

# MOSFET - Power, Single N-Channel

**60 V, 9 mΩ, 38 A**

## NTTFD9D0N06HL

### General Description

This device includes two specialized N-Channel MOSFETs in a dual package. The switch node has been internally connected to enable easy placement and routing of synchronous buck converters. The control MOSFET (Q2) and synchronous (Q1) have been designed to provide optimal power efficiency.

### Features

Q1: N-Channel

- Max  $r_{DS(on)}$  = 9.0 mΩ at  $V_{GS}$  = 10 V,  $I_D$  = 10 A
- Max  $r_{DS(on)}$  = 13 mΩ at  $V_{GS}$  = 4.5,  $I_D$  = 8.0 A

Q2: N-Channel

- Max  $r_{DS(on)}$  = 9.0 mΩ at  $V_{GS}$  = 10 V,  $I_D$  = 10 A
- Max  $r_{DS(on)}$  = 13 mΩ at  $V_{GS}$  = 4.5,  $I_D$  = 8.0 A
- Low Inductance Packaging Shortens Rise/Fall Times, Resulting in Lower Switching Losses
- RoHS Compliant

### Typical Applications

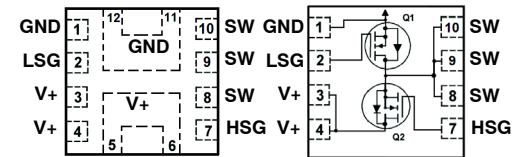
- Computing
- Communications
- General Purpose Point of Load

### PIN DESCRIPTION

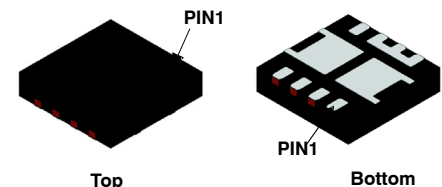
Pin	Name	Description
1, 11, 12	GND (LSS)	Low Side Source
2	LSG	Low Side Gate
3, 4, 5, 6	V + (HSD)	High Side Drain
7	HSG	High Side Gate
8, 9, 10	SW	Switching Node, Low Side Drain

$V_{(BR)DSS}$	$R_{DS(on)}$ MAX	$I_D$ MAX
60 V	9 mΩ @ 10 V	38 A
	13 mΩ @ 4.5 V	

### ELECTRICAL CONNECTION

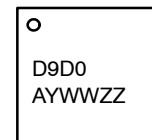


Dual N-Channel MOSFET



WQFN12, 3x3  
CASE 510CJ

### MARKING DIAGRAM



D9D0 = Specific Device Code  
A = Assembly Plant Code  
Y = Numeric Year Code  
WW = Work Week Code  
ZZ = Assembly Lot Code

### ORDERING INFORMATION

Device	Package	Shipping†
NTTFD9D0N06HLTWG	WQFN12 (Pb-Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# NTTFD9D0N06HL

## MOSFET MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ , Unless otherwise specified)

Symbol	Parameter	Q1	Q2	Units
$V_{DS}$	Drain-to-Source Voltage	60	60	V
$V_{GS}$	Gate-to-Source Voltage	$\pm 20$	$\pm 20$	V
$I_D$	Drain Current –Continuous $T_C = 25^\circ\text{C}$ (Note 4)	38	38	A
	–Continuous $T_C = 100^\circ\text{C}$ (Note 4)	23	23	
	–Continuous $T_A = 25^\circ\text{C}$	9 (Note 1a)	9 (Note 1b)	
	–Pulsed $T_A = 25^\circ\text{C}$	349	349	
$E_{AS}$	Single Pulse Avalanche Energy (Note 3)	46	46	mJ
$P_D$	Power Dissipation for Single Operation $T_C = 25^\circ\text{C}$	26	26	W
	Power Dissipation for Single Operation $T_A = 25^\circ\text{C}$	1.7 (Note 1a)	1.7 (Note 1b)	
$T_J, T_{STG}$	Operating and Storage Junction Temperature Range	$-55$ to $+150$		$^\circ\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

## THERMAL CHARACTERISTICS

Symbol	Parameter	Q1	Q2	Units
$R_{\theta JC}$	Thermal Resistance, Junction-to-Case	4.8	4.8	$^\circ\text{C/W}$
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (Note 1a), max copper	70 (Note 1a)	70 (Note 1b)	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (Note 1c), min copper	135 (Note 1a)	135 (Note 1b)	

