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ON Semiconductor®

# NDS9948

## Dual 60V P-Channel PowerTrench® MOSFET

### General Description

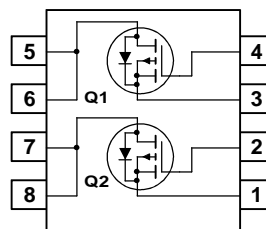
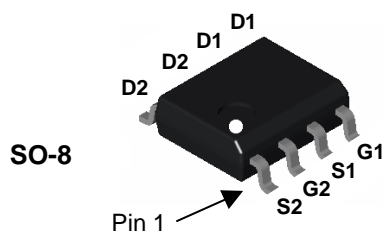
This P-Channel MOSFET is a rugged gate version of ON Semiconductor's advanced PowerTrench process. It has been optimized for power management applications requiring a wide range of gate drive voltage ratings (4.5V – 20V).

### Applications

- Power management
- Load switch
- Battery protection

### Features

- –2.3 A, –60 V  $R_{DS(ON)} = 250 \text{ m}\Omega @ V_{GS} = -10 \text{ V}$   
 $R_{DS(ON)} = 500 \text{ m}\Omega @ V_{GS} = -4.5 \text{ V}$
- Low gate charge (9nC typical)
- Fast switching speed
- High performance trench technology for extremely low  $R_{DS(ON)}$
- High power and current handling capability



### Absolute Maximum Ratings $T_A=25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Ratings	Units
$V_{DSS}$	Drain-Source Voltage	–60	V
$V_{GSS}$	Gate-Source Voltage	$\pm 20$	V
$I_D$	Drain Current – Continuous (Note 1a)	–2.3	A
	– Pulsed	–10	
$P_D$	Power Dissipation for Dual Operation	2	W
	Power Dissipation for Single Operation (Note 1a)	1.6	
	(Note 1b)	1.0	
	(Note 1c)	0.9	
$T_J, T_{STG}$	Operating and Storage Junction Temperature Range	–55 to +175	$^\circ\text{C}$

### Thermal Characteristics

$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (Note 1a)	78	$^\circ\text{C}/\text{W}$
		135	$^\circ\text{C}/\text{W}$
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case (Note 1)	40	$^\circ\text{C}/\text{W}$

### Package Marking and Ordering Information

Device Marking	Device	Reel Size	Tape width	Quantity
NDS9948	NDS9948	13"	12mm	2500 units

### Electrical Characteristics

$T_A = 25^\circ\text{C}$  unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
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#### Drain-Source Avalanche Ratings (Note 2)

$W_{DSS}$	Drain-Source Avalanche Energy	Single Pulse, $V_{DD} = -54\text{ V}$			15	mJ
$I_{AR}$	Drain-Source Avalanche Current				-10	A

#### Off Characteristics

$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{GS} = 0\text{ V}, I_D = -250\ \mu\text{A}$	-60			V
$\frac{\Delta BV_{DSS}}{\Delta T_J}$	Breakdown Voltage Temperature Coefficient	$I_D = -250\ \mu\text{A}$ , Referenced to $25^\circ\text{C}$		-52		mV/ $^\circ\text{C}$
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = -40\text{ V}, V_{GS} = 0\text{ V}$ $V_{DS} = -40\text{ V}, V_{GS} = 0\text{ V}, T_J = -55^\circ\text{C}$			-2 -25	$\mu\text{A}$
$I_{GSSF}$	Gate-Body Leakage, Forward	$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$			100	nA
$I_{GSSR}$	Gate-Body Leakage, Reverse	$V_{GS} = -20\text{ V}, V_{DS} = 0\text{ V}$			-100	nA

