

## 900V Cascode GaN FET in TO-247

Not Recommended for New Design

## Description

The TP90H050WS 900V, 50mΩ Gallium Nitride (GaN) FET is a normally-off device. It combines state-of-the-art high voltage GaN HEMT and low voltage silicon MOSFET technologies—offering superior reliability and performance.

Transphorm GaN offers improved efficiency over silicon, through lower gate charge, lower crossover loss, and smaller reverse recovery charge.

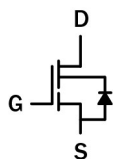
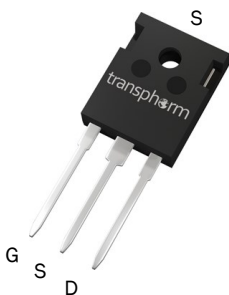
## Related Literature

- [AN0009](#): Recommended External Circuitry for GaN FETs
- [AN0003](#): Printed Circuit Board Layout and Probing
- [AN0010](#): Paralleling GaN FETs

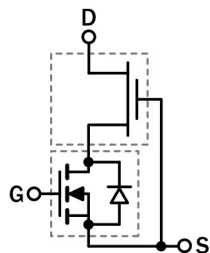
## Ordering Information

Part Number	Package	Package Configuration
TP90H050WS	3 lead TO-247	Source

TP90H050WS  
TO-247  
(top view)



Cascode Schematic Symbol



Cascode Device Structure

## Features

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

## Benefits

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

## Applications

- Datacom
- Broad industrial
- PV inverter
- Servo motor

## Key Specifications

$V_{DS}$ (V)	900
$V_{(TR)DSS}$ (V) max	1000
$R_{DS(on)eff}$ (mΩ) max*	63
$Q_{RR}$ (nC) typ	156
$Q_G$ (nC) typ	15

\* Reflects both static and dynamic on-resistance; see Figures 18 and 19

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**Absolute Maximum Ratings** ( $T_J=25^{\circ}\text{C}$  unless otherwise stated. All recommended current levels ( $I_{DM}$ ) are based on adequate heat sinking, ensuring  $T_J=150^{\circ}\text{C}$  )

Symbol	Parameter		Limit Value	Unit
$I_D$	Continuous drain current @ $T_C=25^{\circ}\text{C}$ <sup>a</sup>		34	A
	Continuous drain current @ $T_C=100^{\circ}\text{C}$ <sup>a</sup>		22	A
$I_{DM}$	Pulsed drain current (pulse width: 10 $\mu\text{s}$ )		150	A
$di/dt_{RDMC}$	Reverse diode $di/dt$ , repetitive <sup>b</sup>		1600	A/ $\mu\text{s}$
$I_{RDMC1}$	Reverse diode switching current, repetitive (dc) <sup>c</sup>		24	A
$I_{RDMC2}$	Reverse diode switching current, repetitive (ac) <sup>c</sup>		28	A
$di/dt_{RDMT}$	Reverse diode $di/dt$ , transient <sup>d</sup>		3000	A/ $\mu\text{s}$
$I_{RDMT}$	Reverse diode switching current, transient		36	A
$V_{(TR)DSS}$	Transient drain to source voltage <sup>e</sup>		1000	V
$V_{GSS}$	Gate to source voltage		$\pm 20$	V
$P_D$	Maximum power dissipation @ $T_C=25^{\circ}\text{C}$		119	W
$T_C$	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	$^{\circ}\text{C}$
$T_{SOLD}$	Soldering peak temperature <sup>f</sup>		260	$^{\circ}\text{C}$
-	Mounting Torque		80	N cm

Notes:

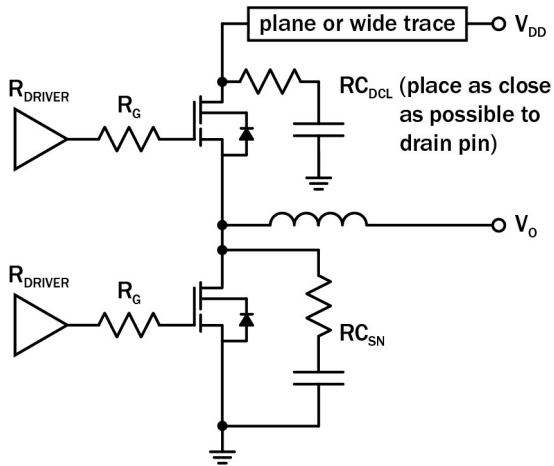
- a. For increased stability at high current operation, see Circuit Implementation on page 3
- b. Continuous switching operation
- c. Definitions: dc = dc to dc converter topologies; ac = inverter and PFC topologies, 50-60Hz line frequency
- d.  $\leq 300$  pulses in 1 second
- e. In off-state, spike duty cycle  $D < 0.01$ , spike duration  $< 1\mu\text{s}$
- f. For 10 sec., 1.6mm from the case

## Thermal Resistance

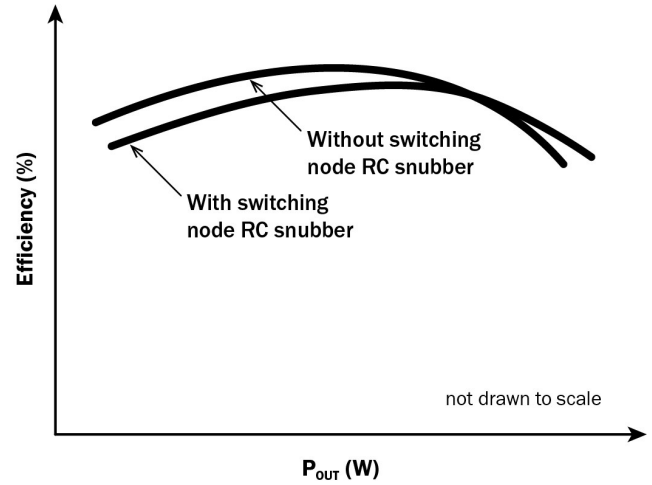
Symbol	Parameter	Typical	Unit
$R_{\theta JC}$	Junction-to-case	1.05	$^{\circ}\text{C/W}$
$R_{\theta JA}$	Junction-to-ambient	40	$^{\circ}\text{C/W}$

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## Circuit Implementation



Simplified Half-bridge Schematic



Efficiency vs Output Power

Recommended gate drive: (0V, 12-14V) with  $R_{G(tot)} = 22-30\Omega$ , where  $R_{G(tot)} = R_G + R_{DRIVER}$

Required DC Link RC Snubber ( $RC_{DCL}$ ) <sup>a</sup>	Recommended Switching Node RC Snubber ( $RC_{SN}$ ) <sup>b</sup>
$[10nF + 8\Omega] \times 2$	$100pF + 10\Omega$

Notes:

- $RC_{DCL}$  should be placed as close as possible to the drain pin
- A switching node RC snubber (C, R) is recommended for high switching currents ( $>70\%$  of  $I_{RDMC1}$  or  $I_{RDMC2}$ )

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## Electrical Parameters (T<sub>J</sub>=25 °C unless otherwise stated)

