

## 650V GaN FET

**Datasheet  
Preliminary**

### 1. Description

The G2N65 series FETs are hybrid normally-off Gallium Nitride (GaN) field effect transistors with the strongest gate and the lowest reverse voltage drop of all wide-band-gap devices in the market. They allow simple gate drive, offer best-in-class performance and outstanding reliability.

#### Features

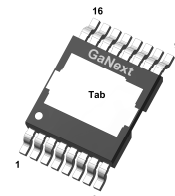
- Strong gate with a high threshold, no need for negative gate drive, and a high repetitive input voltage tolerance of  $\pm 20\text{V}$ .
- Fast turn-on/off speed for reduced cross-over losses.
- Low  $Q_g$  and simple gate drive for lowest driver consumption at high frequencies.
- Lowest  $V_F$  in off-state reverse conduction among all SiC and GaN FETs for low loss during dead-times.
- Negligible  $Q_{rr}$  for outstanding hard-switched bridge applications.
- High spike tolerance of 800V for enhanced reliability.
- Top cooling design, better cooling efficiency under water-cooling conditions.

#### Benefits

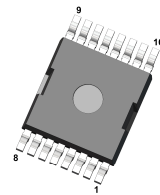
- Enable very high conversion efficiencies.
- Enable higher frequency for compact power supplies.
- End-product cost & size savings due to reduced cooling requirements.
- Improved safety & reliability due to cooler operation temperature.
- Low loop inductance.

#### Applications

- Datacenter power supplies, telecom power supplies, micro inverters, photovoltaic inverter, high voltage DC/DC converters and EV OBC & DC-DC based on the half-bridge and/or full-bridge topologies for hard and/or soft switching such as Totem pole bridgeless PFC and high frequency LLC.

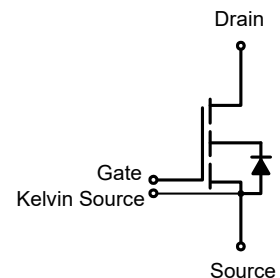


Top View



Bottom View

|               |              |
|---------------|--------------|
| Drain         | 1 ~ 8        |
| Gate          | 9            |
| Kelvin Source | 10           |
| Source        | 11 ~ 16, Tab |



#### Key Performance Parameters

|                                               |      |
|-----------------------------------------------|------|
| $V_{DSS}$ (V)                                 | 650  |
| $V_{DSS(PK)}$ (V) <sup>a)</sup>               | 800  |
| $R_{DS(on), typ}$ (m $\Omega$ ) <sup>b)</sup> | 92   |
| $Q_{oss}$ (nC)                                | 56   |
| $Q_g$ (nC)                                    | 14.4 |

<sup>a)</sup> Duty cycle < 1%, spike duration < 30 $\mu$ s, repetitive for  $\leq 85^\circ\text{C}$ , non-repetitive up to  $150^\circ\text{C}$

<sup>b)</sup> Dynamic on-resistance



\*Lead plating Pb-free  
in compliance with RoHS

#### Part Number & Package Information

| Part #        | Package | Package Base |
|---------------|---------|--------------|
| G2N65R092TT-H | TOLT    | Source       |

## 2. Maximum Ratings

| Symbol                              | Parameter                                                                             | Value      |
|-------------------------------------|---------------------------------------------------------------------------------------|------------|
| $V_{DSS}$ (V)                       | Drain-source maximum voltage ( $T_J = -55^{\circ}\text{C}$ to $150^{\circ}\text{C}$ ) | 650        |
| $V_{DSS(PK)}$ (V)                   | Drain-source maximum peak voltage <sup>a)</sup>                                       | 800        |
| $V_{GSS, DC}$ (V)                   | Gate-source maximum voltage                                                           | $\pm 20$   |
| $V_{GSS, AC}$ (V)                   | Gate-source maximum voltage ( $f \geq 50\text{Hz}$ )                                  | $\pm 30$   |
| $P_D$ (W)                           | Maximum power dissipation ( $T_C = 25^{\circ}\text{C}$ )                              | 65.8       |
| $I_{DS}$ (A)                        | Maximum continuous drain current ( $T_C = 25^{\circ}\text{C}$ )                       | 18.9       |
|                                     | Maximum continuous drain current ( $T_C = 100^{\circ}\text{C}$ )                      | 12         |
| $I_{DS (pulse)}$ (A)                | Maximum pulsed drain current ( $T_C = 25^{\circ}\text{C}$ ) <sup>b)</sup>             | 95         |
| $T_J$ ( $^{\circ}\text{C}$ )        | Operating junction temperature                                                        | -55 to 150 |
| $T_S$ ( $^{\circ}\text{C}$ )        | Storage temperature                                                                   | -55 to 150 |
| $T_{solder}$ ( $^{\circ}\text{C}$ ) | Reflow soldering temperature <sup>c)</sup>                                            | 260        |

