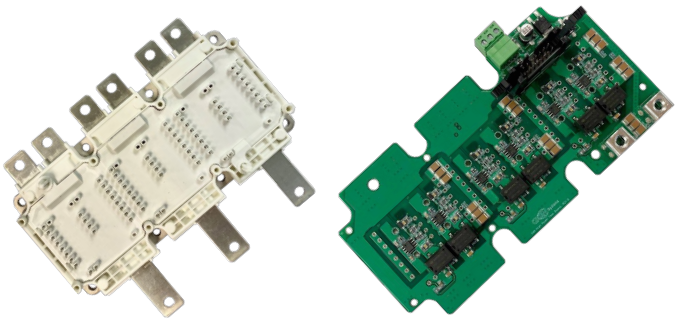
GS-EVx-3PH-650V300A-SM1x

GS-EVM-3PH-650V300A-SM1
GS-EVB-3PH-650V300A-SM1A

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

Technical Manual



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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.

Please refer to the Evaluation Board/Kit Important Notice on page 16

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

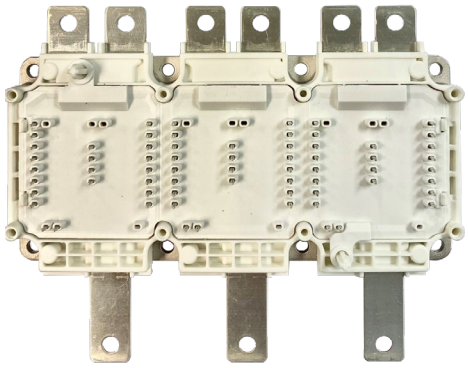

Figure 1 650V 300A GaN 3 phase Power Module

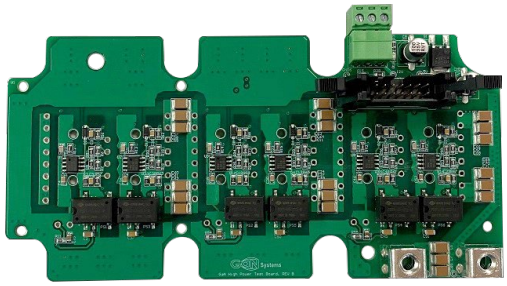

Figure 2 External Gate Driver Board

Technical Specifications

Block Diagram of Power Module

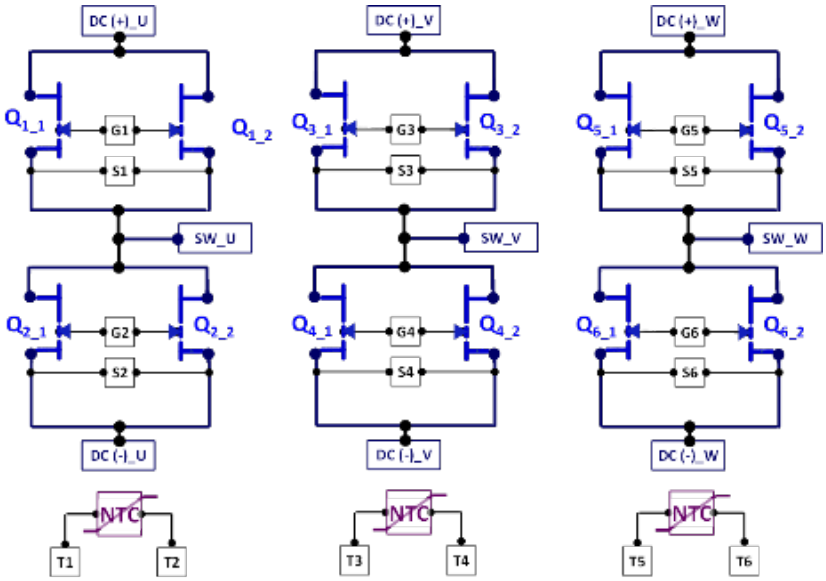

Figure 3 650V 300A GaN 3 phase Power Module Block Diagram

Driver Board Pin Description

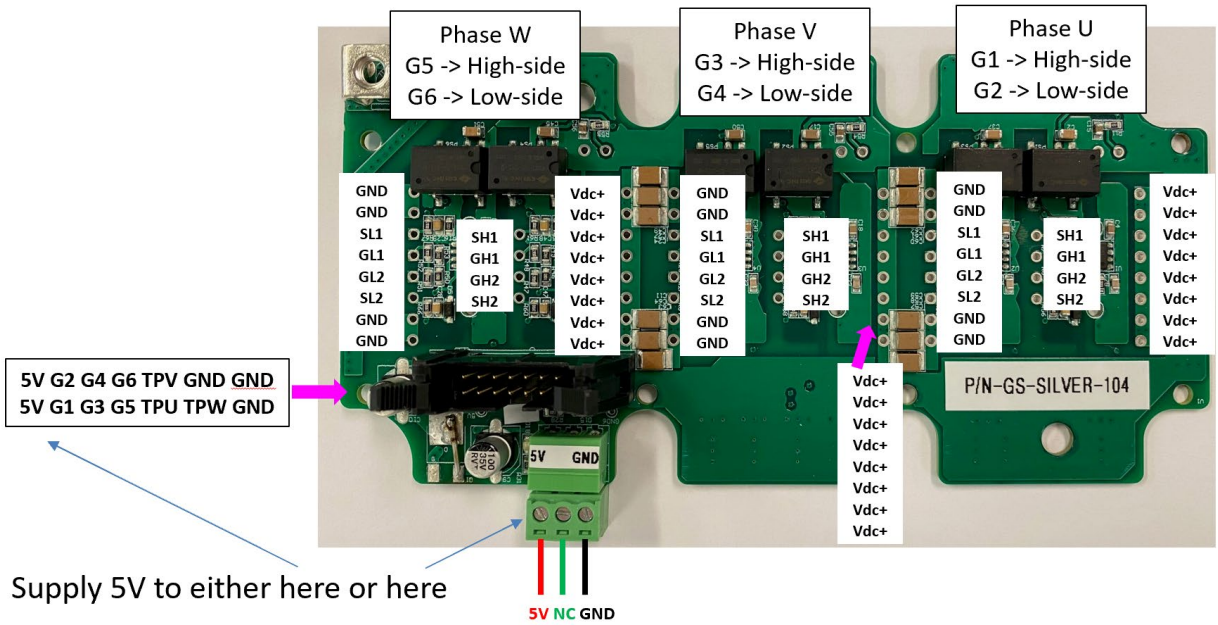

Figure 4 Driver Board Pin Description

Driver Board Schematics

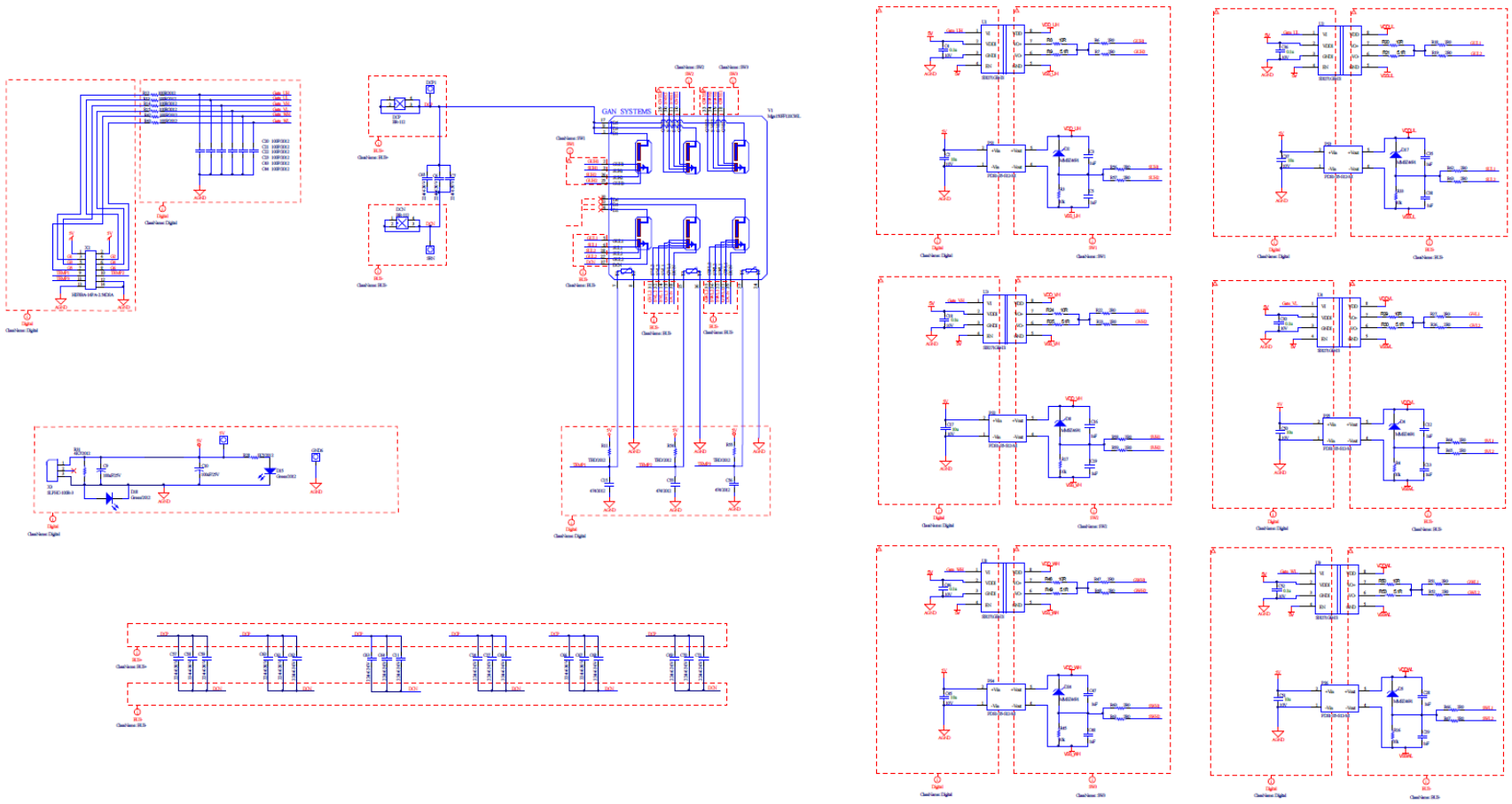

Figure 5 Driver Board Schematics

