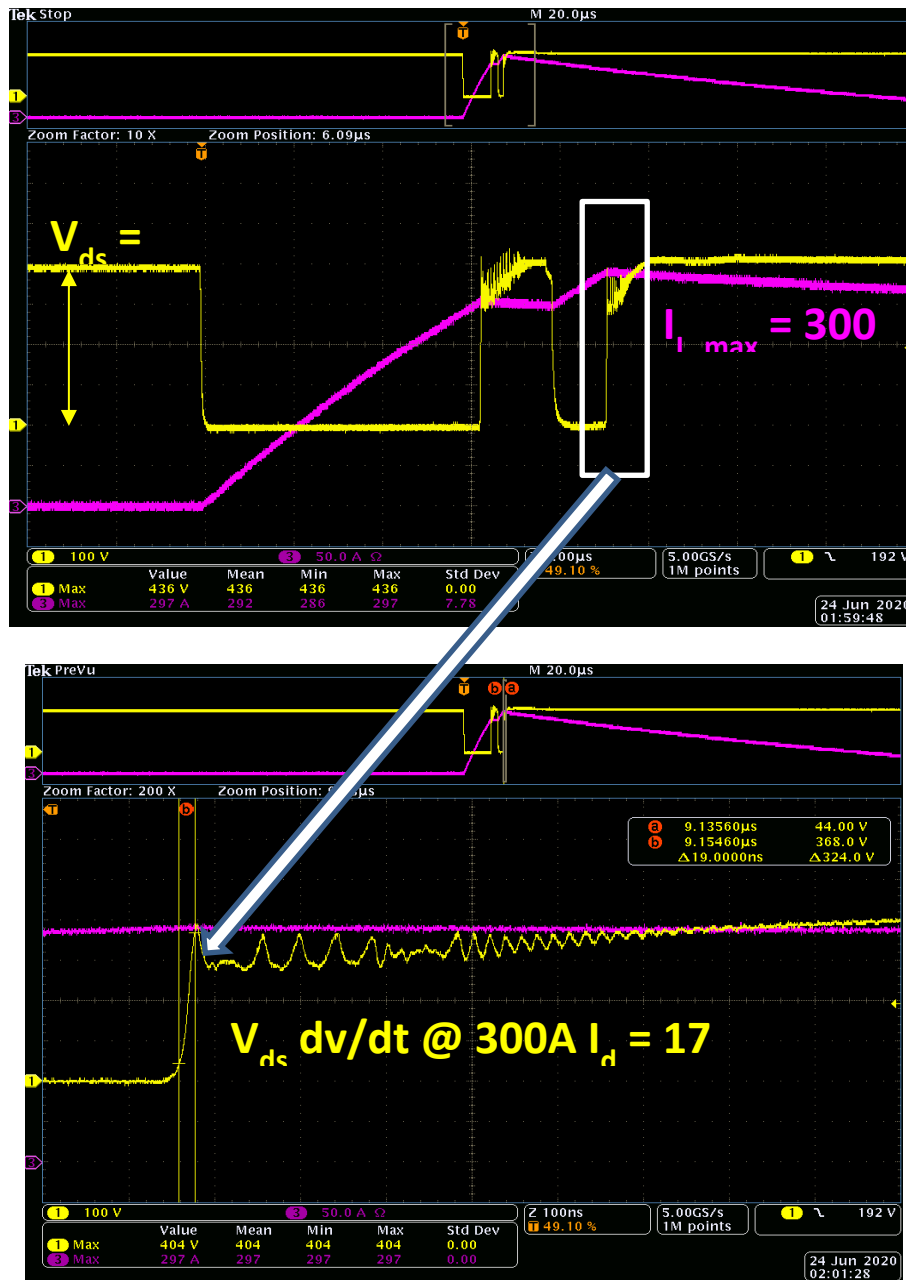


Figure 6 Double pulse test – Low Side GaN Switching OFF waveforms

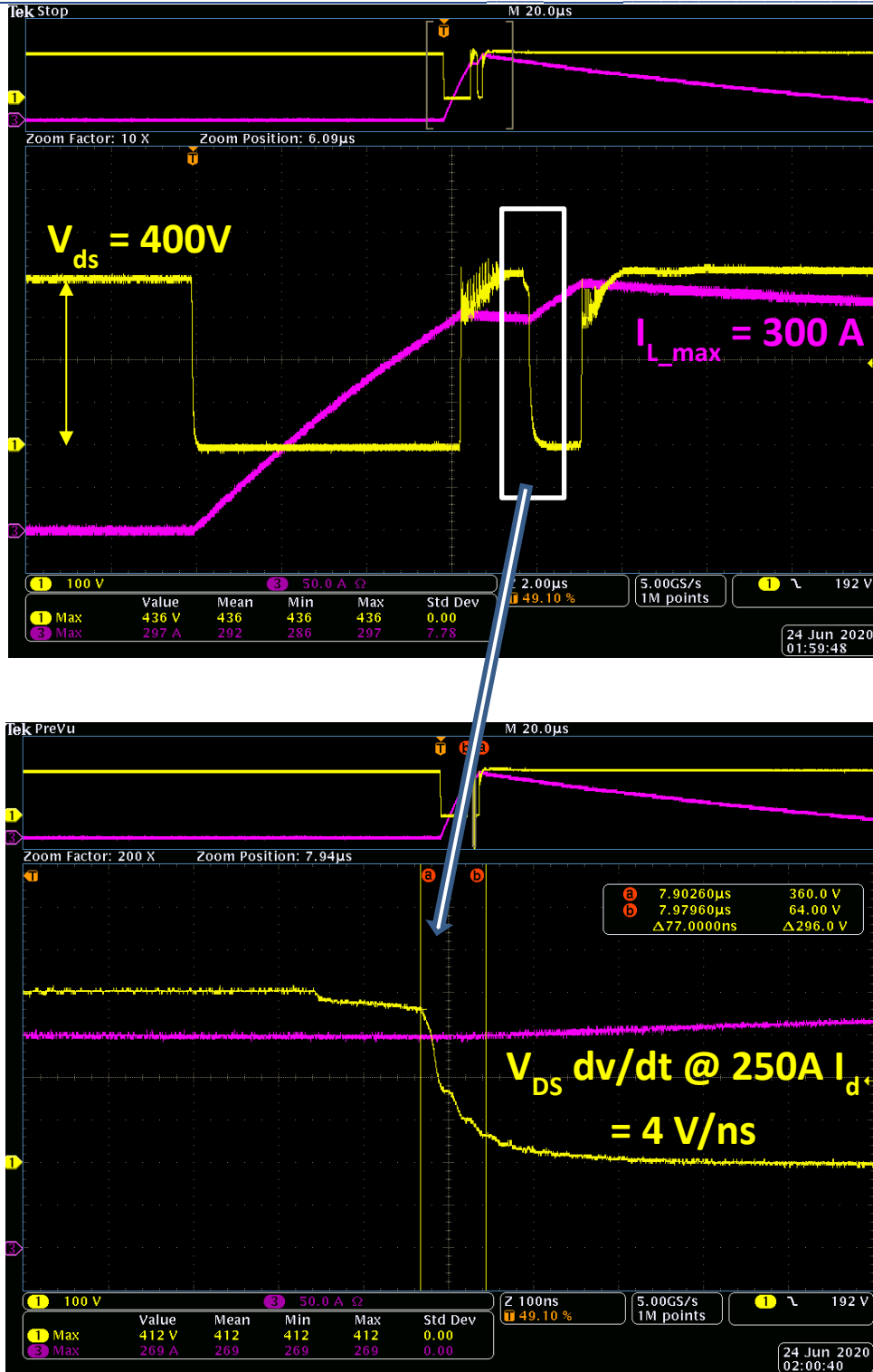


Figure 7 Double pulse test – Low Side GaN Switching ON waveforms

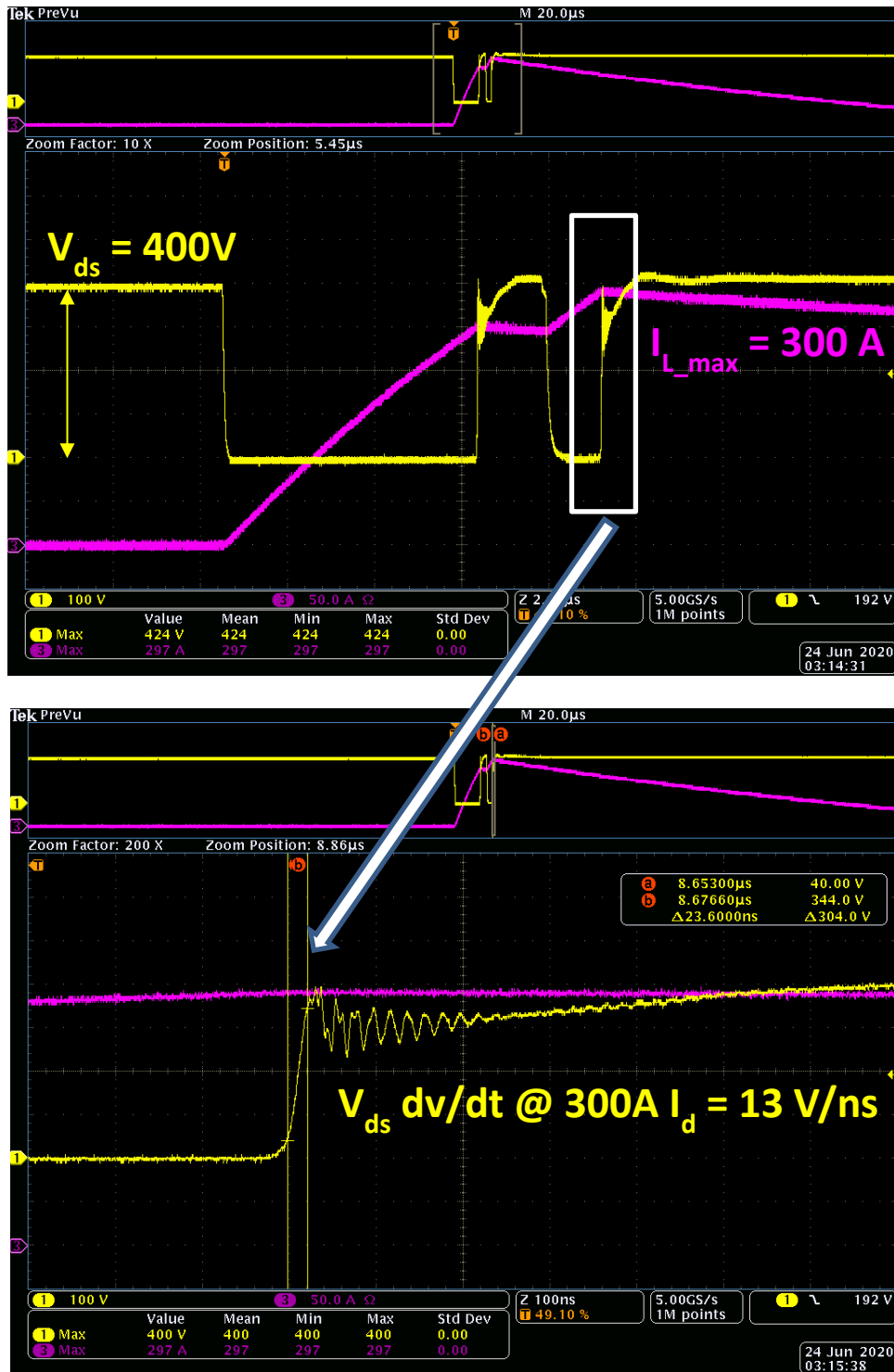


Figure 8 Double pulse test – High Side GaN Switching OFF waveforms

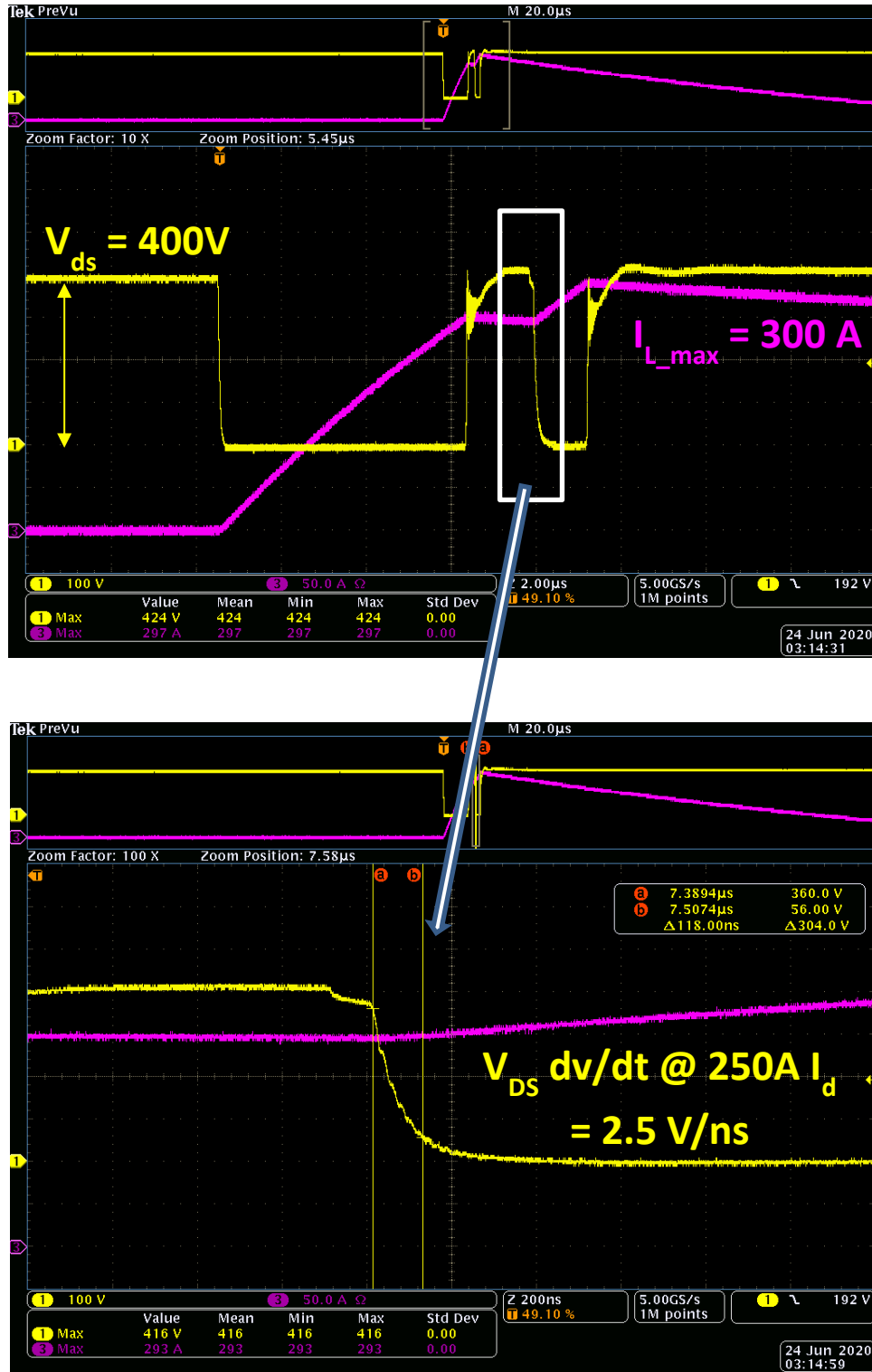


Figure 9 Double pulse test – High Side GaN Switching ON waveforms

## Mechanical Drawing

### Power Module

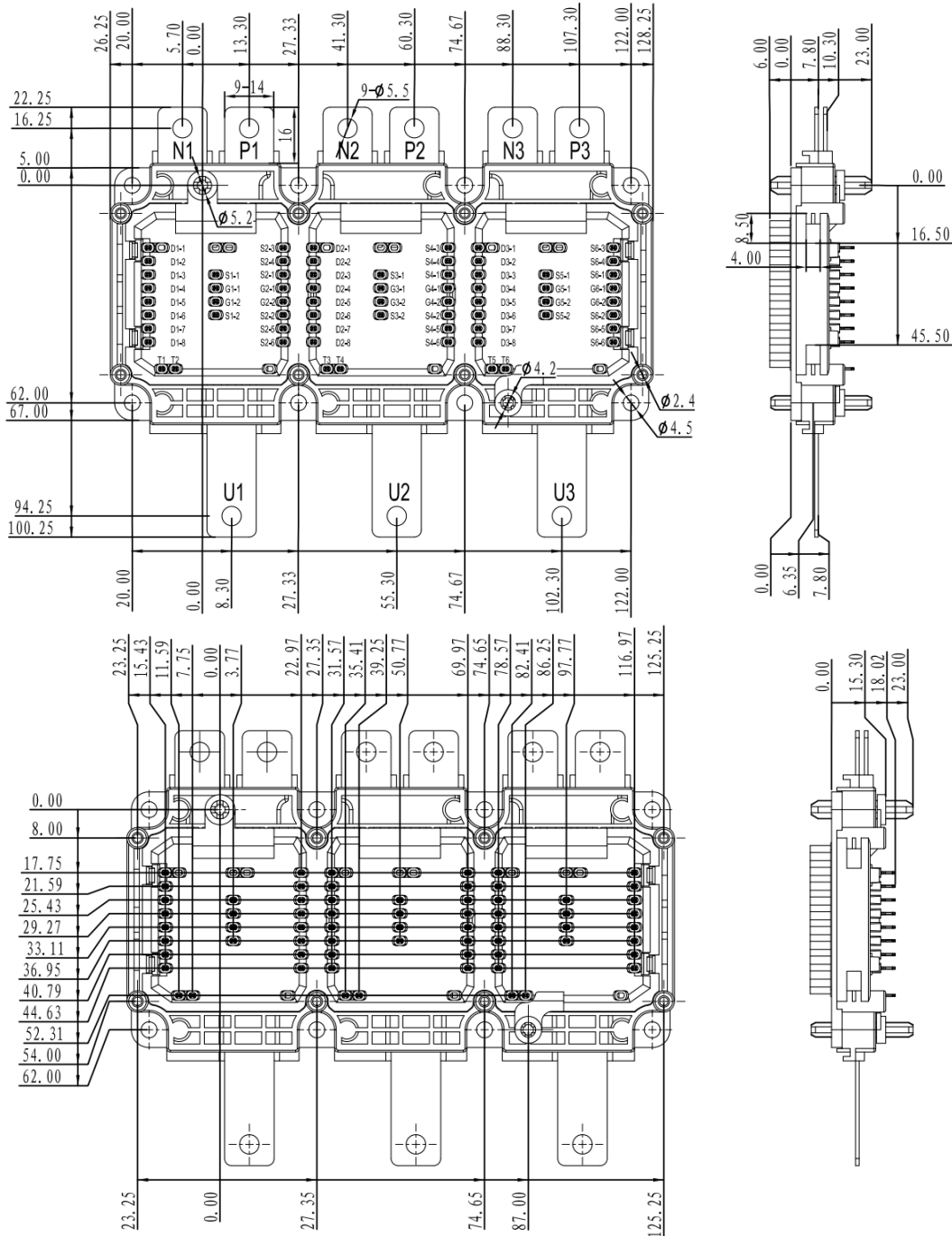


Figure 10 650V 300A GaN 3 phase Power Module Package Outline

## Evaluation Board/kit Important Notice

GaN Systems Inc. (GaN Systems) provides the enclosed product(s) under the following **AS IS** conditions:

This evaluation board/kit being sold or provided by GaN Systems is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, and OR EVALUATION PURPOSES ONLY** and is not considered by GaN Systems to be a finished end-product fit for general consumer use. As such, the goods being sold or provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives, or other related regulations.

If this evaluation board/kit does not meet the specifications indicated in the Technical Manual, the board/kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies GaN Systems from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

No License is granted under any patent right or other intellectual property right of GaN Systems whatsoever. **GaN Systems assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or any other intellectual property rights of any kind.**

GaN Systems currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

**Please read the Technical Manual and, specifically, the Warnings and Restrictions notice in the Technical Manual prior to handling the product.** Persons handling the product(s) must have electronics training and observe good engineering practice standards.

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a GaN Systems' application engineer.



In Canada:

GaN Systems Inc.  
1145 Innovation Drive Suite 101  
Ottawa, Ontario, Canada K2K 3G8  
T +1 613-686-1996

In Europe:

GaN Systems Ltd., German Branch  
Terminalstrasse Mitte 18,  
85356 München, Germany  
T +49 (0) 8165 9822 7260

In the United States:

GaN Systems Corp.  
2723 South State Street, Suite 150,  
Ann Arbor, MI. USA 48104  
T +1 248-609-7643

[www.gansystems.com](http://www.gansystems.com)

**Important Notice** – Unless expressly approved in writing by an authorized representative of GaN Systems, GaN Systems components are not designed, authorized or warranted for use in lifesaving, life sustaining, military, aircraft, or space applications, nor in products or systems where failure or malfunction may result in personal injury, death, or property or environmental damage. The information given in this document shall not in any event be regarded as a guarantee of performance. GaN Systems hereby disclaims any or all warranties and liabilities of any kind, including but not limited to warranties of non-infringement of intellectual property rights. All other brand and product names are trademarks or registered trademarks of their respective owners. Information provided herein is intended as a guide only and is subject to change without notice. The information contained herein or any use of such information does not grant, explicitly, or implicitly, to any party any patent rights, licenses, or any other intellectual property rights. General Sales and Terms Conditions apply.

© 2009-2020 GaN Systems Inc. All rights reserved.