#### On Characteristics (Note 2)

$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = -250\ \mu\text{A}$	-1	-1.5	-3	V
$\frac{\Delta V_{GS(th)}}{\Delta T_J}$	Gate Threshold Voltage Temperature Coefficient	$I_D = -250\ \mu\text{A}$ , Referenced to $25^\circ\text{C}$		4		mV/ $^\circ\text{C}$
$R_{DS(on)}$	Static Drain-Source On-Resistance	$V_{GS} = -10\text{ V}, I_D = -2.3\text{ A}$ $V_{GS} = -4.5\text{ V}, I_D = -1.6\text{ A}$ $V_{GS} = -10\text{ V}, I_D = -2.3\text{ A}, T_J = 125^\circ\text{C}$		138 175 225	250 500 433	m $\Omega$
$I_{D(on)}$	On-State Drain Current	$V_{GS} = -10\text{ V}, V_{DS} = -5\text{ V}$	-10			A
$g_{FS}$	Forward Transconductance	$V_{DS} = -10\text{ V}, I_D = -2.3\text{ A}$		5		S

#### Dynamic Characteristics

$C_{iss}$	Input Capacitance	$V_{DS} = -30\text{ V}, V_{GS} = 0\text{ V},$ $f = 1.0\text{ MHz}$		394		pF
$C_{oss}$	Output Capacitance			53		pF
$C_{rss}$	Reverse Transfer Capacitance			23		pF

#### Switching Characteristics (Note 2)

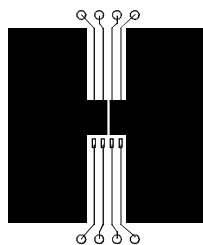
$t_{d(on)}$	Turn-On Delay Time	$V_{DD} = -30\text{ V}, I_D = -1\text{ A},$ $V_{GS} = -10\text{ V}, R_{GEN} = 6\ \Omega$		6	12	ns
$t_r$	Turn-On Rise Time			9	18	ns
$t_{d(off)}$	Turn-Off Delay Time			16	29	ns
$t_f$	Turn-Off Fall Time			3	6	ns
$Q_g$	Total Gate Charge	$V_{DS} = -30\text{ V}, I_D = -2.3\text{ A},$ $V_{GS} = -10\text{ V}$		9	13	nC
$Q_{gs}$	Gate-Source Charge			1.4		nC
$Q_{gd}$	Gate-Drain Charge			1.7		nC

**Electrical Characteristics (cont.)**  $T_A = 25^\circ\text{C}$  unless otherwise noted

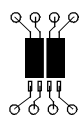
Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
<b>Drain–Source Diode Characteristics and Maximum Ratings</b>						
$I_S$	Maximum Continuous Drain–Source Diode Forward Current				-1.7	A
$V_{SD}$	Drain–Source Diode Forward Voltage	$V_{GS} = 0\text{ V}$ , $I_S = -1.7\text{ A}$ (Note 2)		-0.8	-1.2	V
$t_{rr}$	Reverse Recovery Time	$V_{GS} = 0\text{ V}$ , $I_F = -2.3\text{ A}$ , $di_F/dt = 100\text{ A}/\mu\text{s}$		25		nS

**Notes:**

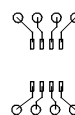
1.  $R_{\theta JA}$  is the sum of the junction-to-case and case-to-ambient thermal resistance where the case thermal reference is defined as the solder mounting surface of the drain pins.  $R_{\theta JC}$  is guaranteed by design while  $R_{\theta CA}$  is determined by the user's board design.



a) 78°C/W when mounted on a 0.5in<sup>2</sup> pad of 2 oz copper



b) 125°C/W when mounted on a 0.02 in<sup>2</sup> pad of 2 oz copper



c) 135°C/W when mounted on a minimum pad.

Scale 1 : 1 on letter size paper

2. Pulse Test: Pulse Width < 300μs, Duty Cycle < 2.0%

## Typical Characteristics

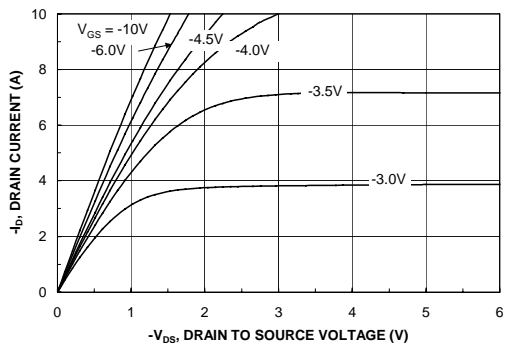


Figure 1. On-Region Characteristics.

