

650V SuperGaN® GaN FET in PQFN (source tab)

Description

The TP65H480G4JSG 650V, 480mΩ Gallium Nitride (GaN) FET is a normally-off device using Transphorm's Gen IV platform. It combines a state-of-the-art high voltage GaN HEMT with a low voltage silicon MOSFET to offer superior reliability and performance.

The Gen IV SuperGaN® platform uses advanced epi and patented design technologies to simplify manufacturability while improving efficiency over silicon via lower gate charge, output capacitance, crossover loss, and reverse recovery charge.

Related Literature

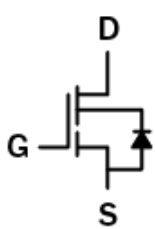
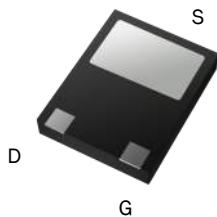
- [AN0003](#): Printed Circuit Board Layout and Probing
- [AN0007](#): Recommendations for Vapor Phase Reflow
- [AN0009](#): Recommended External Circuitry for GaN FETs
- [AN0012](#): PQFN Tape and Reel Information

Product Series and Ordering Information

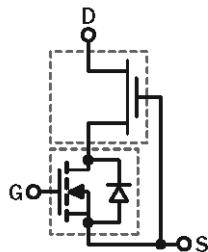
| Part Number | Package | Package Configuration |
|-------------------|----------|-----------------------|
| TP65H480G4JSG-TR* | 5x6 PQFN | Source |

* "-TR" suffix refers to tape and reel. Refer to AN0012 for details.

TP65H480G4JSG
PQFN
(top view)



Cascode Schematic Symbol



Cascode Device Structure

Features

- Gen IV technology
- JEDEC-qualified GaN technology
- Dynamic $R_{DS(on)eff}$ production tested
- Robust design, defined by
 - Wide gate safety margin
 - Transient over-voltage capability
- Very low Q_{RR}
- Reduced crossover loss
- RoHS compliant and Halogen-free packaging

Benefits

- Achieves increased efficiency in both hard- and soft-switched circuits
 - Increased power density
 - Reduced system size and weight
 - Overall lower system cost
- Easy to drive with commonly-used gate drivers
- GSD pin layout improves high speed design

Applications

- Consumer
- Power adapters
- Low power SMPS
- Lighting



Key Specifications

| | |
|------------------------|-----|
| V_{DS} (V) | 650 |
| $V_{DSS(TR)}$ (V) | 800 |
| $R_{DS(on)}$ (mΩ) max* | 560 |
| Q_{RR} (nC) typ | 14 |
| Q_G (nC) typ | 9 |

* Dynamic $R_{DS(on)}$; see Figures 18 and 19

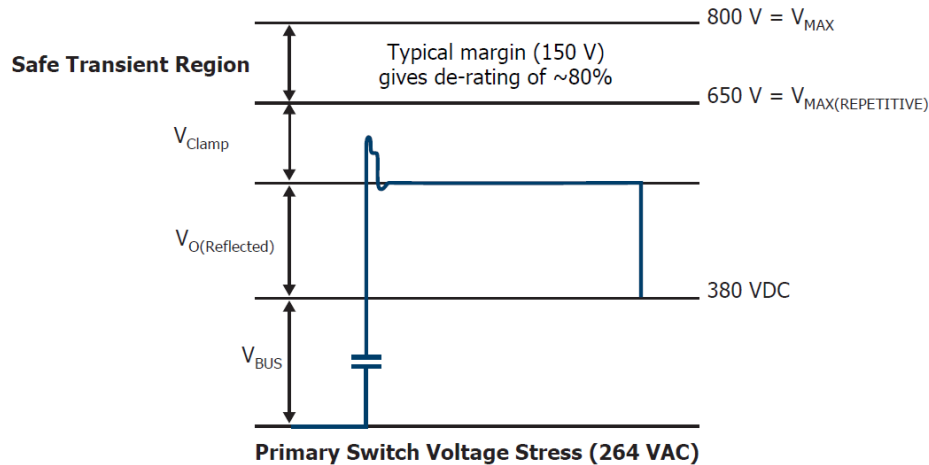
TP65H480G4JSG

Absolute Maximum Ratings ($T_C=25^\circ\text{C}$ unless otherwise stated.)