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Symbol	Parameter	Test Conditions	Type	Min	Typ	Max	Units
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### OFF CHARACTERISTICS

$BV_{DSS}$	Drain-to-Source Breakdown Voltage	$I_D = 250\ \mu\text{A}, V_{GS} = 0\ \text{V}$	Q1	60			V
		$I_D = 250\ \mu\text{A}, V_{GS} = 0\ \text{V}$	Q2	60			
$\frac{\Delta BV_{DSS}}{\Delta T_J}$	Breakdown Voltage Temperature Coefficient	$I_D = 250\ \mu\text{A}$ , referenced to $25^\circ\text{C}$	Q1		37.38		$\text{mV}/^\circ\text{C}$
		$I_D = 250\ \mu\text{A}$ , referenced to $25^\circ\text{C}$	Q2		37.38		
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 60\ \text{V}, V_{GS} = 0\ \text{V}$	Q1			10	$\mu\text{A}$
		$V_{DS} = 60\ \text{V}, V_{GS} = 0\ \text{V}$	Q2			10	
$I_{GSS}$	Gate-to-Source Leakage Current, Forward	$V_{GS} = +20/-16\ \text{V}, V_{DS} = 0\ \text{V}$	Q1			$\pm 100$	nA
		$V_{GS} = +20/-16\ \text{V}, V_{DS} = 0\ \text{V}$	Q2			$\pm 100$	

### ON CHARACTERISTICS

$V_{GS(th)}$	Gate-to-Source Threshold Voltage	$V_{GS} = V_{DS}, I_D = 50\ \mu\text{A}$	Q1	1.2	1.6	2.0	V
		$V_{GS} = V_{DS}, I_D = 50\ \mu\text{A}$	Q2	1.2	1.6	2.0	
$\frac{\Delta V_{GS(th)}}{\Delta T_J}$	Gate-to-Source Threshold Voltage Temperature Coefficient	$I_D = 50\ \mu\text{A}$ , referenced to $25^\circ\text{C}$	Q1		-6.19		$\text{mV}/^\circ\text{C}$
		$I_D = 50\ \mu\text{A}$ , referenced to $25^\circ\text{C}$	Q2		-6.19		
$r_{DS(on)}$	Drain-to-Source On Resistance	$V_{GS} = 10\ \text{V}, I_D = 10\ \text{A}$	Q1		7.3	9.0	$\text{m}\Omega$
		$V_{GS} = 4.5\ \text{V}, I_D = 8\ \text{A}$			9.8	13	
		$V_{GS} = 10\ \text{V}, I_D = 10\ \text{A}, T_J = 125^\circ\text{C}$			12.7		
$r_{DS(on)}$	Drain-to-Source On Resistance	$V_{GS} = 10\ \text{V}, I_D = 10\ \text{A}$	Q2		7.3	9.0	$\text{m}\Omega$
		$V_{GS} = 4.5\ \text{V}, I_D = 8\ \text{A}$			9.8	13	
		$V_{GS} = 10\ \text{V}, I_D = 10\ \text{A}, T_J = 125^\circ\text{C}$			12.7		
$g_{FS}$	Forward Transconductance	$V_{DS} = 15\ \text{V}, I_D = 10\ \text{A}$	Q1		53		S
		$V_{DS} = 15\ \text{V}, I_D = 10\ \text{A}$	Q2		53		

# NTTFD9D0N06HL

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Symbol	Parameter	Test Conditions	Type	Min	Typ	Max	Units
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### DYNAMIC CHARACTERISTICS

$C_{ISS}$	Input Capacitance	Q1: $V_{DS} = 30\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$	Q1		948		pF
			Q2		948		
$C_{OSS}$	Output Capacitance	Q2: $V_{DS} = 30\text{ V}$ , $V_{GS} = 0\text{ V}$ , $f = 1\text{ MHz}$	Q1		188		pF
			Q2		188		
$C_{RSS}$	Reverse Transfer Capacitance		Q1		12.3		pF
			Q2		12.3		
$R_G$	Gate Resistance	$T_A = 25^\circ\text{C}$	Q1		2.0		$\Omega$
			Q2		2.0		

