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# FDS8960C

## Dual N & P-Channel PowerTrench® MOSFET

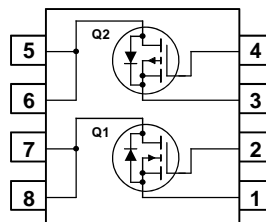
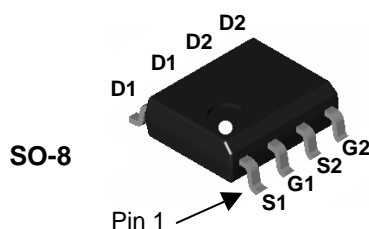
### General Description

These dual N- and P-Channel enhancement mode power field effect transistors are produced using Fairchild Semiconductor's advanced PowerTrench process that has been especially tailored to minimize on-state resistance and yet maintain superior switching performance.

These devices are well suited for low voltage and battery powered applications where low in-line power loss and fast switching are required.

### Features

- **Q1:** N-Channel  
7.0A, 35V  $R_{DS(on)} = 0.024\Omega @ V_{GS} = 10V$   
 $R_{DS(on)} = 0.032\Omega @ V_{GS} = 4.5V$
- **Q2:** P-Channel  
-5A, -35V  $R_{DS(on)} = 0.053\Omega @ V_{GS} = -10V$   
 $R_{DS(on)} = 0.087\Omega @ V_{GS} = -4.5V$
- Fast switching speed
- RoHS compliant



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

Symbol	Parameter	Q1	Q2	Units
$V_{DSS}$	Drain-Source Voltage	35	-35	V
$V_{DS(Avalanche)}$	Drain-Source Avalanche Voltage (maximum) (Note 3)	40	-40	V
$V_{GSS}$	Gate-Source Voltage	$\pm 20$	$\pm 25$	V
$I_D$	Drain Current - Continuous (Note 1a)	7	-5	A
	- Pulsed	20	-20	
$P_D$	Power Dissipation for Dual Operation	2		W
	Power Dissipation for Single Operation (Note 1a)	1.6		
	(Note 1b)	1		
	(Note 1c)	0.9		
$T_J, T_{STG}$	Operating and Storage Junction Temperature Range	-55 to +150		$^\circ\text{C}$

### Thermal Characteristics

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

### Package Marking and Ordering Information

Device Marking	Device	Reel Size	Tape width	Quantity
FDS8960C	FDS8960C	13"	12mm	2500 units

### Electrical Characteristics

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

Symbol	Parameter	Test Conditions	Type	Min	Typ	Max	Units
<b>Drain-Source Avalanche Ratings</b>							
$E_{AS}$	Drain-Source Avalanche Energy (Single Pulse)	$V_{DD} = 35\text{ V}, I_D = 7\text{ A}, L = 1\text{ mH}$	Q1			24.5	mJ
		$V_{DD} = -35\text{ V}, I_D = -5\text{ A}, L = 1\text{ mH}$	Q2			12.5	mJ
$I_{AS}$	Drain-Source Avalanche Current		Q1		7		A
			Q2		-5		

### Off Characteristics

$BV_{DSS}$	Drain-Source Breakdown Voltage	$V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$ $V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$	Q1 Q2	35 -35			V
$\frac{\Delta BV_{DSS}}{\Delta T_J}$	Breakdown Voltage Temperature Coefficient	$I_D = 250\text{ }\mu\text{A}$ , Referenced to $25^\circ\text{C}$ $I_D = -250\text{ }\mu\text{A}$ , Referenced to $25^\circ\text{C}$	Q1 Q2		31 -40		mV/ $^\circ\text{C}$
$I_{DSS}$	Zero Gate Voltage Drain Current	$V_{DS} = 28\text{ V}, V_{GS} = 0\text{ V}$	Q1			1	$\mu\text{A}$
		$V_{DS} = -28\text{ V}, V_{GS} = 0\text{ V}$	Q2			-1	
$I_{GSSF}$	Gate-Body Leakage, Forward	$V_{GS} = 20\text{ V}, V_{DS} = 0\text{ V}$	Q1			100	nA
$I_{GSSR}$	Gate-Body Leakage, Reverse	$V_{GS} = -20\text{ V}, V_{DS} = 0\text{ V}$				-100	nA
$I_{GSSR}$	Gate-Body Leakage, Forward	$V_{GS} = 25\text{ V}, V_{DS} = 0\text{ V}$	Q2			100	nA
$I_{GSSF}$	Gate-Body Leakage, Reverse	$V_{GS} = -25\text{ V}, V_{DS} = 0\text{ V}$				-100	nA