Electrical Characteristics

Test Conditions, unless otherwise noted: T_{JUNC} = 25^{0}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_{DSS}< 560 µA
Module ON Resistance T_{JUNC} = 25 °C	R_{ON}	-	6	7.5	mΩ	V_{GS} = 6.0V, I_{DS} = 100A T_{JUNC} = 25 °C
Module ON Resistance T_{JUNC} = 150 °C(Note 4)	R_{ON}	-	14	-	mΩ	V_{GS} = 6.0V, I_{DS} = 100A T_{JUNC} = 150 °C
Drain-to-Source Leakage T_{JUNC} = 25 °C	I_{DSS}	-	22	550	µA	V_{GS} = 0V, V_{DS} = 650V T_{JUNC} = 25 °C
Drain-to-Source Leakage T_{JUNC} = 150 °C(Note 4)	I_{DSS}	-	4400	-	µA	V_{GS} = 0V, V_{DS} = 650V T_{JUNC} = 150 °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	-	µA	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	$t_{D(ON)}$	-	*tbd*	-	ns	V_{GS} = -3V to 6V, V_{DS} = 400V, I_{DS} = 160A, $R_{G(ON)}$ = 5Ω, T_{JUNC} = 25 °C (Note 5)
Rise Time	t_{RISE}	-	*tbd*	-	ns	
Turn-Off Delay Time	$t_{D(OFF)}$	-	*tbd*	-	ns	
Fall Time	t_{FALL}	-	*tbd*	-	ns	