| Symbol | Parameter | Limit Value | Unit | |
|---------------|--|-----------------|------------------|------------------|
| V_{DSS} | Drain to source voltage ($T_J = -55^\circ\text{C}$ to 150°C) | 650 | V | |
| $V_{DSS(TR)}$ | Transient drain to source voltage ^a | 800 | | |
| V_{GSS} | Gate to source voltage | ± 18 | | |
| P_D | Maximum power dissipation @ $T_C=25^\circ\text{C}$ | 13.2 | W | |
| I_D | Continuous drain current @ $T_C=25^\circ\text{C}$ ^b | 3.6 | A | |
| | Continuous drain current @ $T_C=100^\circ\text{C}$ ^b | 2.3 | A | |
| I_{DM} | Pulsed drain current (pulse width: $10\mu\text{s}$) | 17 | A | |
| T_C | Operating temperature | Case | -55 to $+150$ | $^\circ\text{C}$ |
| T_J | | Junction | -55 to $+150$ | $^\circ\text{C}$ |
| T_S | Storage temperature | -55 to $+150$ | $^\circ\text{C}$ | |
| T_{SOLD} | Reflow soldering temperature ^c | 260 | $^\circ\text{C}$ | |

Notes:

- In off-state, spike duty cycle $D < 0.01$, spike duration $< 30\mu\text{s}$.
- For increased stability at high current operation, see Circuit Implementation on page 3
- Reflow MSL3



Thermal Resistance

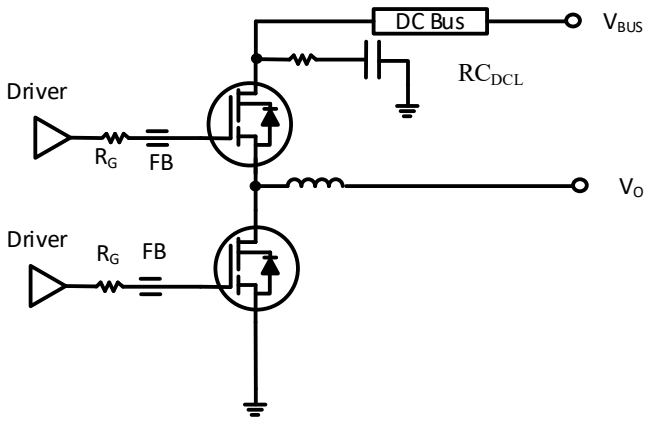
| Symbol | Parameter | Maximum | Unit |
|-----------------|----------------------------------|---------|---------------------------|
| $R_{\theta JC}$ | Junction-to-case | 9.5 | $^\circ\text{C}/\text{W}$ |
| $R_{\theta JA}$ | Junction-to-ambient ^d | 50 | $^\circ\text{C}/\text{W}$ |

Notes:

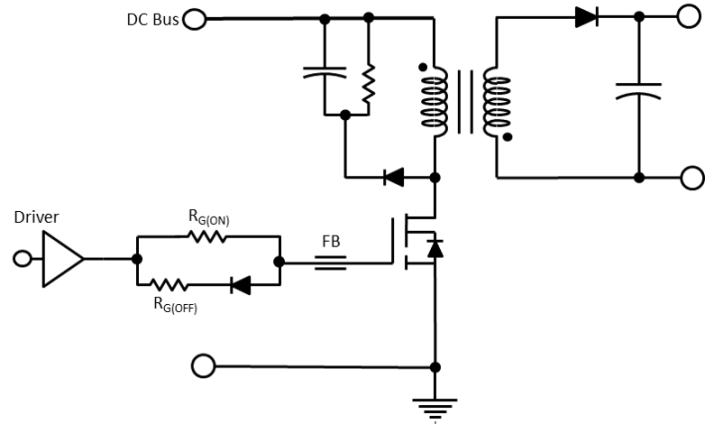
- Device on one layer epoxy PCB for drain connection (vertical and without air stream cooling, with 6cm^2 copper area and $70\mu\text{m}$ thickness)

TP65H480G4JSG

Circuit Implementation



Simplified Half-bridge Schematic



Simplified Single Ended Schematic

Recommended gate drive: (0V, 8V) with $R_{G(tot)} = 30 \Omega^a$

Recommended gate drive: (0V, 12V) with $R_{G(ON)} = 100$ to 300Ω
 $R_{G(OFF)} = 0$ to 15Ω

| Gate Ferrite Bead (FB1) | Required DC Link RC Snubber (RC_{DCL}) ^b |
|-------------------------|---|
| 240 Ω @ 100MHz | 4.7-10nF + 5 Ω |

Notes:

- For bridge topologies only. R_G could be much smaller in single ended topologies.
- RC_{DCL} should be placed as close as possible to the drain pin.