### SWITCHING CHARACTERISTICS

$t_{d(ON)}$	Turn-On Delay Time	Q1: $V_{DD} = 48\text{ V}$ , $I_D = 19\text{ A}$ , $V_{GS} = 4.5\text{ V}$ , $R_{GEN} = 2.5\ \Omega$	Q1		9.4		ns
			Q2		9.4		
$t_r$	Rise Time	Q2: $V_{DD} = 48\text{ V}$ , $I_D = 19\text{ A}$ , $V_{GS} = 4.5\text{ V}$ , $R_{GEN} = 2.5\ \Omega$	Q1		5.8		ns
			Q2		5.8		
$t_{d(OFF)}$	Turn-Off Delay Time		Q1		12.8		ns
			Q2		12.8		
$t_f$	Fall Time		Q1		4.4		ns
			Q2		4.4		
$Q_g$	Total Gate Charge	$V_{GS} = 0\text{ V to }10\text{ V}$	Q1		13.5		nC
			Q2		13.5		
$Q_g$	Total Gate Charge	$V_{GS} = 0\text{ V to }4.5\text{ V}$	Q1		6.4		nC
			Q2		6.4		
$Q_{gs}$	Gate-to-Source Gate Charge	Q1: $V_{DD} = 48\text{ V}$ , $I_D = 19\text{ A}$ Q2: $V_{DD} = 48\text{ V}$ , $I_D = 19\text{ A}$	Q1		2.6		nC
			Q2		2.6		
$Q_{gd}$	Gate-to-Drain "Miller" Charge		Q1		2.8		nC
			Q2		2.8		

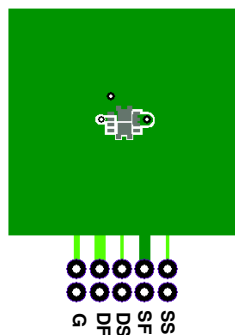
### DRAIN-SOURCE DIODE CHARACTERISTICS

$V_{SD}$	Source to Drain Diode Forward Voltage	$V_{GS} = 0\text{ V}$ , $I_S = 10\text{ A}$ (Note 2)	Q1		0.79	1.2	V
		$V_{GS} = 0\text{ V}$ , $I_S = 10\text{ A}$ (Note 2)	Q2		0.79	1.2	
$t_{rr}$	Reverse Recovery Time	Q1: $I_F = 19\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ Q2: $I_F = 19\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$	Q1		29		ns
			Q2		29		
$Q_{rr}$	Reverse Recovery Charge		Q1		14		nC
			Q2		14		

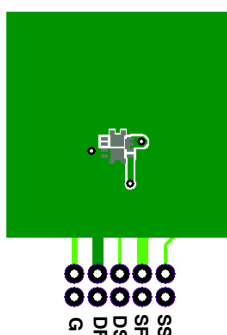
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

1.  $R_{\theta JA}$  is determined with the device mounted on a 1 in<sup>2</sup> pad 2 oz copper pad on a 1.5 × 1.5 in. board of FR-4 material.  $R_{\theta CA}$  is determined by the user's board design.

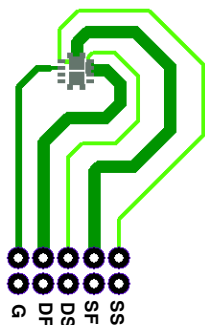
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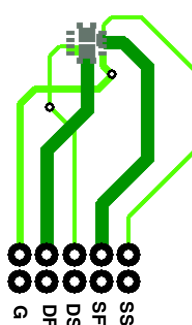
a) 70°C/W when mounted on a 1 in<sup>2</sup> pad of 2 oz copper.



b) 70°C/W when mounted on a 1 in<sup>2</sup> pad of 2 oz copper.



c) 135°C/W when mounted on a minimum pad of 2 oz copper.



d) 135°C/W when mounted on a minimum pad of 2 oz copper.