### On Characteristics (Note 2)

$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	Q1	1	2	3	V
		$V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$	Q2	-1	-1.8	-3	
$\frac{\Delta V_{GS(th)}}{\Delta T_J}$	Gate Threshold Voltage Temperature Coefficient	$I_D = 250\text{ }\mu\text{A}$ , Referenced to $25^\circ\text{C}$	Q1		-5		mV/ $^\circ\text{C}$
		$I_D = -250\text{ }\mu\text{A}$ , Referenced to $25^\circ\text{C}$	Q2		4		
$R_{DS(on)}$	Static Drain-Source On-Resistance	$V_{GS} = 10\text{ V}, I_D = 7\text{ A}$	Q1		20	24	m $\Omega$
		$V_{GS} = 4.5\text{ V}, I_D = 6\text{ A}$			25	32	
		$V_{GS} = 10\text{ V}, I_D = 7\text{ A}, T_J = 125^\circ\text{C}$			29	37	
		$V_{GS} = -10\text{ V}, I_D = -5\text{ A}$	Q2		44	53	
		$V_{GS} = -4.5\text{ V}, I_D = -4\text{ A}$			70	87	
		$V_{GS} = -10\text{ V}, I_D = -5\text{ A}, T_J = 125^\circ\text{C}$			61	79	
$g_{FS}$	Forward Transconductance	$V_{DS} = 5\text{ V}, I_D = 7\text{ A}$	Q1		23		S
		$V_{DS} = -5\text{ V}, I_D = -5\text{ A}$	Q2		9		

### Dynamic Characteristics

$C_{iss}$	Input Capacitance	Q1	570		pF
		Q2	540		
$C_{oss}$	Output Capacitance	Q1	126		pF
		Q2	113		
$C_{rss}$	Reverse Transfer Capacitance	Q1	52		pF
		Q2	60		
$R_G$	Gate Resistance	f = 1.0 MHz	Q1	2	$\Omega$
			Q2	6	

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

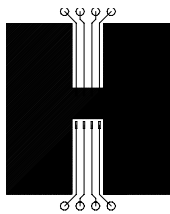
Symbol	Parameter	Test Conditions	Type	Min	Typ	Max	Units
<b>Switching Characteristics</b> (Note 2)							
$t_{d(on)}$	Turn-On Delay Time	Q1 $V_{DD} = 15\text{ V}, I_D = 1\text{ A},$ $V_{GS} = 10\text{ V}, R_{GEN} = 6\ \Omega$	Q1 Q2		8 12	16 22	ns
$t_r$	Turn-On Rise Time		Q1 Q2		5 16	10 29	ns
$t_{d(off)}$	Turn-Off Delay Time	Q2 $V_{DD} = -15\text{ V}, I_D = -1\text{ A},$ $V_{GS} = -10\text{ V}, R_{GEN} = 6\ \Omega$	Q1 Q2		23 20	37 32	ns
$t_f$	Turn-Off Fall Time		Q1 Q2		3 5	6 10	ns
$Q_g$	Total Gate Charge	Q1 $V_{DS} = 15\text{ V}, I_D = 7\text{ A}, V_{GS} = 5\text{ V}$	Q1 Q2		5.5 5.7	7.7 8	nC
$Q_{gs}$	Gate-Source Charge	Q2	Q1 Q2		1.8 1.8		nC
$Q_{gd}$	Gate-Drain Charge	$V_{DS} = -15\text{ V}, I_D = -5\text{ A}, V_{GS} = -5\text{ V}$	Q1 Q2		1.8 2		nC