<sup>a)</sup> Duty cycle < 1%, spike duration < 30 $\mu\text{s}$ , repetitive for  $\leq 85^{\circ}\text{C}$ , non-repetitive up to  $150^{\circ}\text{C}$

<sup>b)</sup> Pulse width = 10 $\mu\text{s}$

<sup>c)</sup> Reflow MSL3

## 3. Thermal Characteristics

| Symbol                                   | Parameter                                            | Typ. |
|------------------------------------------|------------------------------------------------------|------|
| $R_{\theta JC}$ ( $^{\circ}\text{C/W}$ ) | Junction-to-case thermal resistance                  | 1.9  |
| $R_{\theta JA}$ ( $^{\circ}\text{C/W}$ ) | Junction-to-ambient thermal resistance <sup>a)</sup> | 40   |

<sup>a)</sup> Soldered on a PCB of 6cm<sup>2</sup> metal area and 70 $\mu\text{m}$  thickness

## 4. Device Characteristics

$T_J = 25^\circ\text{C}$  unless specified

| Symbol       | Parameter                                      | Min. | Typ. | Max. | Unit             | Test Conditions                                                                                                                                                      |
|--------------|------------------------------------------------|------|------|------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $V_{GS(th)}$ | Gate threshold voltage                         | 3.2  | 3.65 | 4.1  | V                | $V_{DS} = V_{GS}$ , $I_D = 1.5\text{mA}$                                                                                                                             |
| $R_{DS(on)}$ | Drain-source on resistance <sup>a)</sup>       | -    | 92   | 110  | $\text{m}\Omega$ | $V_{GS} = 10\text{V}$ , $I_D = 12\text{A}$                                                                                                                           |
|              |                                                | -    | 184  | -    | $\text{m}\Omega$ | $V_{GS} = 10\text{V}$ , $I_D = 12\text{A}$ ,<br>$T_J = 150^\circ\text{C}$                                                                                            |
| $I_{DSS}$    | Drain-source leakage current                   | -    | 2.5  | 25   | $\mu\text{A}$    | $V_{DS} = 650\text{V}$ , $V_{GS} = 0\text{V}$                                                                                                                        |
|              |                                                | -    | 5    | -    | $\mu\text{A}$    | $V_{DS} = 650\text{V}$ , $V_{GS} = 0\text{V}$ ,<br>$T_J = 150^\circ\text{C}$                                                                                         |
| $I_{GSS}$    | Gate-source leakage current                    | -100 | -    | 100  | nA               | $V_{GS} = \pm 20\text{V}$                                                                                                                                            |
| $C_{iss}$    | Input capacitance                              | -    | 818  | -    | pF               | $V_{GS} = 0\text{V}$ , $V_{DS} = 400\text{V}$ ,<br>$f = 500\text{kHz}$                                                                                               |
| $C_{oss}$    | Output capacitance                             | -    | 53   | -    | pF               | $V_{GS} = 0\text{V}$ , $V_{DS} = 400\text{V}$ ,<br>$f = 500\text{kHz}$                                                                                               |
| $C_{rss}$    | Reverse transfer capacitance                   | -    | 3.6  | -    | pF               | $V_{GS} = 0\text{V}$ , $V_{DS} = 400\text{V}$ ,<br>$f = 500\text{kHz}$                                                                                               |
| $C_{o(er)}$  | Equivalent output capacitance (energy related) | -    | 78   | -    | pF               | $V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 400\text{V}$                                                                                                          |
| $C_{o(tr)}$  | Equivalent output capacitance (time related)   | -    | 139  | -    | pF               | $V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 400\text{V}$                                                                                                          |
| $Q_g$        | Gate charge total                              | -    | 14.4 | -    | nC               | $V_{DS} = 400\text{V}$ , $V_{GS} = 0\text{V to } 10\text{V}$ ,<br>$I_D = 12\text{A}$                                                                                 |
| $Q_{gs}$     | Gate to source charge                          | -    | 4.7  | -    | nC               |                                                                                                                                                                      |
| $Q_{gd}$     | Gate to drain charge                           | -    | 5.2  | -    | nC               |                                                                                                                                                                      |
| $Q_{oss}$    | Output charge                                  | -    | 56   | -    | nC               | $V_{GS} = 0\text{V}$ , $V_{DS} = 0\text{V to } 400\text{V}$                                                                                                          |
| $t_{d(on)}$  | Turn-on delay time                             | -    | 23   | -    | ns               | $V_{DS} = 400\text{V}$ , $V_{GS} = 0\text{V to } 12\text{V}$ ,<br>$I_D = 13\text{A}$ , $R_G = 36\Omega$ ,<br>$Z_{FB} = 120\Omega @ 100\text{MHz}$ ,<br>see Figure 13 |
| $t_r$        | Rise time                                      | -    | 7.1  | -    | ns               |                                                                                                                                                                      |
| $t_{d(off)}$ | Turn-off delay time                            | -    | 58   | -    | ns               |                                                                                                                                                                      |
| $t_f$        | Fall time                                      | -    | 7.5  | -    | ns               |                                                                                                                                                                      |