2. Pulse Test: Pulse Width < 300  $\mu$ s, Duty cycle < 2.0%.
3. Q1: E<sub>AS</sub> of 46 mJ is based on starting T<sub>J</sub> = 25°C; N-ch: L = 1 mH, I<sub>AS</sub> = 9.6 A, V<sub>DD</sub> = 60 V, V<sub>GS</sub> = 10 V. 100% test at L = 1 mH, I<sub>AS</sub> = 9.6 A.  
Q2: E<sub>AS</sub> of 46 mJ is based on starting T<sub>J</sub> = 25°C; N-ch: L = 1 mH, I<sub>AS</sub> = 9.6 A, V<sub>DD</sub> = 60 V, V<sub>GS</sub> = 10 V. 100% test at L = 1 mH, I<sub>AS</sub> = 9.6 A.
4. Computed continuous current limited to Max Junction Temperature only, actual continuous current will be limited by thermal & electro-mechanical application board design.

TYPICAL CHARACTERISTICS

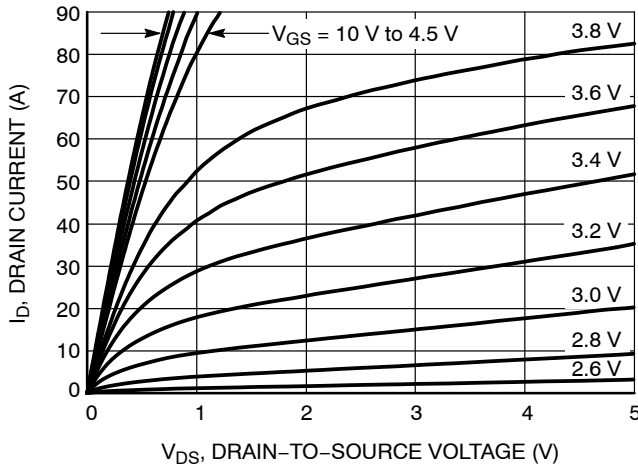