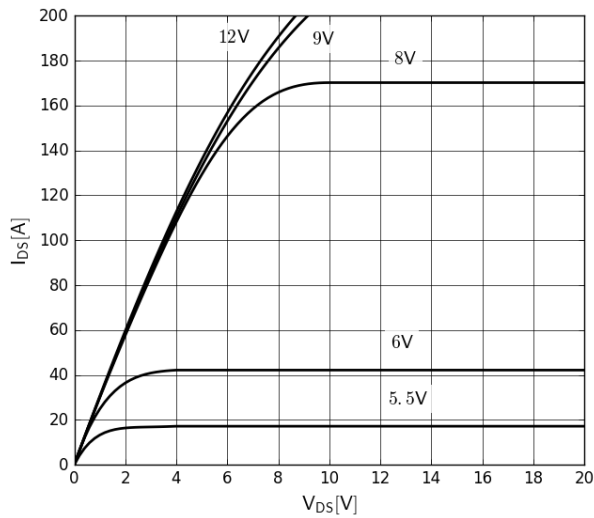
Symbol	Parameter	Min	Typ	Max	Unit	Test Conditions
Forward Device Characteristics						
V <sub>(BL)DSS</sub>	Maximum drain-source voltage	900	—	—	V	V <sub>GS</sub> =0V
V <sub>GS(th)</sub>	Gate threshold voltage	3.4	3.9	4.4	V	V <sub>DS</sub> =V <sub>GS</sub> , I <sub>D</sub> =0.7mA
ΔV <sub>GS(th)</sub> /T <sub>J</sub>	Gate threshold voltage temperature coefficient	—	-6.5	—	mV/°C	
R <sub>DS(on)eff</sub>	Drain-source on-resistance <sup>a</sup>	—	50	63	mΩ	V <sub>GS</sub> =10V, I <sub>D</sub> =22A
		—	105	—		V <sub>GS</sub> =10V, I <sub>D</sub> =22A, T <sub>J</sub> =150°C
I <sub>DSS</sub>	Drain-to-source leakage current	—	4	40	μA	V <sub>DS</sub> =900V, V <sub>GS</sub> =0V
		—	15	—		V <sub>DS</sub> =900V, V <sub>GS</sub> =0V, T <sub>J</sub> =150°C
I <sub>GSS</sub>	Gate-to-source forward leakage current	—	—	100	nA	V <sub>GS</sub> =20V
	Gate-to-source reverse leakage current	—	—	-100		V <sub>GS</sub> =-20V
C <sub>ISS</sub>	Input capacitance	—	1000	—	pF	V <sub>GS</sub> =0V, V <sub>DS</sub> =600V, f=1MHz
C <sub>OSS</sub>	Output capacitance	—	115	—		
C <sub>RSS</sub>	Reverse transfer capacitance	—	3.5	—		
C <sub>O(er)</sub>	Output capacitance, energy related <sup>b</sup>	—	153	—	pF	V <sub>GS</sub> =0V, V <sub>DS</sub> =0V to 600V
C <sub>O(tr)</sub>	Output capacitance, time related <sup>c</sup>	—	260	—		
Q <sub>G</sub>	Total gate charge	—	15	—	nC	V <sub>DS</sub> =600V, V <sub>GS</sub> =10V, I <sub>D</sub> =22A
Q <sub>GS</sub>	Gate-source charge	—	5	—		
Q <sub>GD</sub>	Gate-drain charge	—	4.7	—		
Q <sub>OSS</sub>	Output charge	—	155	—	nC	V <sub>GS</sub> =0V, V <sub>DS</sub> =0V to 600V
t <sub>D(on)</sub>	Turn-on delay	—	48	—	ns	V <sub>DS</sub> =600V, V <sub>GS</sub> =10V, I <sub>D</sub> =22A R <sub>G</sub> =25Ω, 4A driver
t <sub>R</sub>	Rise time	—	12	—		
t <sub>D(off)</sub>	Turn-off delay	—	70	—		
t <sub>F</sub>	Fall time	—	12	—		
Reverse Device Characteristics						
I <sub>S</sub>	Reverse current	—	—	22	A	V <sub>GS</sub> =0V, T <sub>C</sub> =100°C, ≤25% duty cycle
V <sub>SD</sub>	Reverse voltage <sup>a</sup>	—	2.2	2.6	V	V <sub>GS</sub> =0V, I <sub>S</sub> =22A
		—	1.6	1.9		V <sub>GS</sub> =0V, I <sub>S</sub> =11A
t <sub>RR</sub>	Reverse recovery time	—	53	—	ns	I <sub>S</sub> =22A, V <sub>DD</sub> =600V, di/dt=1000A/μs
Q <sub>RR</sub>	Reverse recovery charge	—	156	—	nC	

Notes:

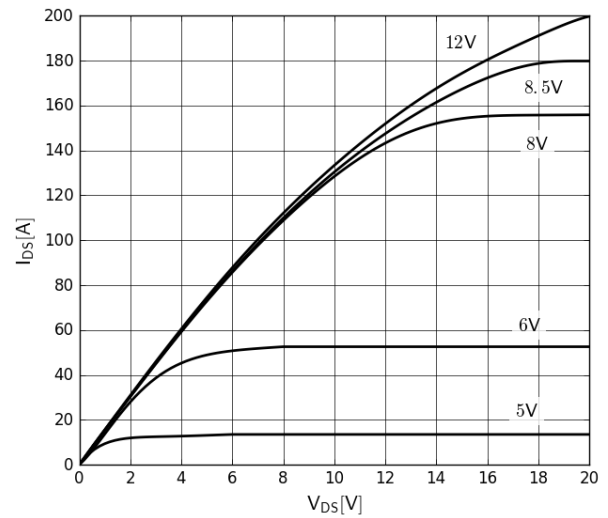
- Reflects both static and dynamic on-resistance; dynamic on-resistance test setup and waveform; see Figures 18 and 19 for conditions
- Equivalent capacitance to give same stored energy from 0V to 600V
- Equivalent capacitance to give same charging time from 0V to 600V

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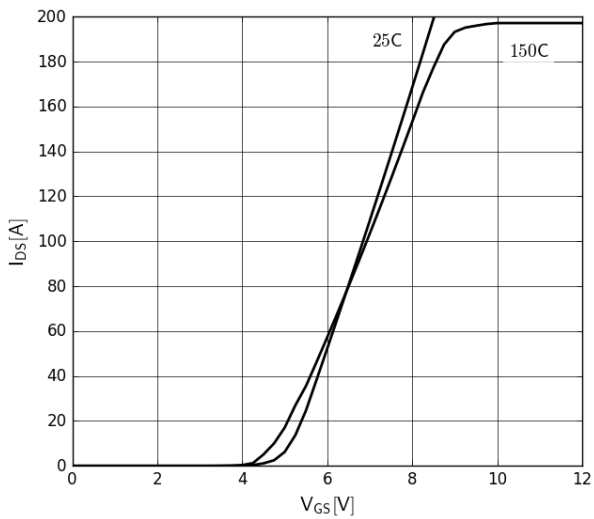
**Typical Characteristics** ( $T_C=25^\circ\text{C}$  unless otherwise stated)



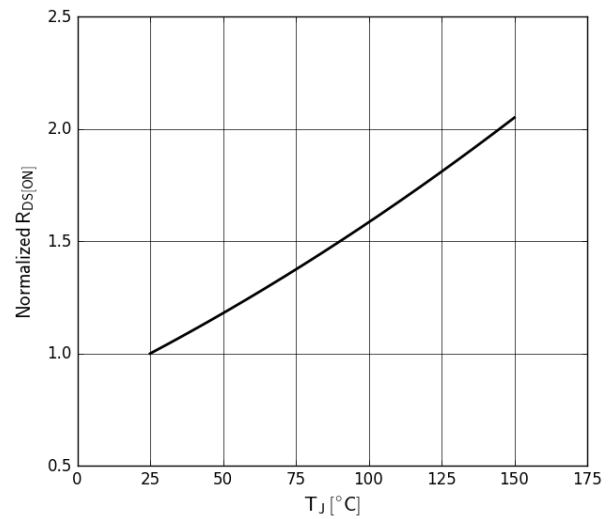
**Figure 1. Typical Output Characteristics  $T_J=25^\circ\text{C}$**   
Parameter:  $V_{GS}$