Turn-On Switching Energy	E_{ON}	-	715	-	µJ	V_{GS} = -3V to 6V, V_{DS} = 400V, I_{DS} = 150A, $R_{G(ON)}$ = 10Ω, $R_{G(OFF)}$ = 1Ω, L = 40µH (Note6)
Turn-Off Switching Energy	E_{OFF}	-	115	-	µJ	

(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	^{0}C
Thermal Resistance, Junction-to-Cold Plate	$R_{\Theta\_JUNCTION\text{-}COLD\ PLATE}$	-	0.20	-	°C/W
Storage Temperature Range	T_{STOR}	-	-	-40 to +125	^{0}C

NTC Characteristics

Parameter	Conditions / Equation	Typical Value	Units
R_{25}	T_C = 25 ^{0}C	5	kΩ
ΔR/R	T_C = 100 ^{0}C, R_{100} = 481Ω	±5	%
P_{25}	T_C = 25 ^{0}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_{ISO}	4.2	-	-	kV	RMS, f = 0Hz, t = 1s
Terminal RMS Current	I_{tRMS}	-	500	-	A	T_F = 85 ^{0}C, T_{Ct}= 105 ^{0}C
Terminal Creepage	$d_{CREEPAGE}$	-	9.0	-	mm	To Heatsink/Terminal
Terminal Clearance	$d_{CLEARANCE}$	-	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_{DSON} 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 1µs.
- 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.