Figure 1. On-Region Characteristics

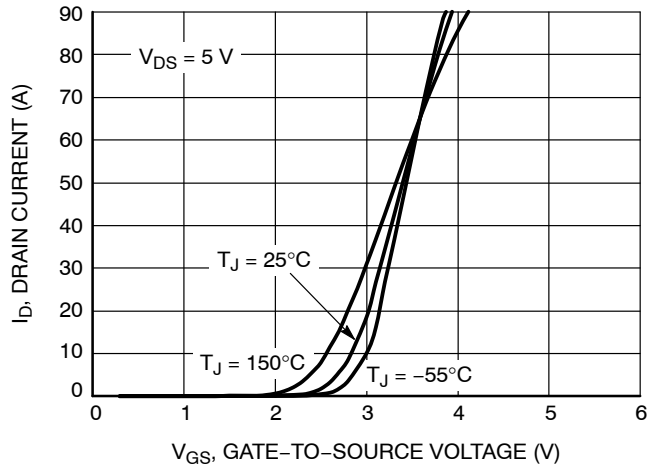


Figure 2. Transfer Characteristics

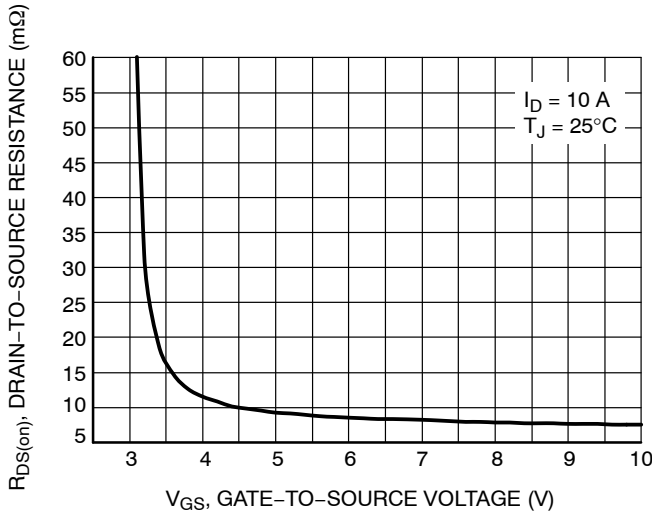


Figure 3. On-Resistance vs. Gate-to-Source Voltage

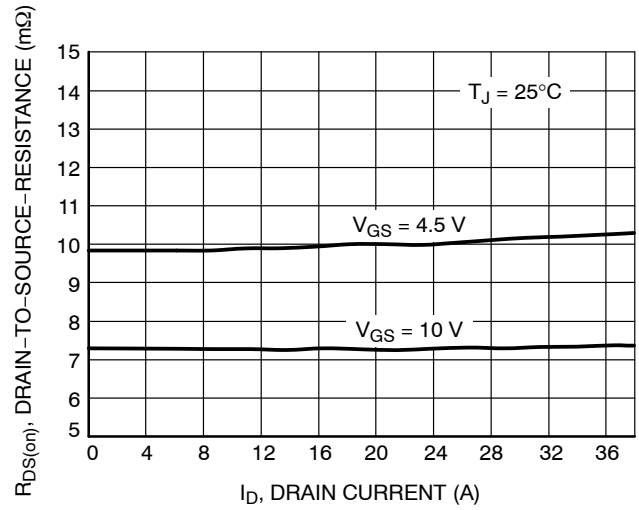


Figure 4. On-Resistance vs. Drain Current and Gate Voltage

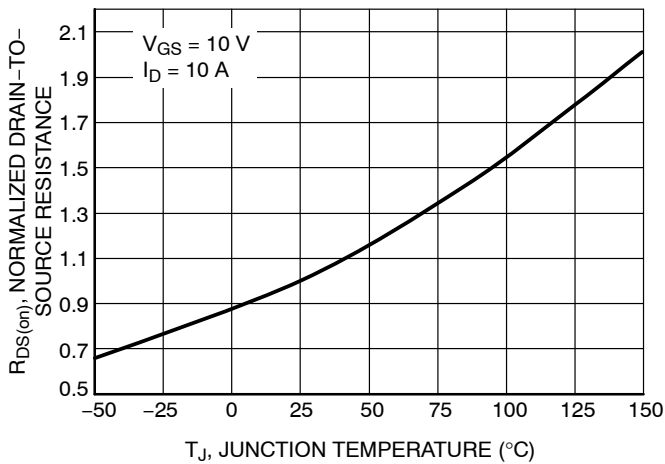


Figure 5. On-Resistance Variation with Temperature

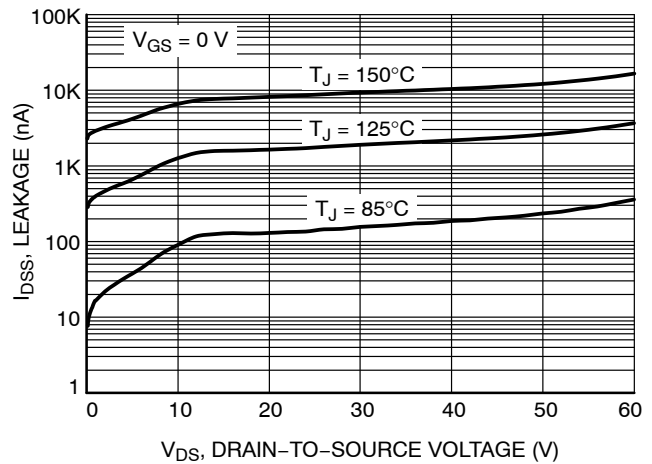


Figure 6. Drain-to-Source Leakage Current vs. Voltage

TYPICAL CHARACTERISTICS

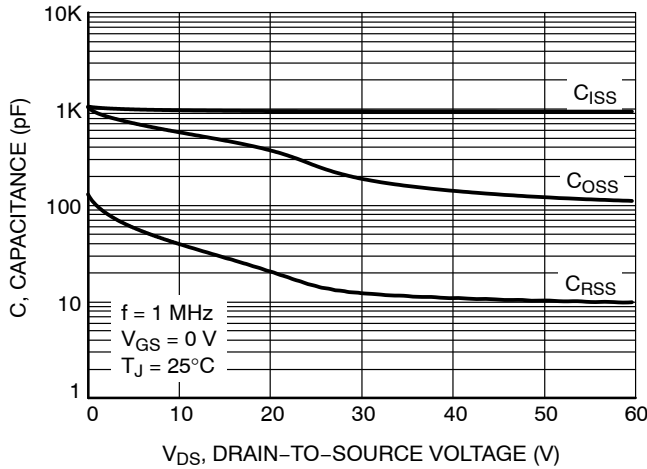


Figure 7. Capacitance Variation

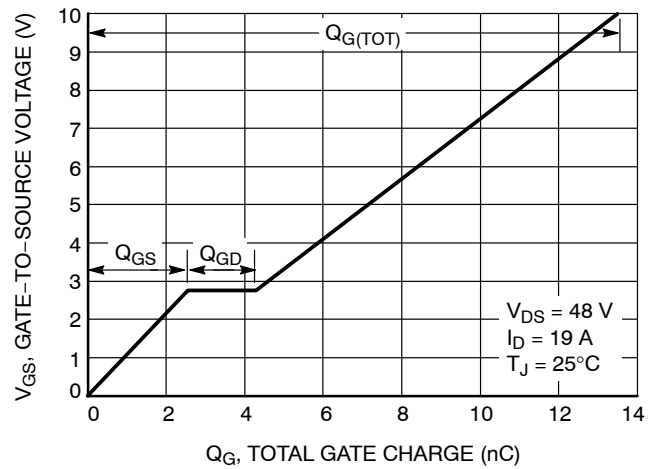


Figure 8. Gate-to-Source vs. Total Charge