<sup>a)</sup> Dynamic on-resistance

Reverse Device Characteristics,  $T_J = 25^\circ\text{C}$  unless specified

| Symbol        | Parameter                             | Min. | Typ. | Max. | Unit | Test Conditions                                                                                 |
|---------------|---------------------------------------|------|------|------|------|-------------------------------------------------------------------------------------------------|
| $I_S$         | Reverse current                       | -    | -    | 12   | A    | $V_{GS} = 0V$ , $T_C = 100^\circ\text{C}$ ,<br>$\leq 25\%$ duty cycle                           |
| $I_S$ (pulse) | Pulsed reverse current                | -    | -    | 35   | A    | $V_{GS} = 0V$ , $V_{SD} = 6V$ ,<br>pulse width $\leq 10\mu\text{s}$ , $T_J = 150^\circ\text{C}$ |
| $V_{SD}$      | Reverse voltage <sup>a)</sup>         | -    | 1.7  | -    | V    | $V_{GS} = 0V$ , $I_S = 12A$                                                                     |
|               |                                       | -    | 1.4  | -    | V    | $V_{GS} = 0V$ , $I_S = 8A$                                                                      |
| $t_{rr}$      | Reverse recovery time                 | -    | 17.9 | -    | ns   | $I_S = 13A$ , $V_{DD} = 400V$ ,<br>$di/dt = 1000A/\mu\text{s}$                                  |
| $Q_{rr}$      | Reverse recovery charge <sup>b)</sup> | -    | 2.5  | -    | nC   |                                                                                                 |

<sup>a)</sup> Including the effect of dynamic on-resistance

<sup>b)</sup> Excluding  $Q_{oss}$

## 5. Typical Characteristics ( $T_C = 25^\circ\text{C}$ unless specified)

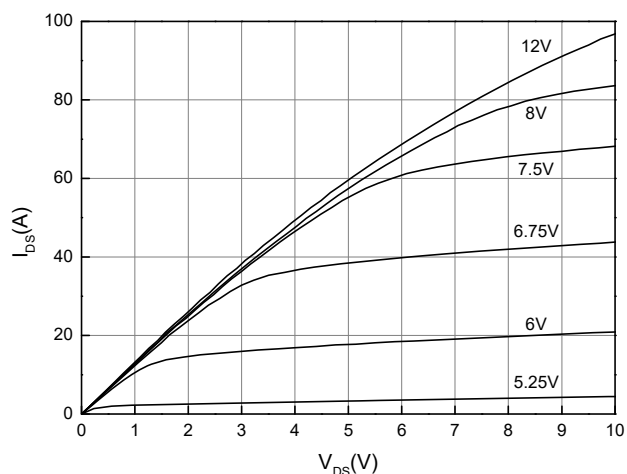


Figure 1. Typical Output Characteristics at  $T_J = 25^\circ\text{C}$   
(Parameter:  $V_{GS}$ )

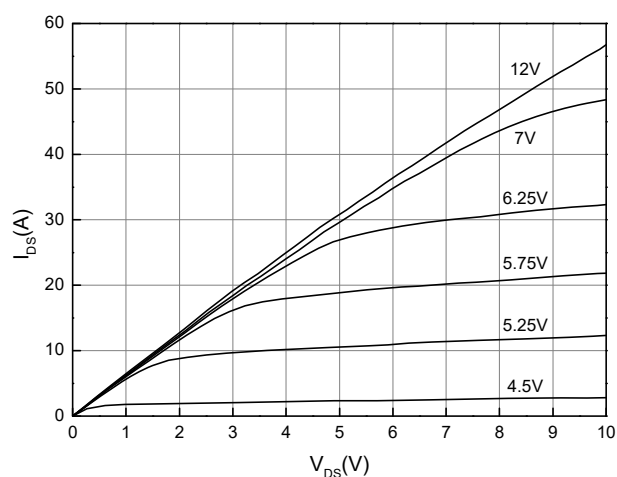


Figure 2. Typical Output Characteristics at  $T_J = 150^\circ\text{C}$   
(Parameter:  $V_{GS}$ )