Please refer to the Evaluation Board/Kit Important Notice on page 16

Test Results

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

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

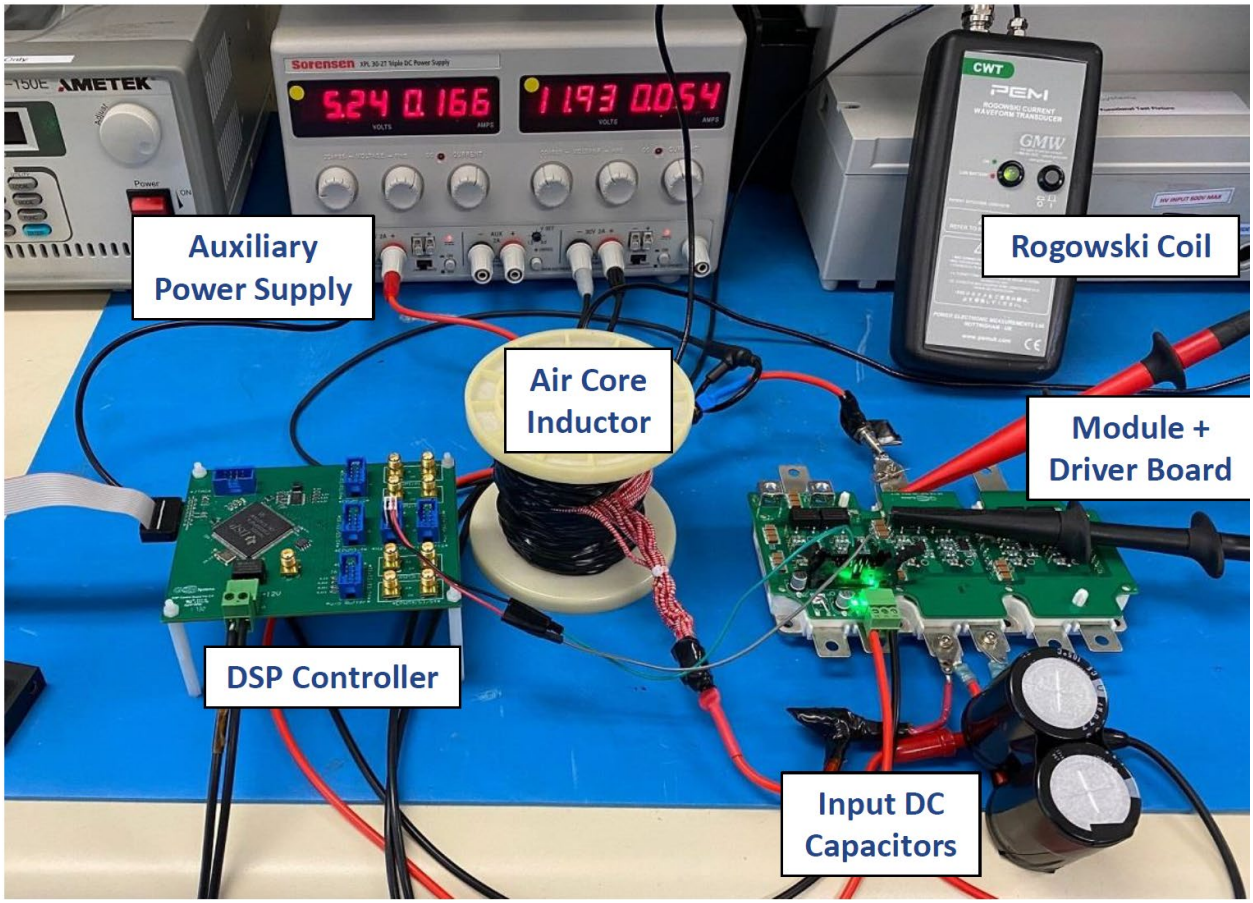

Figure 6 Double pulse test setup

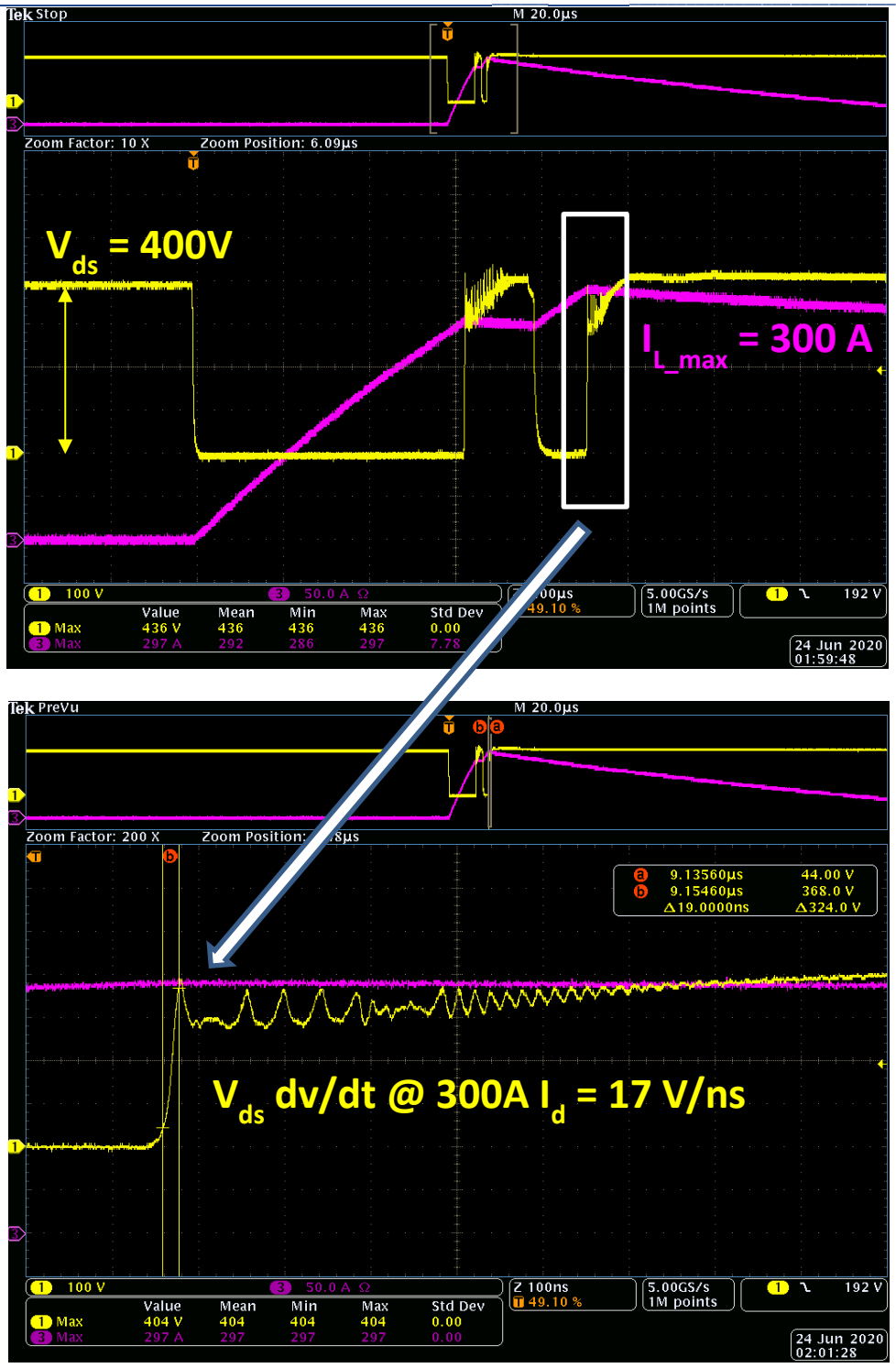

Figure 7 Double pulse test – Low Side GaN Switching OFF waveforms