**Drain-Source Diode Characteristics**

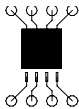
$I_S$	Maximum Continuous Drain-Source Diode Forward Current		Q1 Q2			1.3 -1.3	A
$V_{SD}$	Drain-Source Diode Forward Voltage	$V_{GS} = 0\text{ V}, I_S = 1.3\text{ A}$ (Note 2) $V_{GS} = 0\text{ V}, I_S = -1.3\text{ A}$ (Note 2)	Q1 Q2		0.8 -0.8	1.2 -1.2	V
$t_{rr}$	Diode Reverse Recovery Time	Q1 $I_F = 7\text{ A}, d_{IF}/d_t = 100\text{ A}/\mu\text{s}$	Q1 Q2		20 17		nS
$Q_{rr}$	Diode Reverse Recovery Charge	Q2 $I_F = -5\text{ A}, d_{IF}/d_t = 100\text{ A}/\mu\text{s}$	Q1 Q2		10 5		nC

**Notes:**

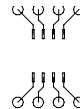
1.  $R_{\theta JA}$  is the sum of the junction-to-case and case-to-ambient thermal resistance where the case thermal reference is defined as the solder mounting surface of the drain pins.  $R_{\theta JC}$  is guaranteed by design while  $R_{\theta CA}$  is determined by the user's board design.



a)  $78^\circ\text{C}/\text{W}$  when mounted on a  $0.5\text{ in}^2$  pad of 2 oz copper



b)  $125^\circ\text{C}/\text{W}$  when mounted on a  $.02\text{ in}^2$  pad of 2 oz copper



c)  $135^\circ\text{C}/\text{W}$  when mounted on a minimum pad.

Scale 1 : 1 on letter size paper

2. Pulse Test: Pulse Width <  $300\mu\text{s}$ , Duty Cycle < 2.0%

3. BV(avalanche) Single-Pulse rating is guaranteed by design if device is operated within the UIS SOA boundary of the device.

### Typical Characteristics: Q1 (N-Channel)

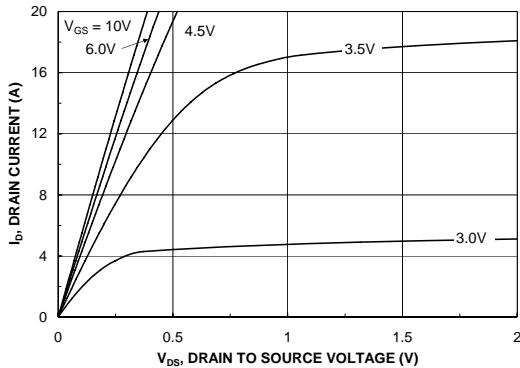


Figure 1. On-Region Characteristics.

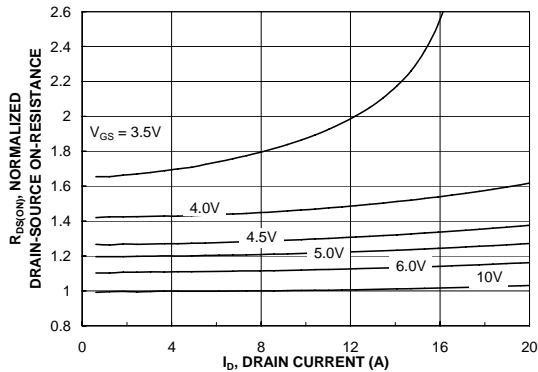


Figure 2. On-Resistance Variation with Drain Current and Gate Voltage.

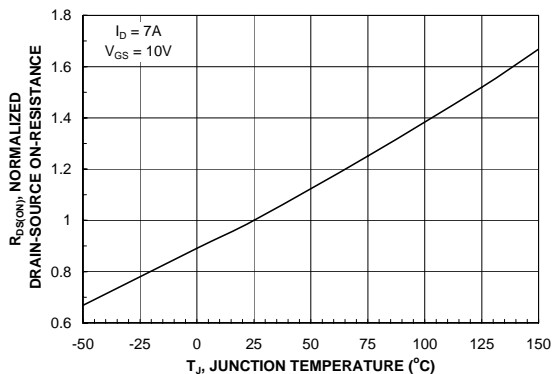


Figure 3. On-Resistance Variation with Temperature.