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



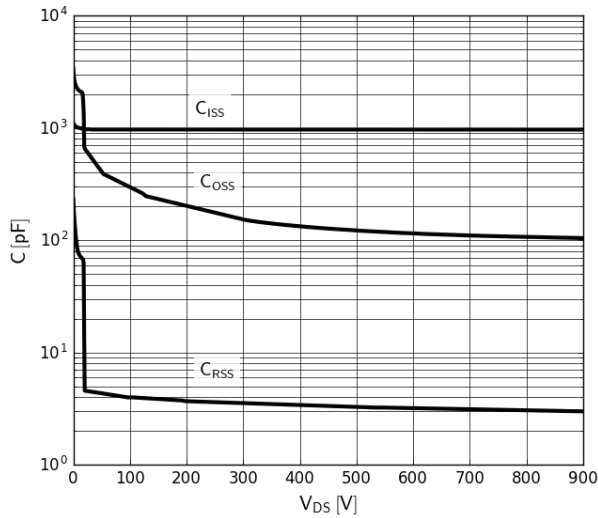
**Figure 3. Typical Transfer Characteristics**  
 $V_{DS}=20\text{V}$ , parameter:  $T_J$



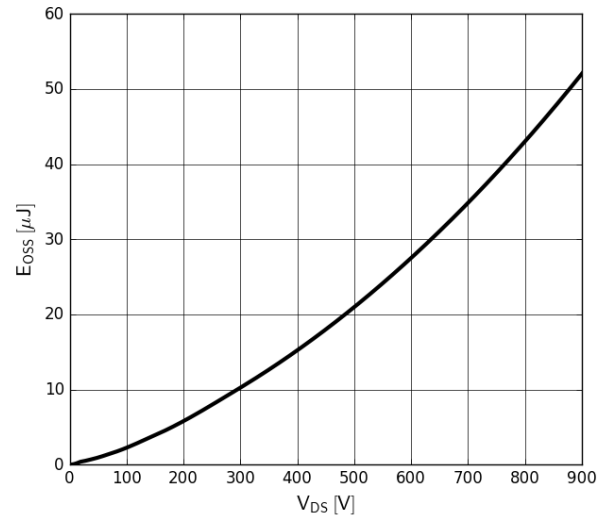
**Figure 4. Normalized On-resistance**  
 $I_D=22\text{A}$ ,  $V_{GS}=8\text{V}$

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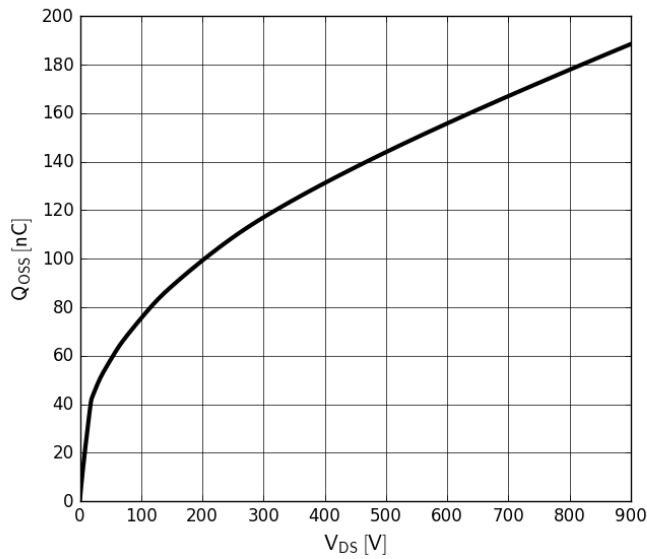
**Typical Characteristics** ( $T_C=25^\circ\text{C}$  unless otherwise stated)



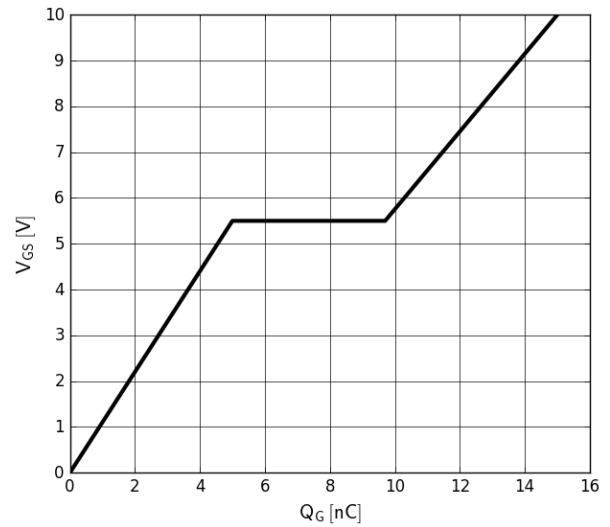
**Figure 5. Typical Capacitance**  
 $V_{GS}=0V$ ,  $f=1\text{MHz}$