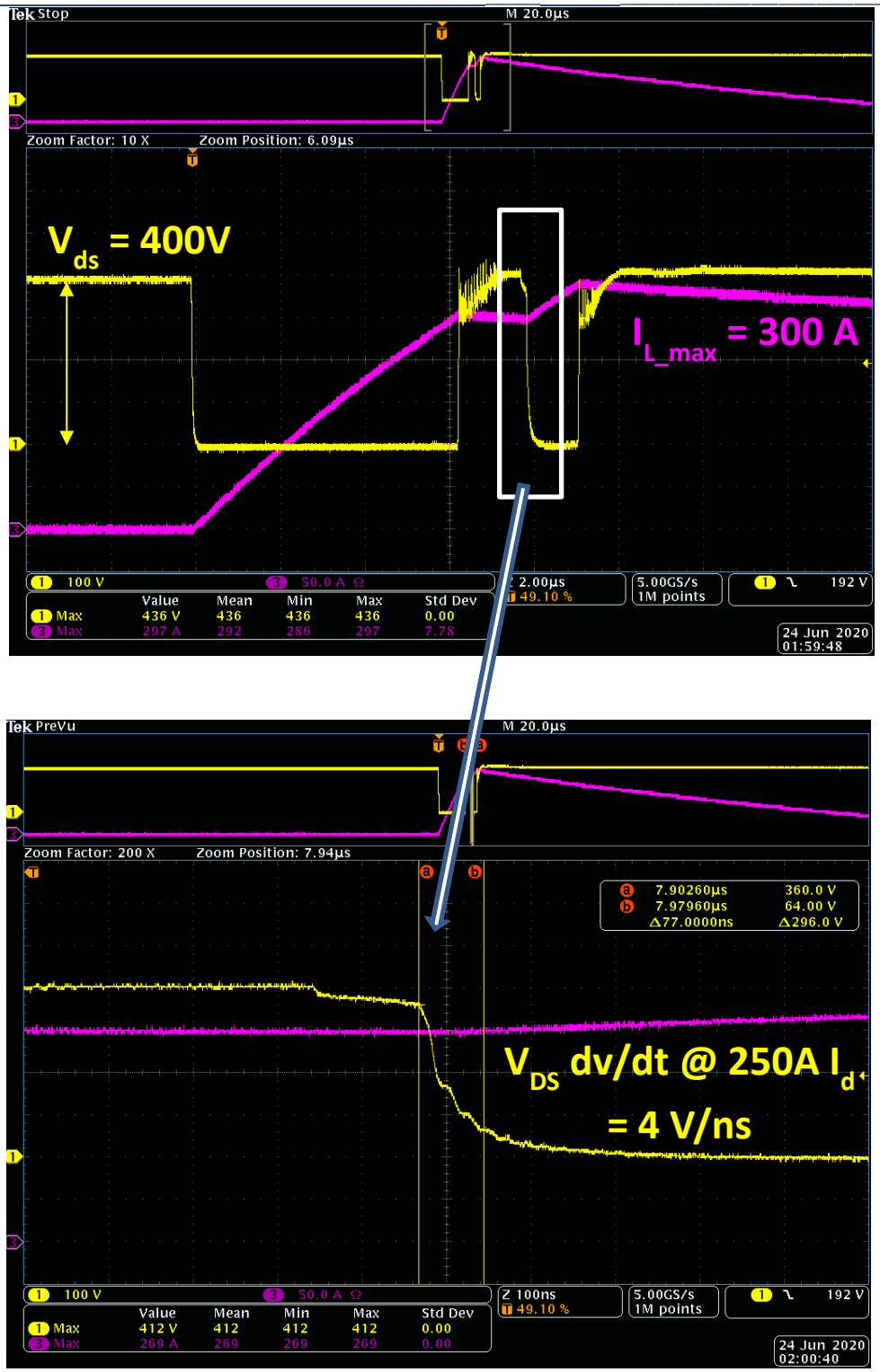

Figure 8 Double pulse test – Low Side GaN Switching ON waveforms

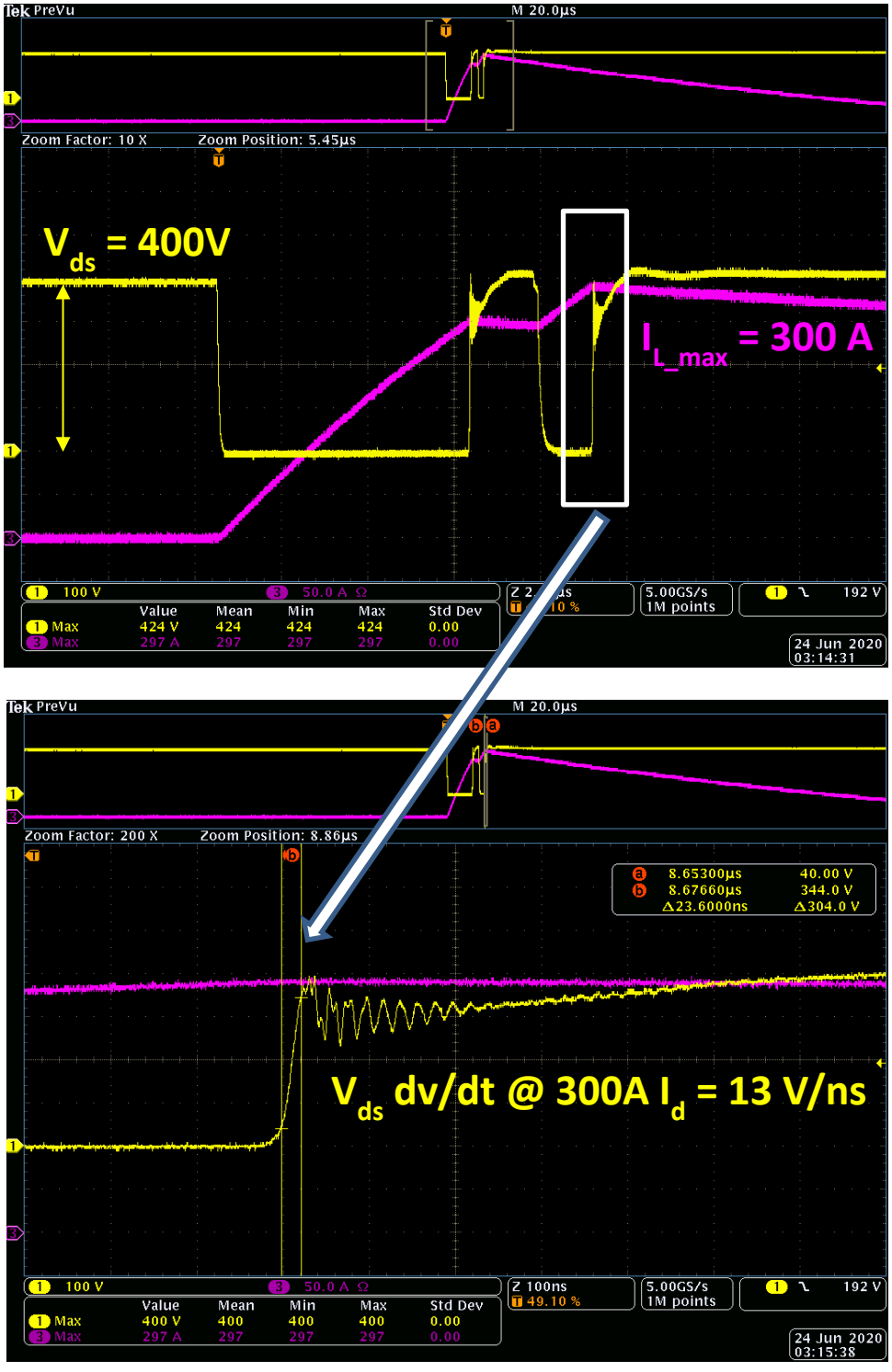

Figure 9 Double pulse test – High Side GaN Switching OFF waveforms