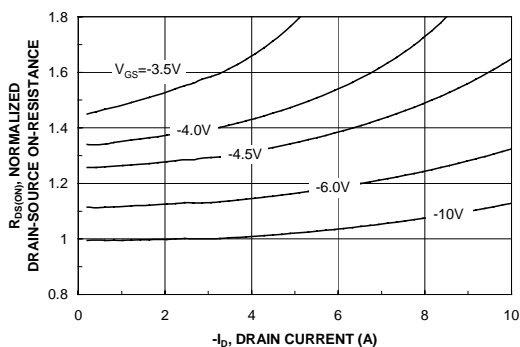


Figure 2. On-Resistance Variation with Drain Current and Gate Voltage.

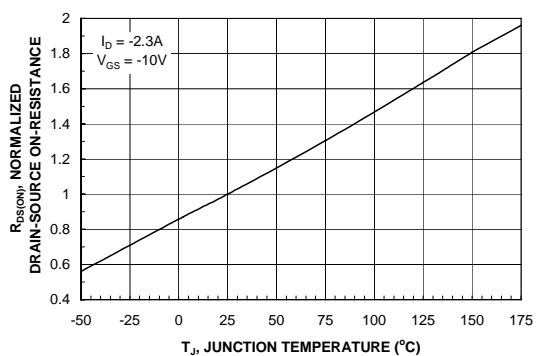


Figure 3. On-Resistance Variation with Temperature.

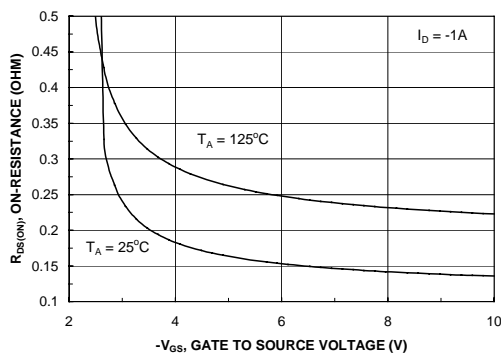


Figure 4. On-Resistance Variation with Gate-to-Source Voltage.

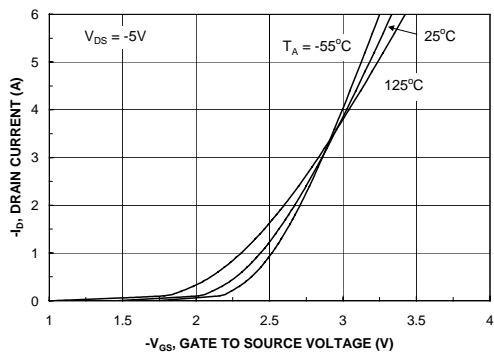


Figure 5. Transfer Characteristics.

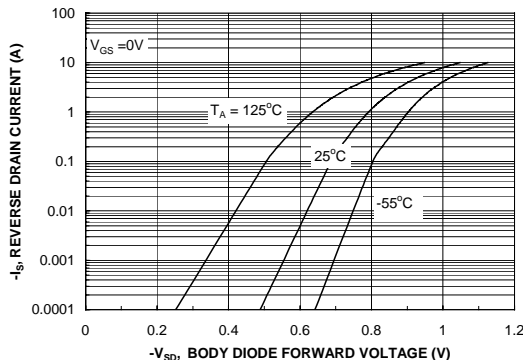


Figure 6. Body Diode Forward Voltage Variation with Source Current and Temperature.