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



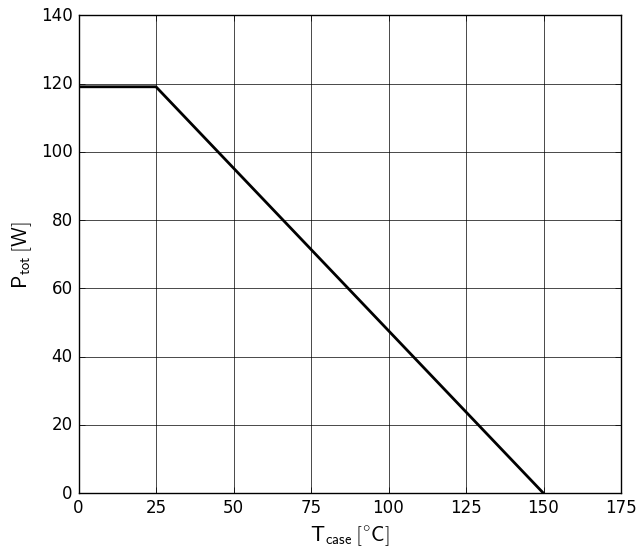
**Figure 7. Typical  $Q_{OSS}$**



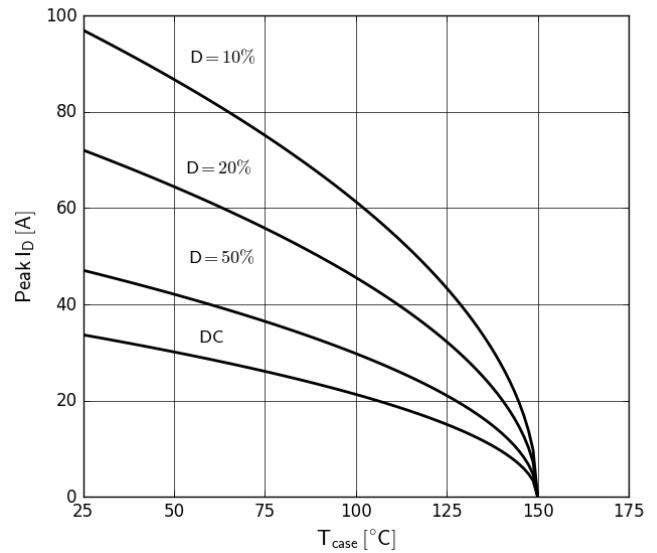
**Figure 8. Typical Gate Charge**  
 $I_{DS}=22A$ ,  $V_{DS}=600V$

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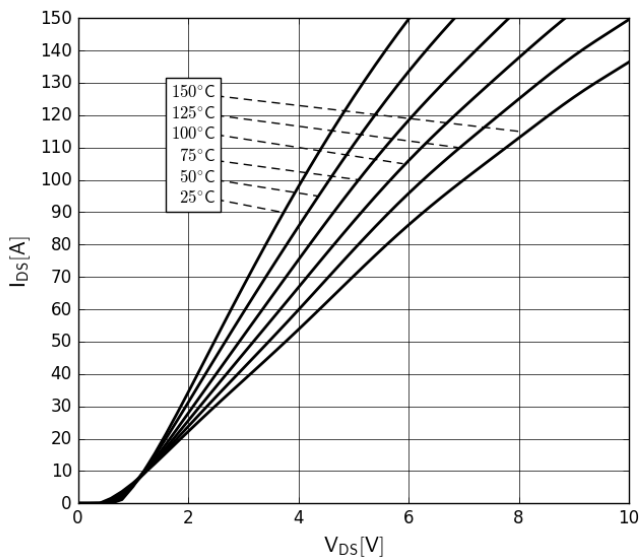
## Typical Characteristics ( $T_C=25^\circ\text{C}$ unless otherwise stated)