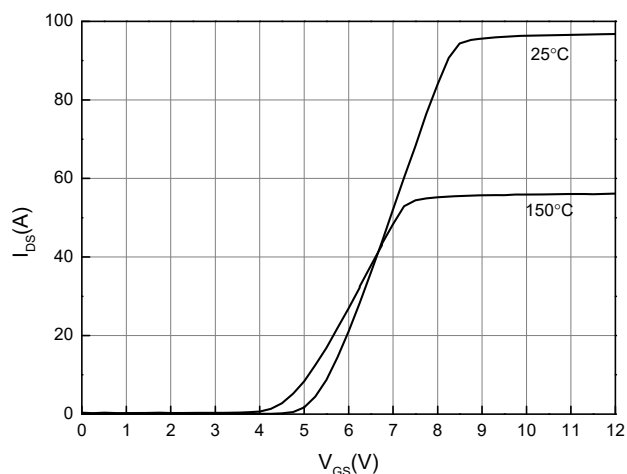


Figure 3. Typical Transfer Characteristics  
( $V_{DS} = 10\text{V}$ , Parameter:  $T_J$ )

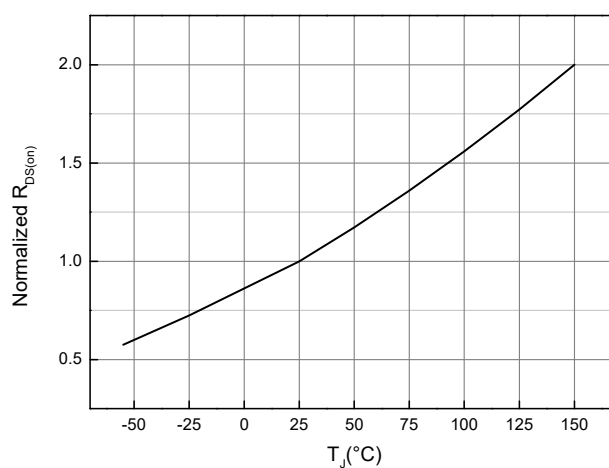
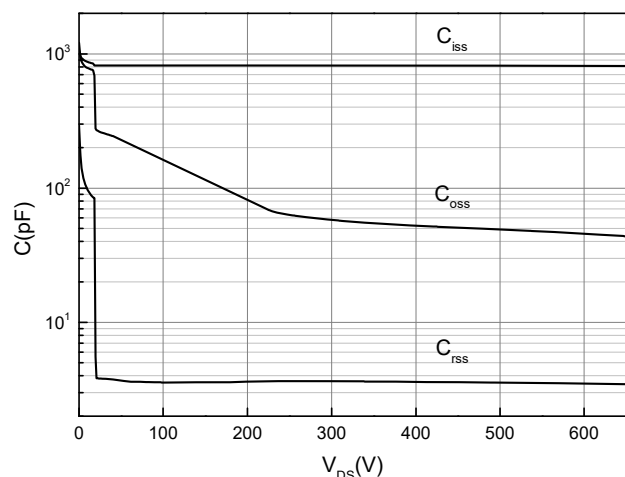
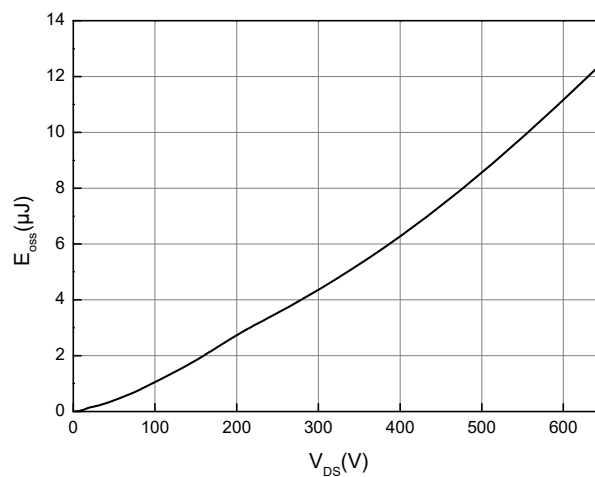