TP65H480G4JSG

Electrical Parameters (T_J=25 °C unless otherwise stated)

| Symbol | Parameter | Min | Typ | Max | Unit | Test Conditions |
|---------------------------------------|---|-----|------|------|-------|--|
| Forward Device Characteristics | | | | | | |
| V _{DSS(BL)} | Maximum drain-source voltage | 650 | — | — | V | V _{GS} =0V |
| V _{GS(th)} | Gate threshold voltage | 1.6 | 2.2 | 2.8 | V | V _{DS} =V _{GS} , I _D =0.5mA |
| ΔV _{GS(th)} /T _J | Gate threshold voltage temperature coefficient | — | -5.8 | — | mV/°C | |
| R _{DS(on)eff} | Drain-source on-resistance ^a | — | 480 | 560 | mΩ | V _{GS} =8V, I _D =3.4A |
| | | — | 1000 | — | | V _{GS} =8V, I _D =3.4A, T _J =150 °C |
| I _{DSS} | Drain-to-source leakage current | — | 1 | 10 | μA | V _{DS} =650V, V _{GS} =0V |
| | | — | 5 | — | | V _{DS} =650V, V _{GS} =0V, T _J =150 °C |
| I _{GSS} | Gate-to-source forward leakage current | — | — | 100 | nA | V _{GS} =18V |
| | Gate-to-source reverse leakage current | — | — | -100 | | V _{GS} =-18V |
| C _{ISS} | Input capacitance | — | 760 | — | pF | V _{GS} =0V, V _{DS} =400V, f=1MHz |
| C _{OSS} | Output capacitance | — | 9 | — | | |
| C _{RSS} | Reverse transfer capacitance | — | 1.5 | — | | |
| C _{O(er)} | Output capacitance, energy related ^b | — | 13 | — | pF | V _{GS} =0V, V _{DS} =0V to 400V |
| C _{O(tr)} | Output capacitance, time related ^c | — | 29 | — | | |
| Q _G | Total gate charge | — | 9 | — | nC | V _{DS} =400V, V _{GS} =0V to 8V, I _D =3.4A |
| Q _{GS} | Gate-source charge | — | 2.1 | — | | |
| Q _{GD} | Gate-drain charge | — | 2.1 | — | | |
| Q _{OSS} | Output charge | — | 13.5 | — | nC | V _{GS} =0V, V _{DS} =0V to 400V |
| t _{D(on)} | Turn-on delay | — | 16.6 | — | ns | V _{DS} =400V, V _{GS} =0V to 8V, I _D =3.4A, R _G =30Ω, Z _F B=240Ω at 100MHz (See Figure 14) |
| t _R | Rise time | — | 3.5 | — | | |
| t _{D(off)} | Turn-off delay | — | 53.2 | — | | |
| t _F | Fall time | — | 7.6 | — | | |

Notes:

- Dynamic R_{DS(on)} value; see Figures 18 and 19 for conditions
- Equivalent capacitance to give same stored energy from 0V to 400V
- Equivalent capacitance to give same charging time from 0V to 400V

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Electrical Parameters ($T_J=25^\circ\text{C}$ unless otherwise stated)

| Symbol | Parameter | Min | Typ | Max | Unit | Test Conditions |
|---------------------------------------|------------------------------|-----|------|-----|------|---|
| Reverse Device Characteristics | | | | | | |
| I_S | Reverse current | — | — | 2.3 | A | $V_{GS}=0V$, $T_C=100^\circ\text{C}$, $\leq 25\%$ duty cycle |
| V_{SD} | Reverse voltage ^a | — | 1.3 | — | V | $V_{GS}=0V$, $I_S=1.15A$ |
| | | — | 1.8 | — | | $V_{GS}=0V$, $I_S=2.3A$ |
| t_{RR} | Reverse recovery time | — | 14.5 | — | ns | $I_S=3.4A$, $V_{DD}=400V$, $di/dt=1000A/\mu s$ |
| Q_{RR} | Reverse recovery charge | — | 14 | — | nC | |

Notes:

a. Includes dynamic $R_{DS(on)}$ effect

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Typical Characteristics ($T_C=25^\circ\text{C}$ unless otherwise stated)