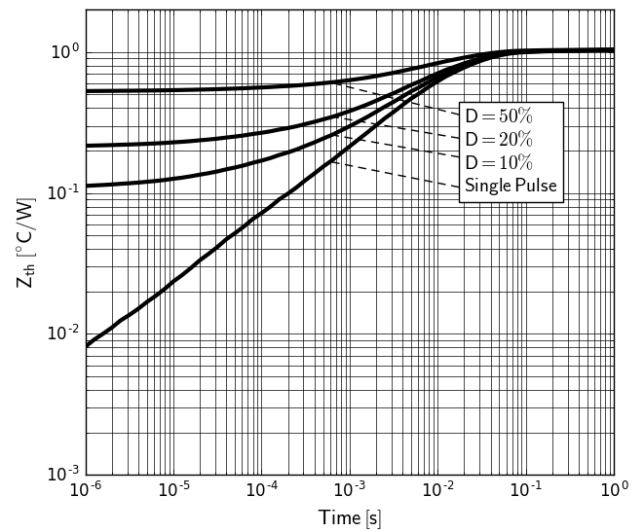
**Figure 9. Power Dissipation**



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



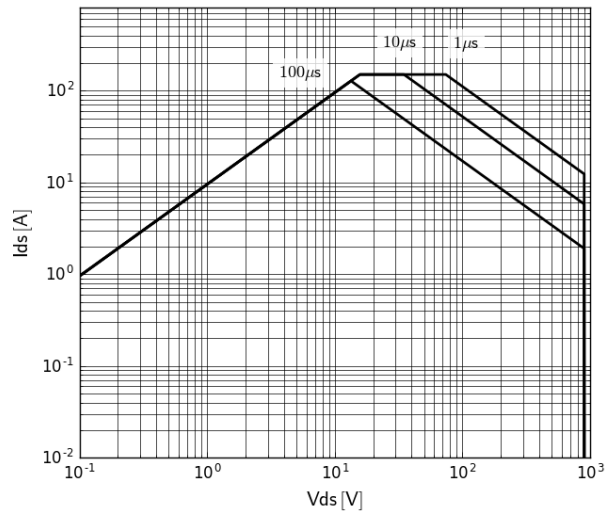
**Figure 11. Forward Characteristics of Rev. Diode**  
 $I_S=f(V_{SD})$ , parameter:  $T_J$