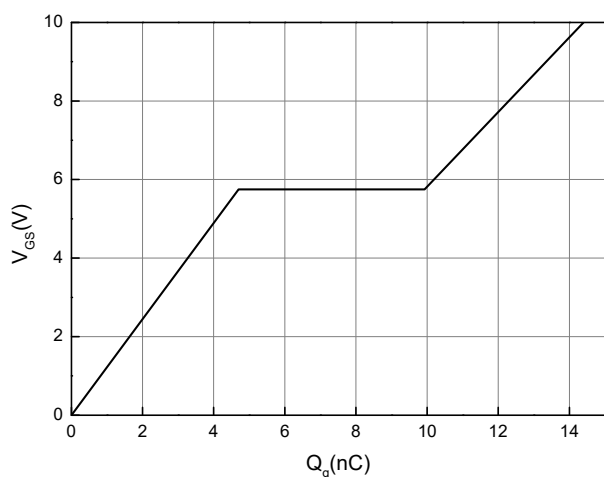
Figure 4. Normalized On-Resistance  
( $I_D = 12\text{A}$ ,  $V_{GS} = 10\text{V}$ )



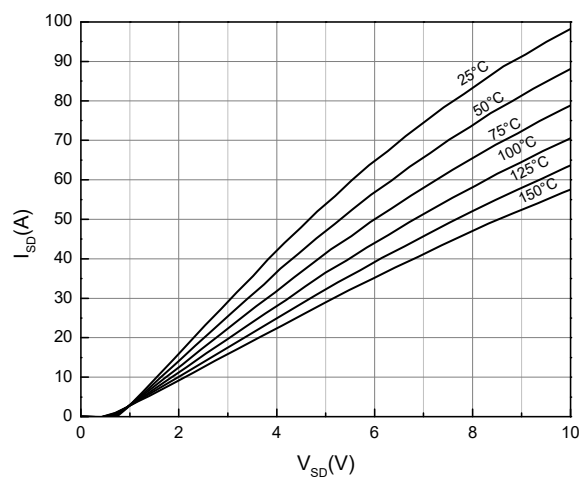
**Figure 5. Typical Capacitance**  
( $V_{GS} = 0V$ ,  $f = 500kHz$ )



**Figure 6. Typical  $C_{oss}$  Stored Energy**



**Figure 7. Typical Gate Charge**  
( $I_{DS} = 12A$ ,  $V_{DS} = 400V$ )



**Figure 8. Reverse Conduction Characteristics**  
( $-20V \leq V_{GS} \leq 0V$ , Parameter:  $T_J$ )

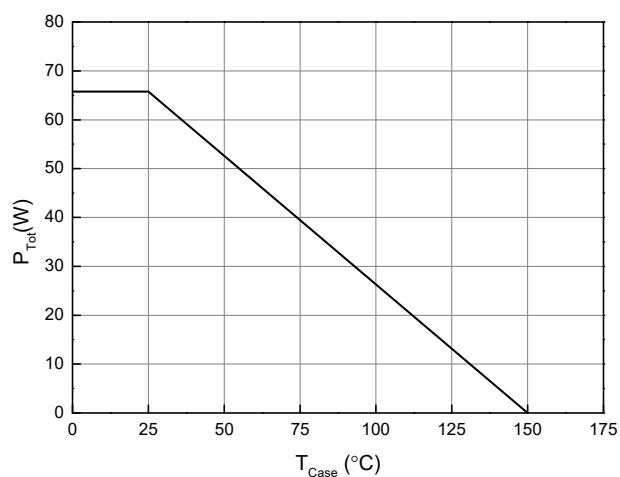


Figure 9. Power Dissipation

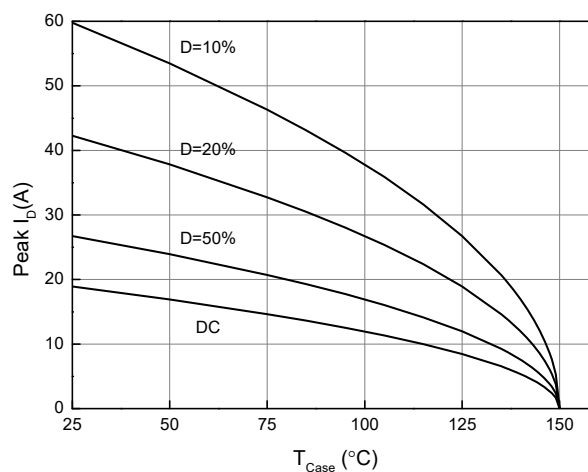


Figure 10. Current Derating  
( Pulse Width  $\leq 10\mu s$ ,  $V_{GS} \geq 10V$  )