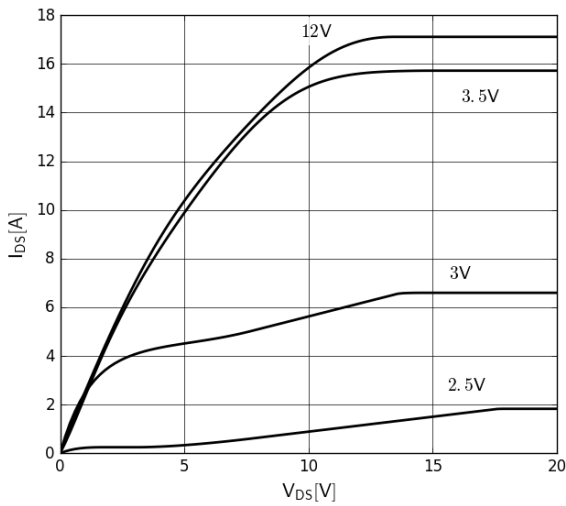


Figure 1. Typical Output Characteristics $T_J=25^\circ\text{C}$

Parameter: V_{GS}

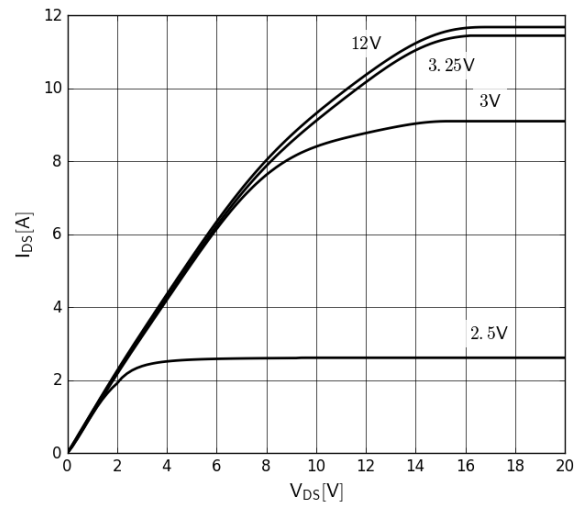


Figure 2. Typical Output Characteristics $T_J=150^\circ\text{C}$

Parameter: V_{GS}

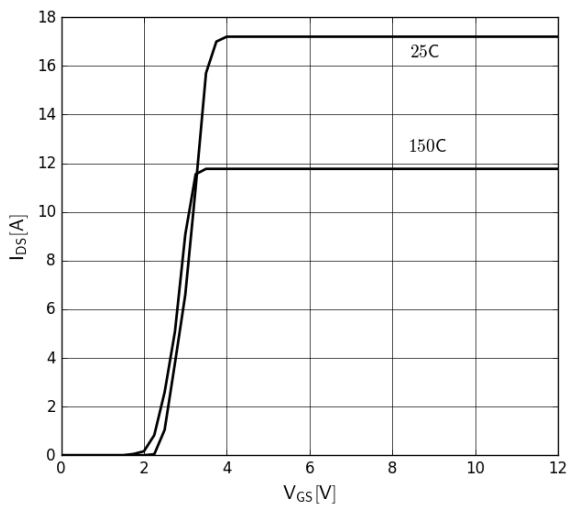


Figure 3. Typical Transfer Characteristics

$V_{DS}=20\text{V}$, parameter: T_J

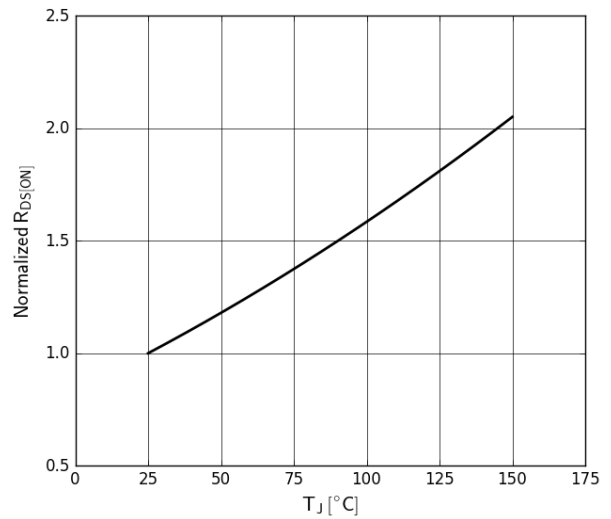


Figure 4. Normalized On-resistance

$I_D=16\text{A}$, $V_{GS}=10\text{V}$

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Typical Characteristics ($T_C=25^\circ\text{C}$ unless otherwise stated)