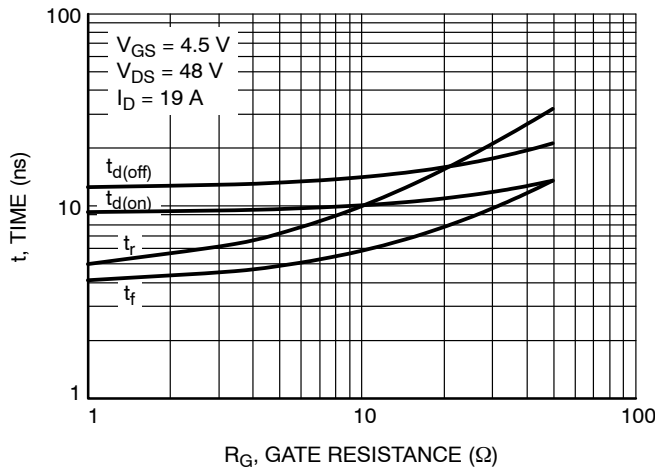


Figure 9. Resistive Switching Time Variation vs. Gate Resistance

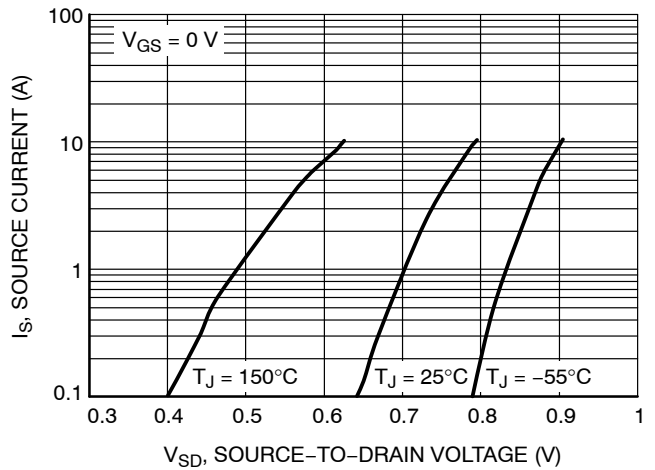


Figure 10. Diode Forward Voltage vs. Current

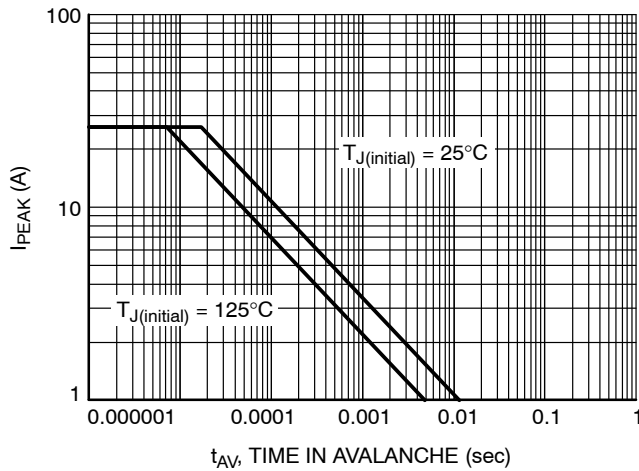


Figure 11. Unclamped Inductive Switching Capability

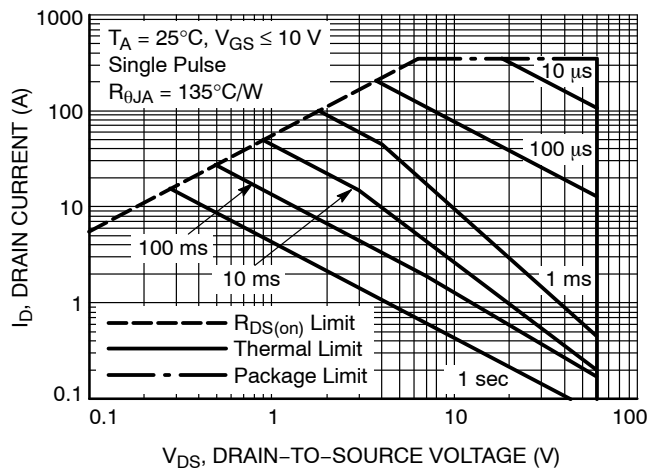


Figure 12. Forward Bias Safe Operating Area

TYPICAL CHARACTERISTICS

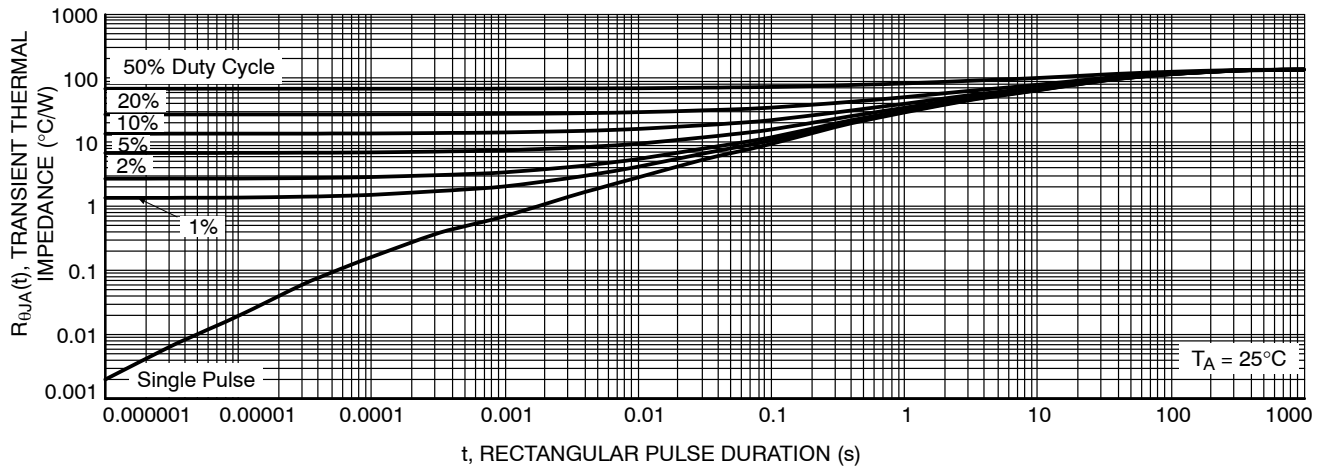


Figure 13. Thermal Response

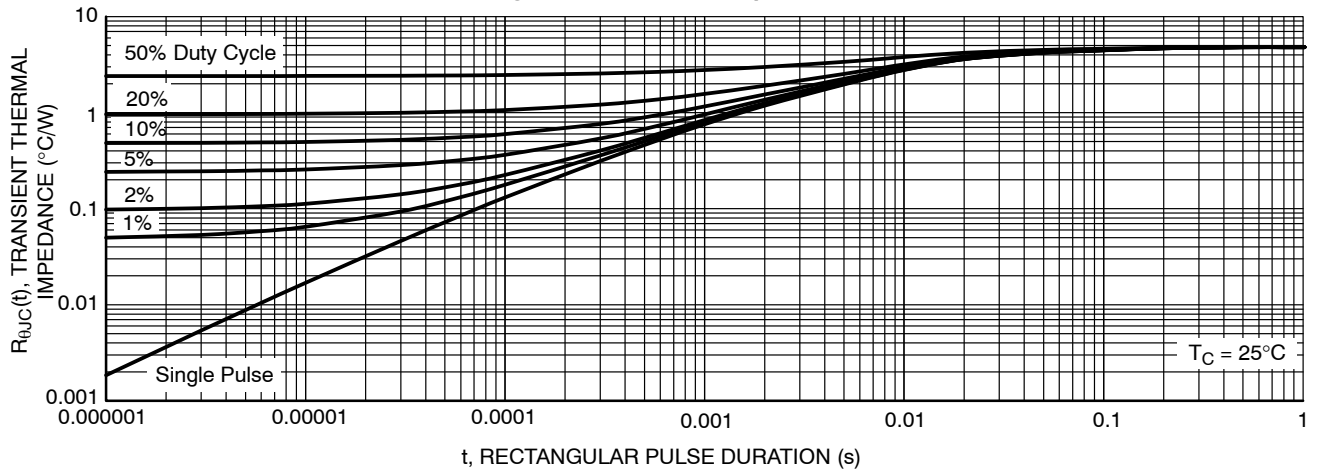
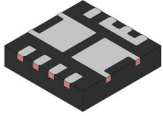
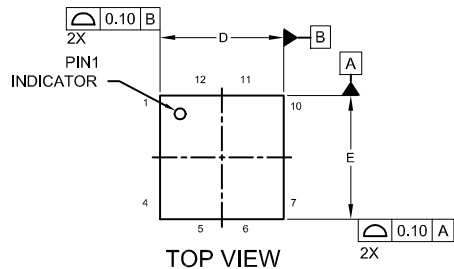


Figure 14. Thermal Response



**WQFN12 3.3X3.3, 0.65P**  
CASE 510CJ  
ISSUE A

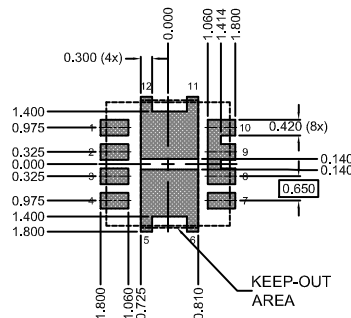