### Typical Characteristics

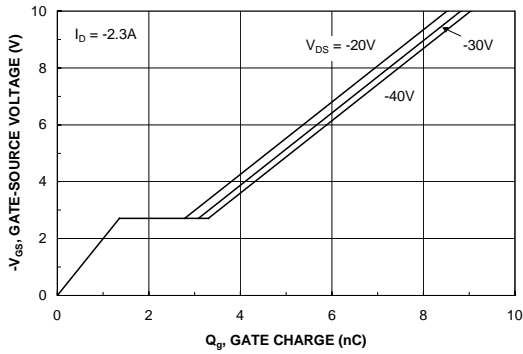


Figure 7. Gate Charge Characteristics.

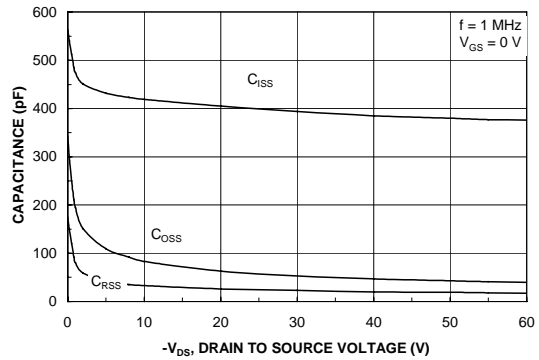


Figure 8. Capacitance Characteristics.

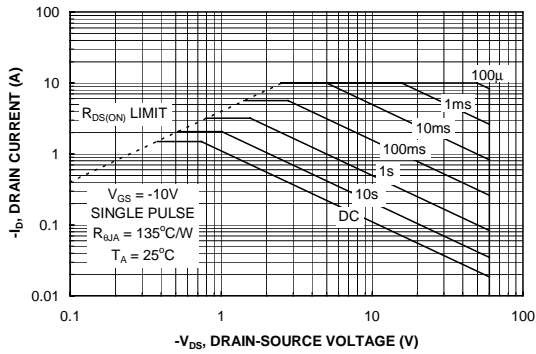


Figure 9. Maximum Safe Operating Area.

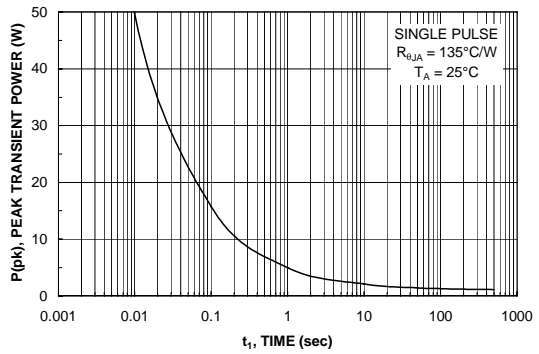


Figure 10. Single Pulse Maximum Power Dissipation.

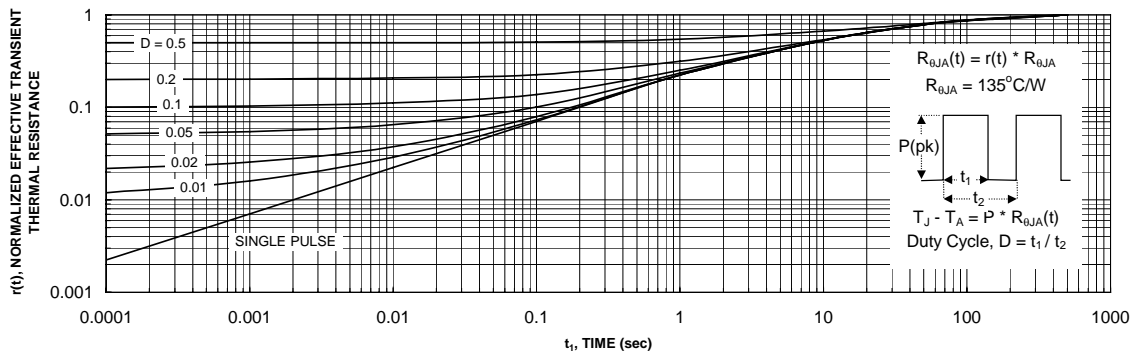



Figure 11. Transient Thermal Response Curve.

Thermal characterization performed using the conditions described in Note 1c.  
Transient thermal response will change depending on the circuit board design.

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