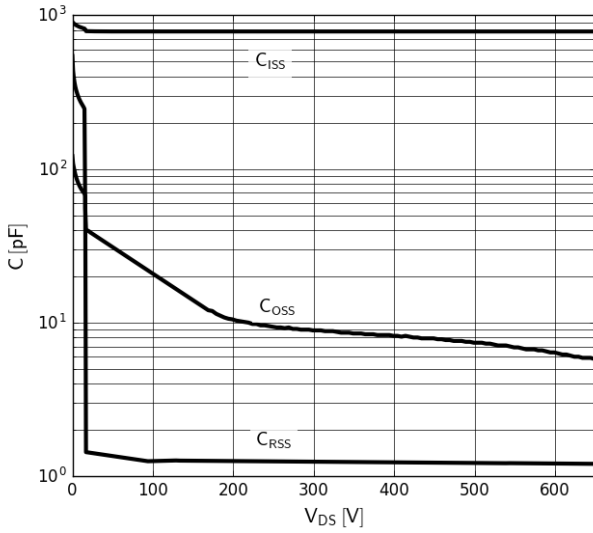


Figure 5. Typical Capacitance

$V_{GS}=0V$, $f=1MHz$

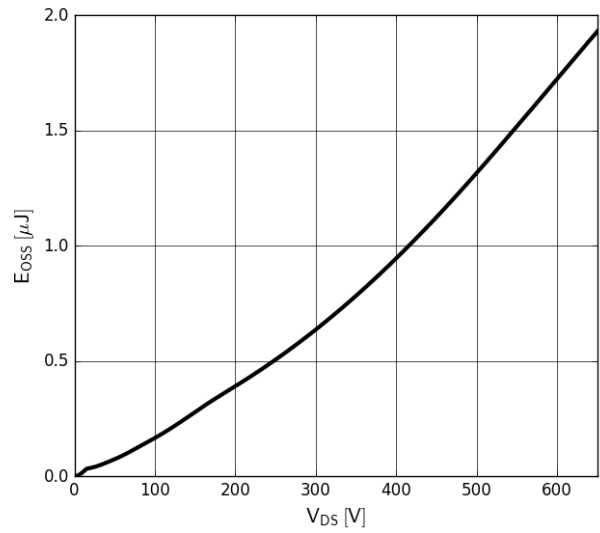


Figure 6. Typical C_{OSS} Stored Energy

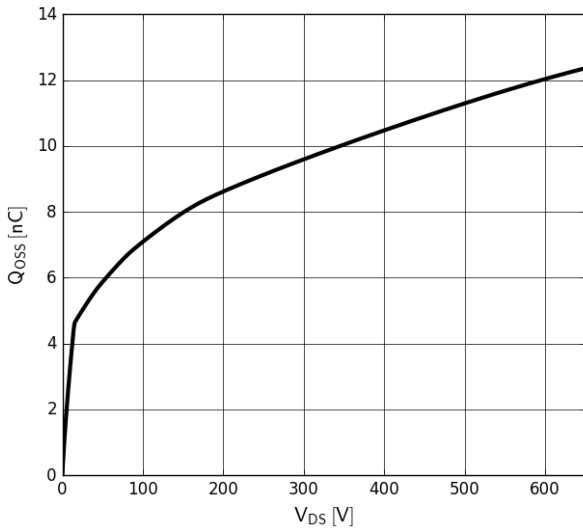


Figure 7. Typical Q_{OSS}

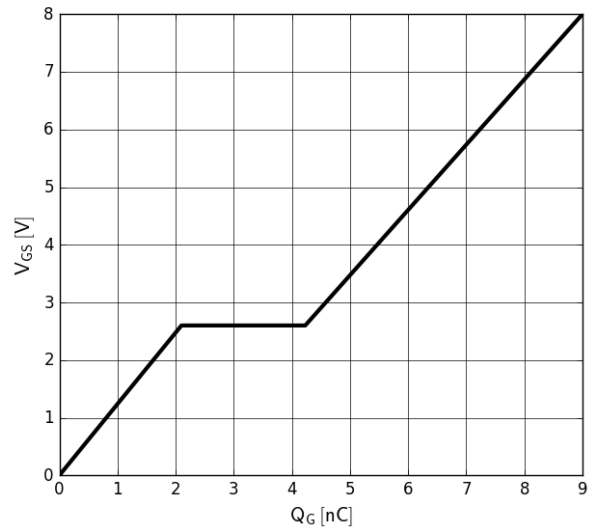


Figure 8. Typical Gate Charge

$I_{DS}=3.4A$, $V_{DS}=400V$

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Typical Characteristics ($T_C=25^\circ\text{C}$ unless otherwise stated)