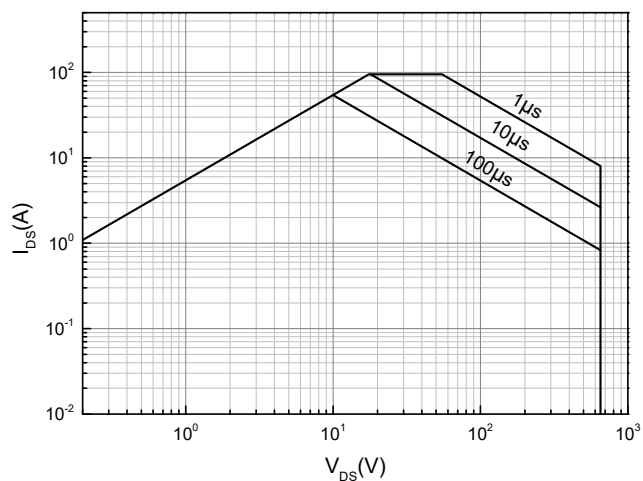


Figure 11. Safe Operating Area at  $T_C = 25°C$

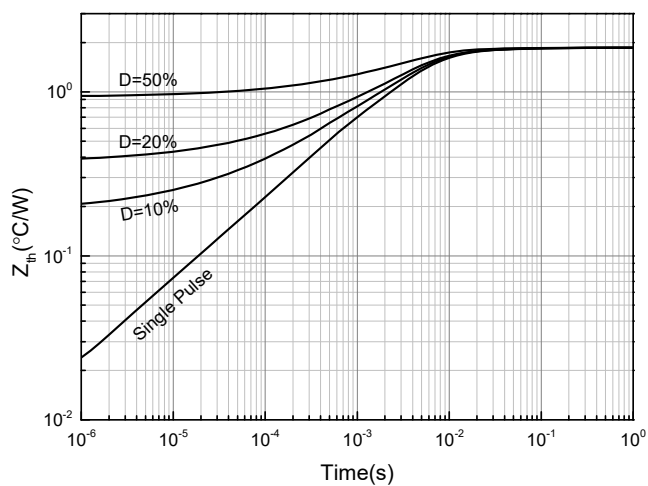


Figure 12. Transient Thermal Resistance

## 6. Design Considerations

The fast switching of GaN devices reduces current-voltage crossover losses and enables high frequency operation while simultaneously achieving high efficiency. However, taking full advantage of the fast switching characteristics of GaN switches requires adherence to specific PCB layout guidelines and probing techniques.

| DO                                                                                     | DO NOT                                                                                     |
|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Place gate driver close to the GaN device and separate input traces from output traces | Use long gate drive traces, long lead length and route the output traces next to the input |
| Use gate ferrite bead and dc-link RC snubber                                           | Use close-by decoupling capacitor without series resistor                                  |
| Minimize trace length of the PCB layout for both drive loop and power loop             | Use a traditional differential voltage probe for $V_{gs}$ of high side device              |