**Figure 12. Transient Thermal Resistance**

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

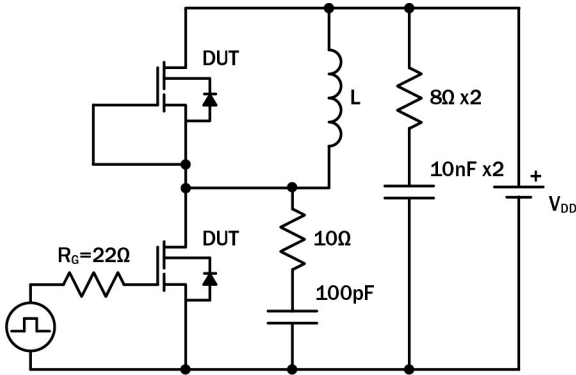


**Figure 13. Safe Operating Area  $T_c=25^\circ\text{C}$**

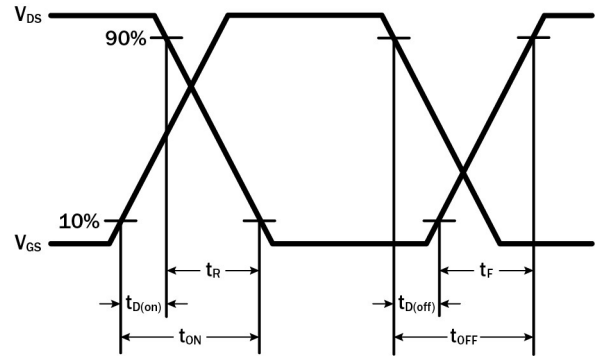


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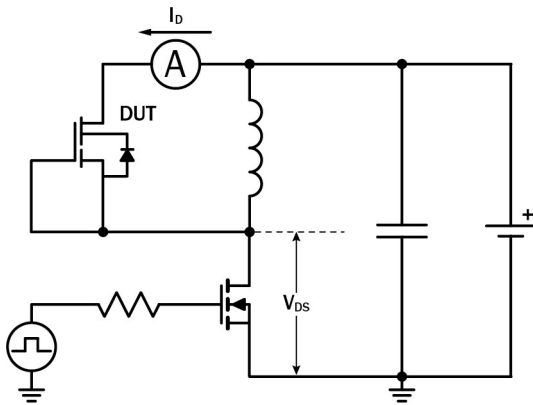
## Test Circuits and Waveforms



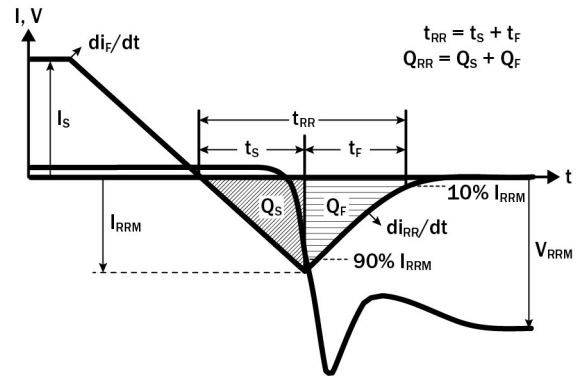
**Figure 14. Switching Time Test Circuit**  
(see Circuit Implementation on page 3  
for methods to ensure clean switching)



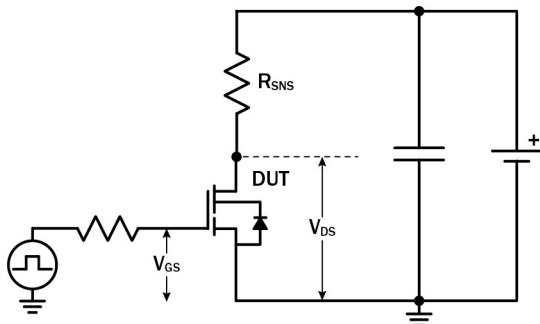
**Figure 15. Switching Time Waveform**



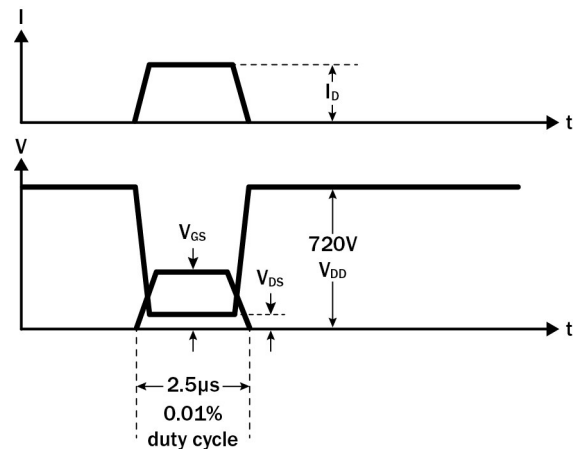
**Figure 16. Diode Characteristics Test Circuit**



**Figure 17. Diode Recovery Waveform**



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



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

# TP90H050WS

## 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 <a href="#">AN0003</a> : Printed Circuit Board Layout and Probing	

## GaN Design Resources

The complete technical library of GaN design tools can be found at [transphormusa.com/design](https://transphormusa.com/design):

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

# TP90H050WS

## Mechanical

## 3 Lead TO-247 Package