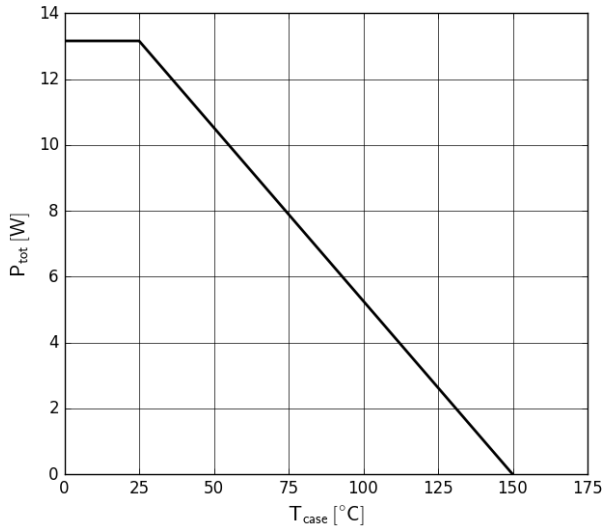


Figure 9. Power Dissipation

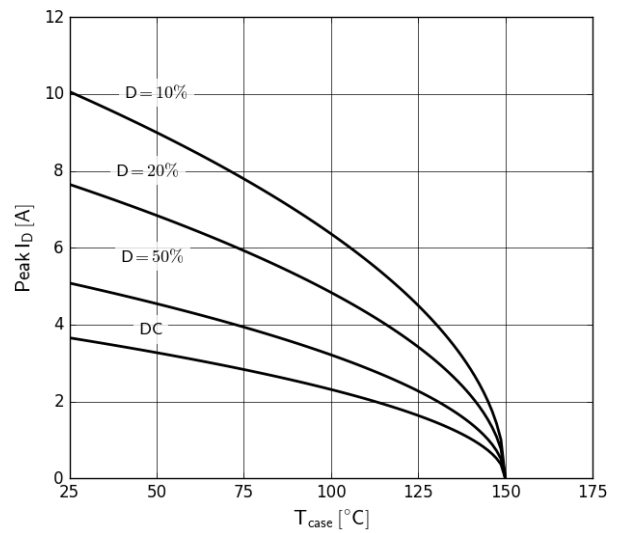


Figure 10. Current Derating
Pulse width $\leq 10\mu\text{s}$, $V_{GS} \geq 10\text{V}$

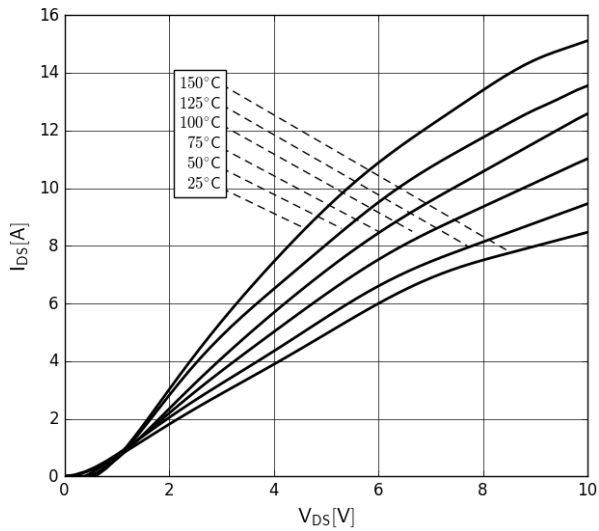


Figure 11. Forward Characteristics of Rev. Diode
 $I_S=f(V_{SD})$, parameter: T_J

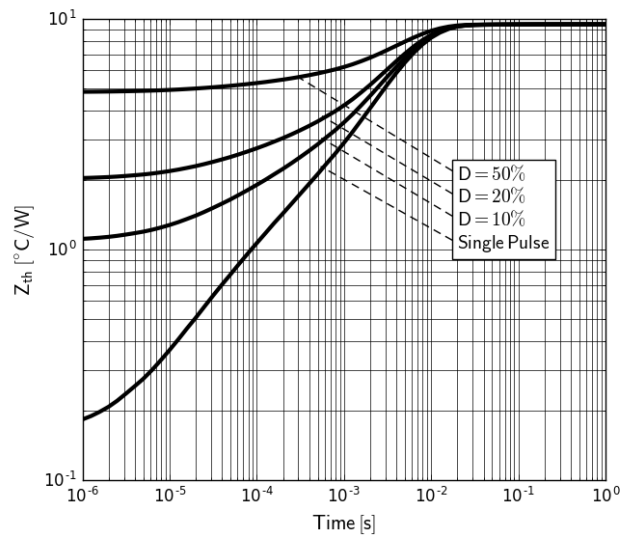


Figure 12. Transient Thermal Resistance

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Typical Characteristics ($T_c=25^\circ\text{C}$ unless otherwise stated)