## 7. Circuit Implementation

### Half-bridge Schematic

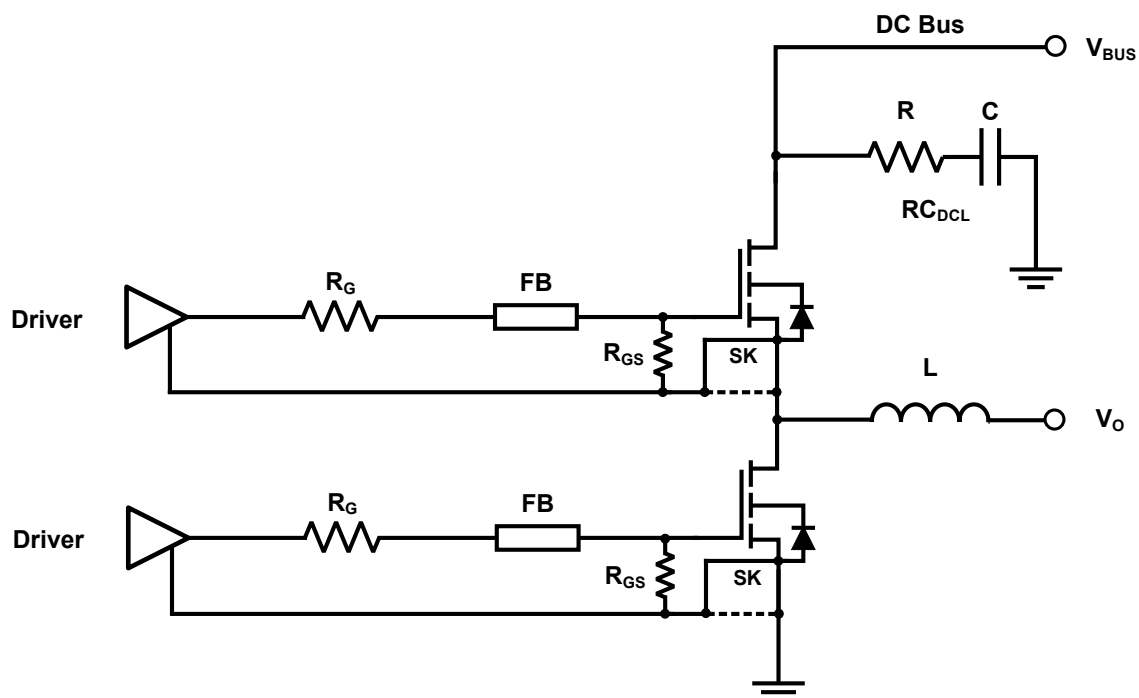


Figure 13. Simplified half-bridge schematic

Recommended gate drive: (0V, 10-12V) with  $R_G = 36\Omega$  <sup>a)</sup>

| Gate Ferrite Bead (FB) <sup>b)</sup> | Required DC Link RC Snubber ( $RC_{DCL}$ ) <sup>c)</sup> |
|--------------------------------------|----------------------------------------------------------|
| 100-330 $\Omega$ @100MHz             | $(10\text{nF}+10\Omega) \times 2$                        |

Notes:

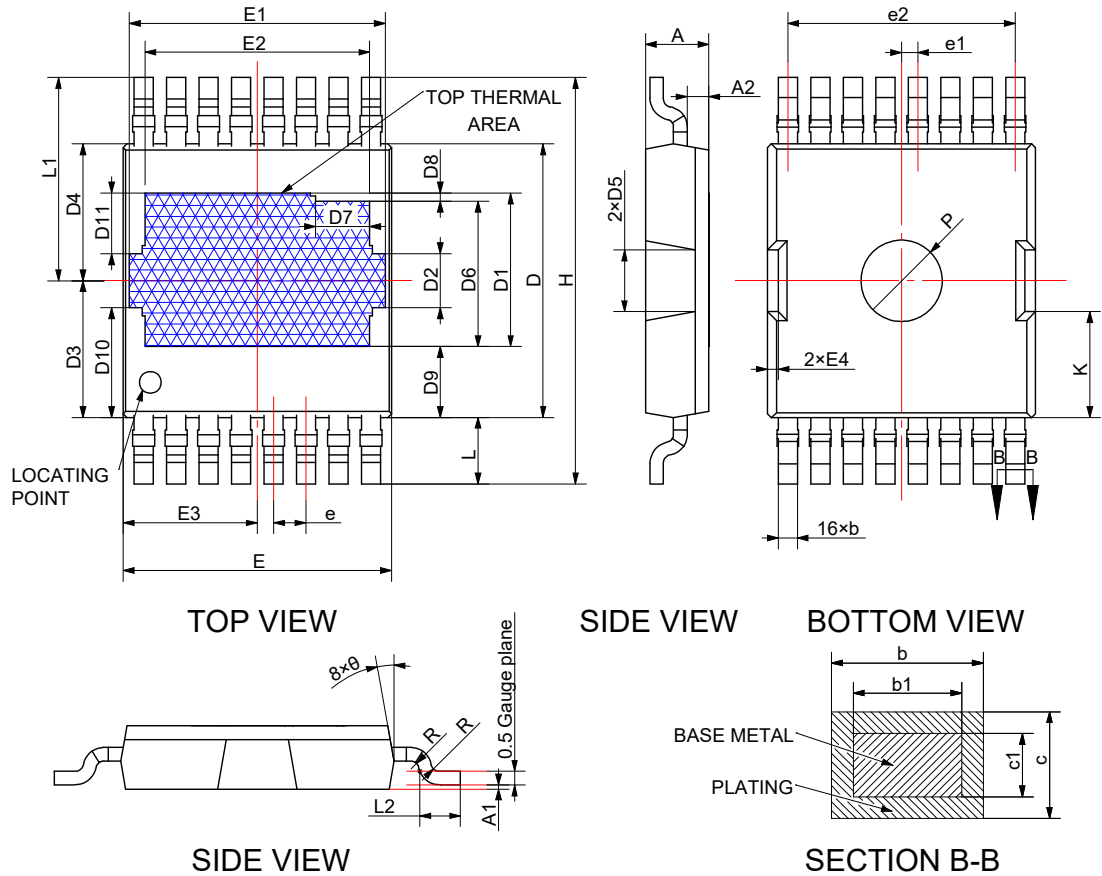
<sup>a)</sup> For bridge topologies only.  $R_G$  could be smaller in single ended topologies.

<sup>b)</sup> Examples of material selection: MPZ2012S\*\*\*AT000(TDK), BLM21PG\*\*\*SZ1D(Murata).

<sup>c)</sup>  $RC_{DCL}$  should be placed as close as possible to the drain pin. Other decoupling capacitors should be located away from the  $RC_{DCL}$ .