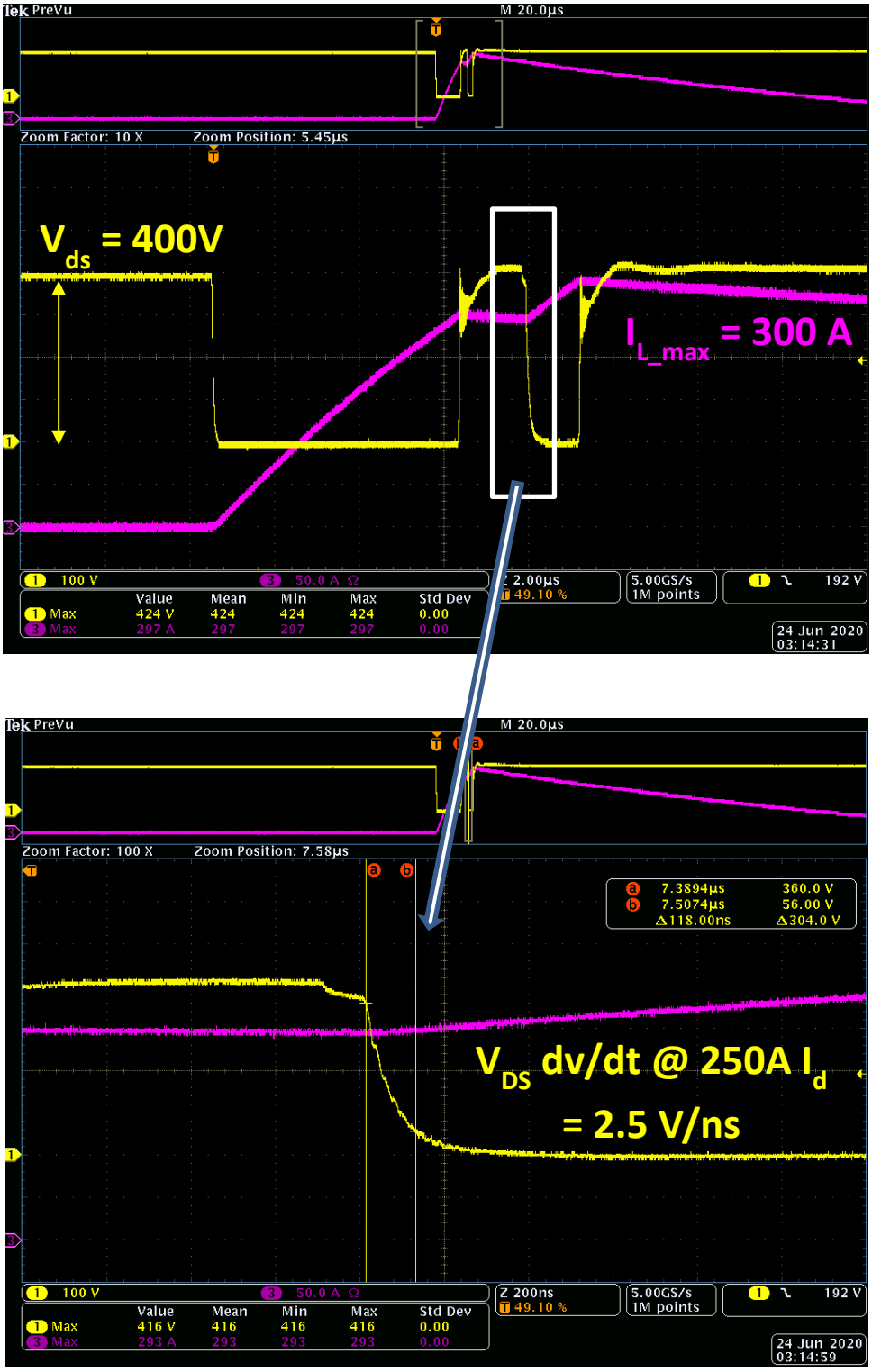

Figure 10 Double pulse test – High Side GaN Switching ON waveforms

Mechanical Drawing

Power Module

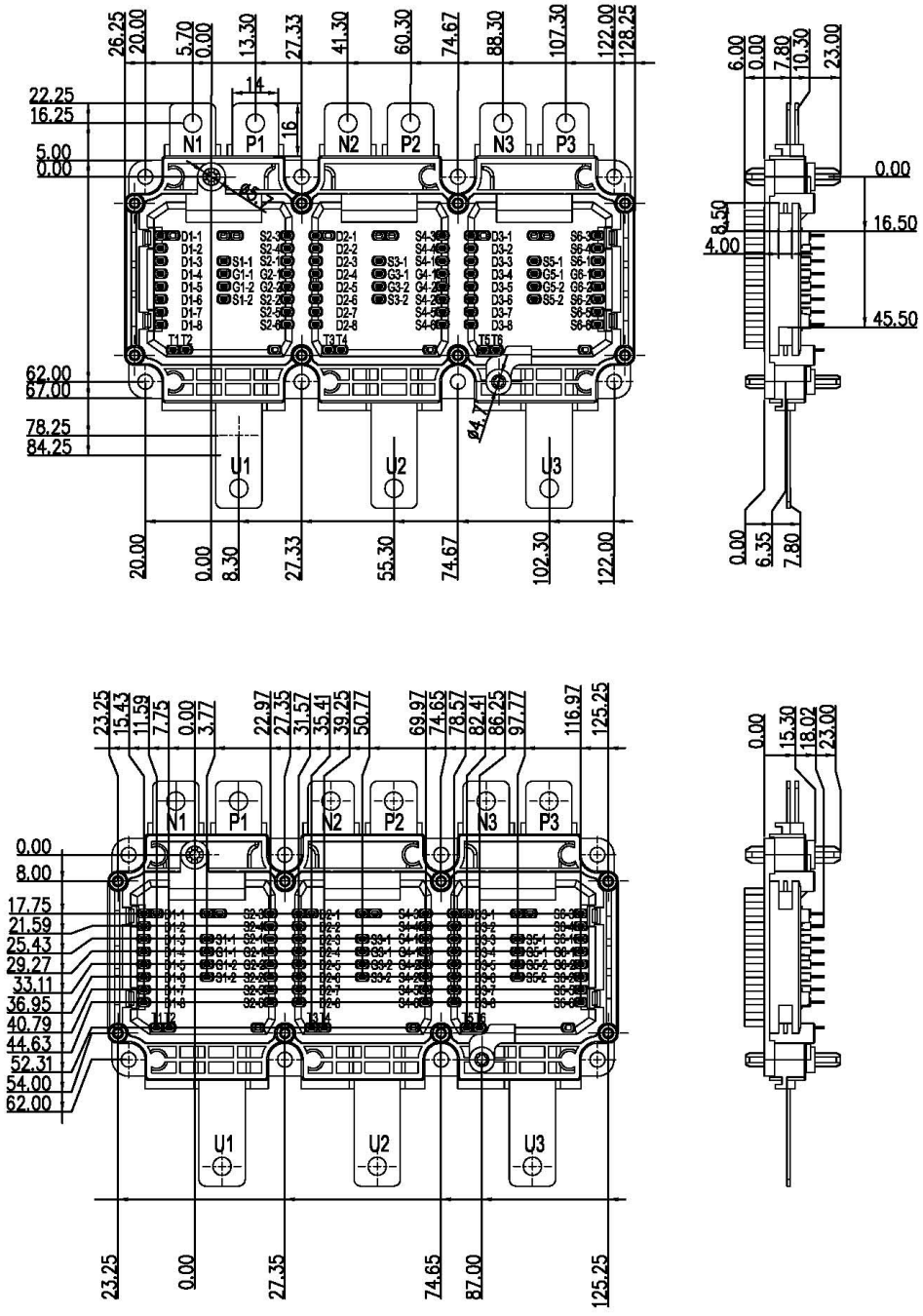

Figure 11 650V 300A GaN 3 phase Power Module Package Outline

Please refer to the Evaluation Board/Kit Important Notice on page 16

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