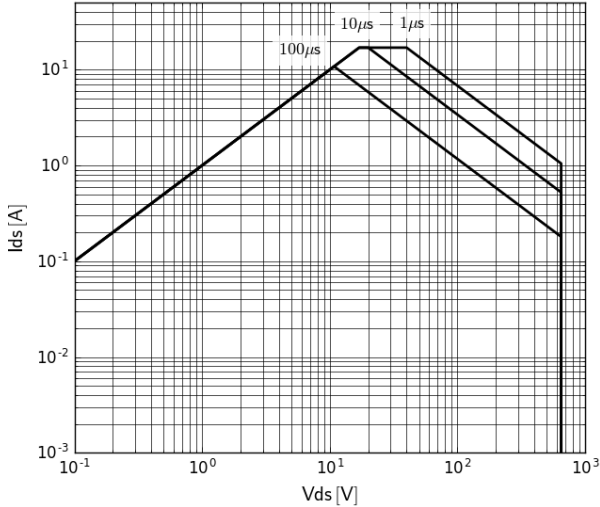


Figure 13. Safe Operating Area $T_c=25^\circ\text{C}$

Test Circuits and Waveforms

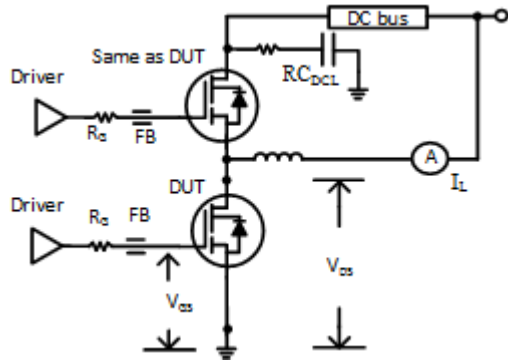


Figure 14. Switching Time Test Circuit
(see circuit implementation on page 3 for methods to ensure clean switching)

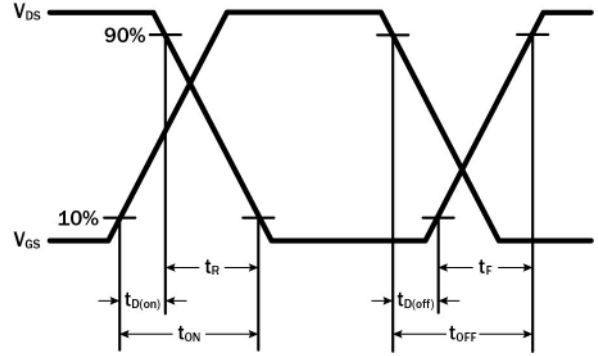


Figure 15. Switching Time Waveform

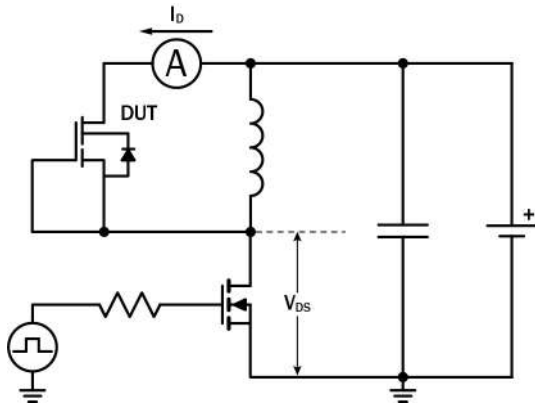


Figure 16. Diode Characteristics Test Circuit

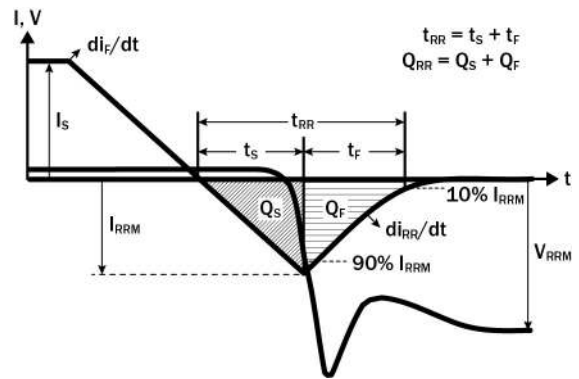


Figure 17. Diode Recovery Waveform

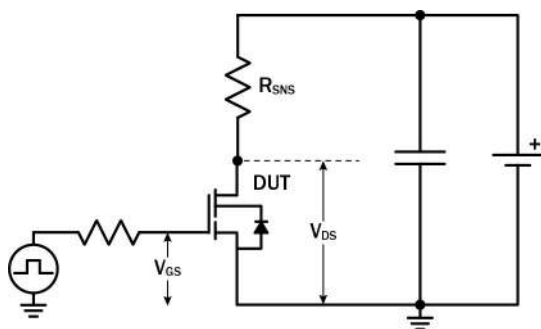


Figure 18. Dynamic $R_{DS(on)eff}$ Test Circuit

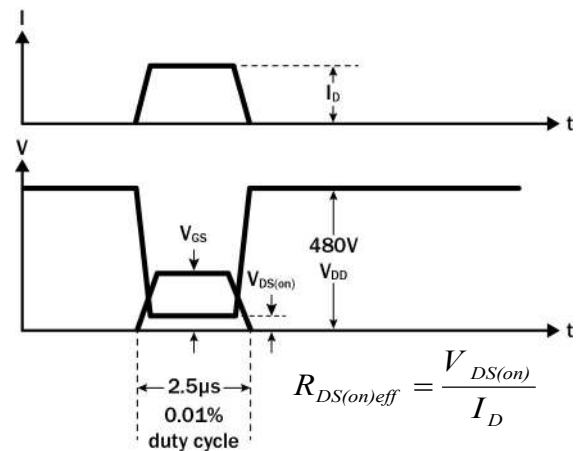


Figure 19. Dynamic $R_{DS(on)eff}$ Waveform

TP65H480G4JSG

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.