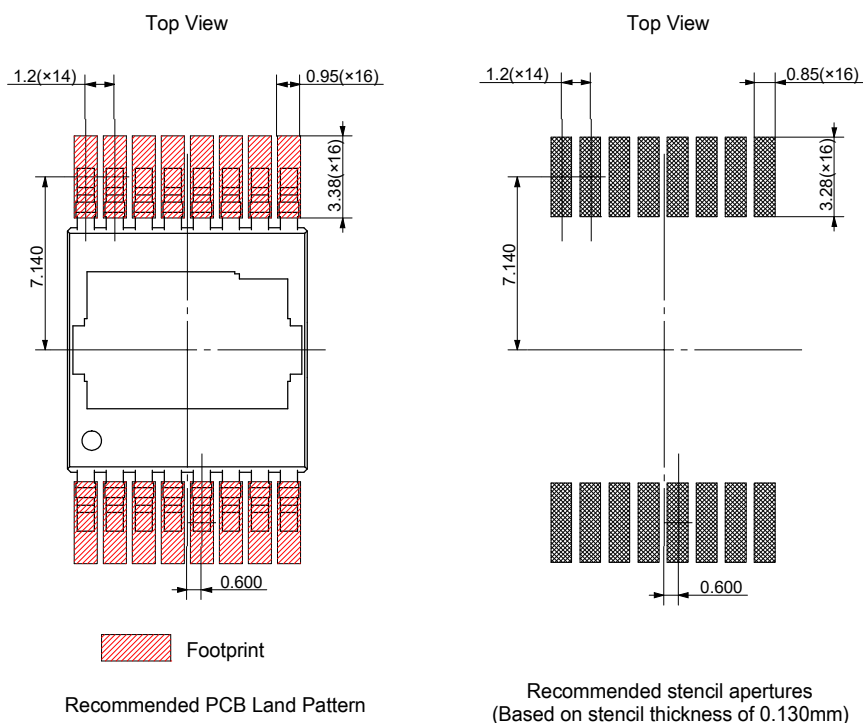
<sup>d)</sup> The typical value of  $R_{GS}$  is 10k $\Omega$ .

8. Package Dimensions



| DIM.           | Millimeters |       |       | DIM.   | Millimeters |       |       |
|----------------|-------------|-------|-------|--------|-------------|-------|-------|
|                | MIN.        | NOM.  | MAX.  |        | MIN.        | NOM.  | MAX.  |
| A              | 2.20        | 2.30  | 2.35  | D11    | 2.04        | 2.24  | 2.44  |
| A1             | 0.01        | -     | 0.11  | E      | 9.70        | 9.90  | 10.10 |
| A2             | 0.56        | 0.76  | 0.96  | E1     | 9.26        | 9.46  | 9.66  |
| b              | 0.60        | 0.75  | 0.85  | E2     | 8.10        | 8.30  | 8.50  |
| b1             | 0.60        | 0.70  | 0.80  | E3     | 4.75        | 4.95  | 5.15  |
| c              | 0.45        | 0.55  | 0.65  | E4     | 0.20        | 0.40  | 0.60  |
| c1             | 0.45        | 0.50  | 0.60  | e      | 1.20 BSC    |       |       |
| D              | 10.00       | 10.10 | 10.30 | e1     | 0.60 BSC    |       |       |
| D1             | 5.47        | 5.67  | 5.87  | e2     | 8.40 BSC    |       |       |
| D2             | 1.80        | 2.00  | 2.20  | H      | 14.80       | 15.00 | 15.20 |
| D3             | 4.85        | 5.05  | 5.25  | K      | 3.71        | 3.91  | 4.11  |
| D4             | 5.00        | 5.05  | 5.13  | L      | 2.25        | 2.45  | 2.65  |
| D5             | 2.08        | 2.28  | 2.48  | L1     | 7.30        | 7.50  | 7.70  |
| D6             | 5.17        | 5.37  | 5.57  | L2     | 1.30        | 1.50  | 1.70  |
| D7             | 1.80        | 2.00  | 2.20  | R      | 0.07        | -     | -     |
| D8             | 0.10        | 0.30  | 0.50  | P      | 2.90        | 3.00  | 3.10  |
| D9             | 2.42        | 2.62  | 2.82  | θ      | 4 °         | -     | 10 °  |
| D10            | 3.85        | 4.05  | 4.25  |        |             |       |       |
| TOLT           |             |       |       |        |             |       |       |
| GaNNext        |             |       |       |        |             |       |       |
| Date : 2023.06 |             |       |       | Rev.01 |             |       |       |

## 9. Recommended PCB Land Pattern



## 10. Part Marking