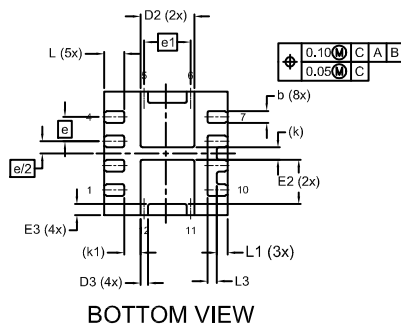
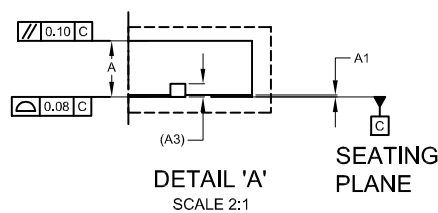
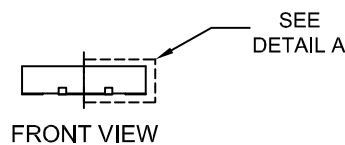
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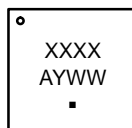
NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS
3. COPLANARITY APPLIES TO THE EXPOSED
4. SEATING PLANE IS DEFINED BY THE TERMINALS. "A1" IS DEFINED AS THE DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT ON THE PACKAGE BODY.
5. IT IS RECOMMENDED TO HAVE NO TRACES OR VIAS WITHIN THE KEEP OUT AREA.

DIM	MILLIMETERS		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	--	0.05
A3	0.20 REF		
b	0.27	0.32	0.37
D	3.20	3.30	3.40
D2	1.34	1.44	1.54
D3	0.10	0.20	0.30
E	3.20	3.30	3.40
E2	1.09	1.19	1.29
E3	0.20	0.30	0.40
e	0.65 BSC		
e/2	0.325 BSC		
e1	1.24 BSC		
k	0.33 REF		
k1	0.43 REF		
L	0.44	0.54	0.64
L1	0.19	0.29	0.39
L3	0.15	0.25	0.35



### GENERIC MARKING DIAGRAM\*



XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
▪ = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

LAND PATTERN  
RECOMMENDATION

\*FOR ADDITIONAL INFORMATION ON OUR PB-FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ON SEMICONDUCTOR SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERRM/D.

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<b>DESCRIPTION:</b>	<b>WQFN12 3.3X3.3, 0.65P</b>	<b>PAGE 1 OF 1</b>

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