Before evaluating Transphorm GaN devices, see application note [Printed Circuit Board Layout and Probing for GaN Power Switches](#). The table below provides some practical rules that should be followed during the evaluation.

When Evaluating Transphorm GaN Devices:

| DO | DO NOT |
|---|--|
| Minimize circuit inductance by keeping traces short, both in the drive and power loop | Twist the pins of TO-220 or TO-247 to accommodate GDS board layout |
| Minimize lead length of TO-220 and TO-247 package when mounting to the PCB | Use long traces in drive circuit, long lead length of the devices |
| Use shortest sense loop for probing; attach the probe and its ground connection directly to the test points | Use differential mode probe or probe ground clip with long wire |
| See AN0003 : Printed Circuit Board Layout and Probing | |

GaN Design Resources

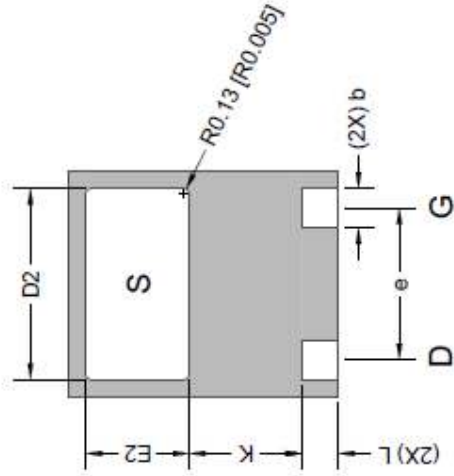
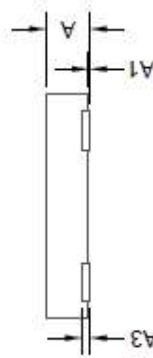
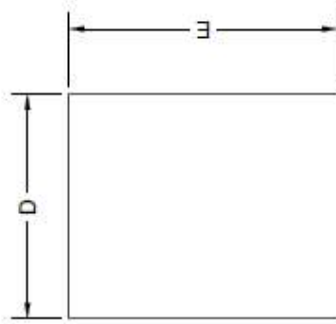
The complete technical library of GaN design tools can be found at transphormusa.com/design:

- Evaluation kits
- Application notes
- Design guides
- Simulation models
- Technical papers and presentations

TP65H480G4JSG

Mechanical

5x6 PQFN Package



G: Gate
S: Source
D: Drain
Lead finish: Sn plating

| DIM | mm | | | inch | | |
|-----|-----------|------|------|-----------|-------|-------|
| | MIN | NOM | MAX | MIN | NOM | MAX |
| A | 0.90 | 1.00 | 1.10 | 0.035 | 0.039 | 0.043 |
| A1 | 0.00 | - | 0.05 | 0.000 | - | 0.002 |
| A3 | 0.20 REF. | | | 0.007 BSC | | |
| b | 0.82 | 0.87 | 0.92 | 0.032 | 0.034 | 0.036 |
| D | 4.90 | 5.00 | 5.10 | 0.193 | 0.197 | 0.201 |
| D2 | 4.09 | 4.24 | 4.39 | 0.161 | 0.167 | 0.173 |
| E | 5.90 | 6.00 | 6.10 | 0.232 | 0.236 | 0.240 |
| e | 3.37 BSC | | | 0.133 BSC | | |
| E2 | 2.15 | 2.30 | 2.45 | 0.085 | 0.091 | 0.096 |
| K | 2.50 | - | - | 0.098 | - | - |
| L | 0.71 | 0.81 | 0.91 | 0.028 | 0.032 | 0.036 |

PQFN 5mm x 6mm POD (TP65HxxG4JSG)

transphorm

SCALE 1:1 SHEET 1/1 DRAWING NO.:200120 VER. 2

TP65H480G4JSG

Revision History

| Version | Date | Change(s) |
|---------|------------|---|
| 0 | 1/15/2020 | Preliminary Datasheet |
| 0.1 | 1/31/2020 | Preliminary Datasheet updated Qg and added AN0007 |
| 1 | 10/30/2020 | Released Datasheet |
| 2 | 1/6/2021 | Updated $V_{DSS (TR)}(V)$ |
| 3 | 2/17/2021 | Page 3: Added Single Ended simplified circuit |
| 3.1 | 3/2/2021 | Added Safe Transient Region on Page2 |