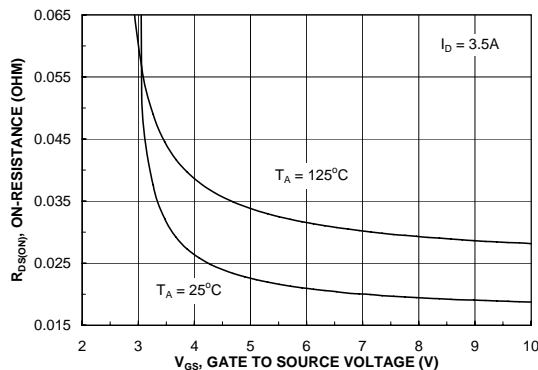


Figure 4. On-Resistance Variation with Gate-to-Source Voltage.

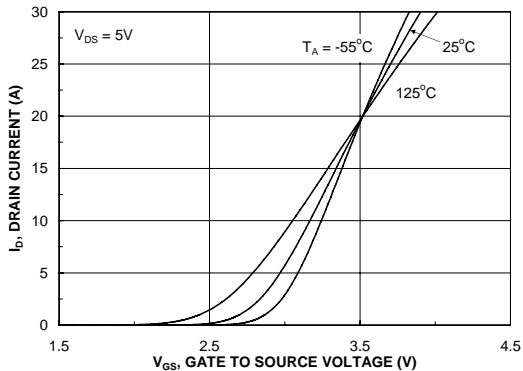


Figure 5. Transfer Characteristics.

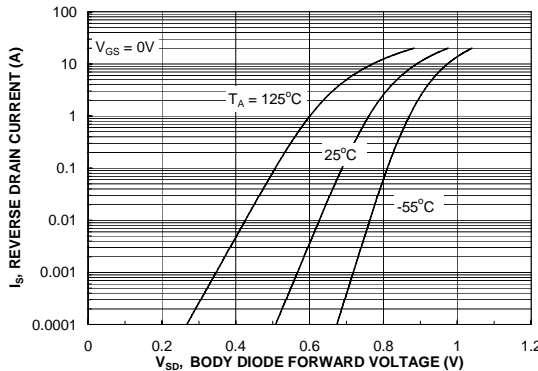


Figure 6. Body Diode Forward Voltage Variation with Source Current and Temperature.

### Typical Characteristics: Q1 (N-Channel)

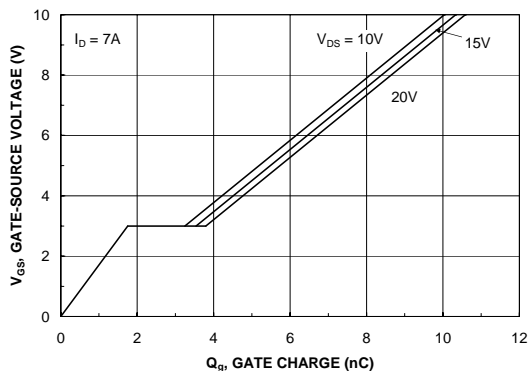


Figure 7. Gate Charge Characteristics.

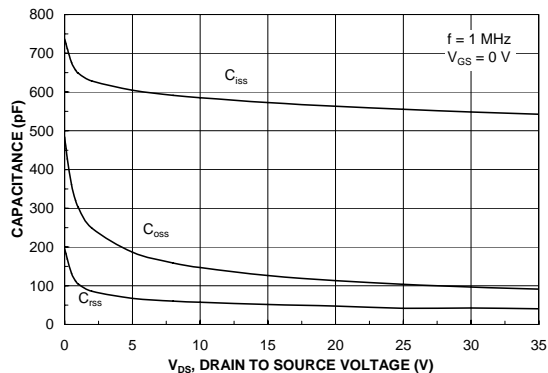


Figure 8. Capacitance Characteristics.

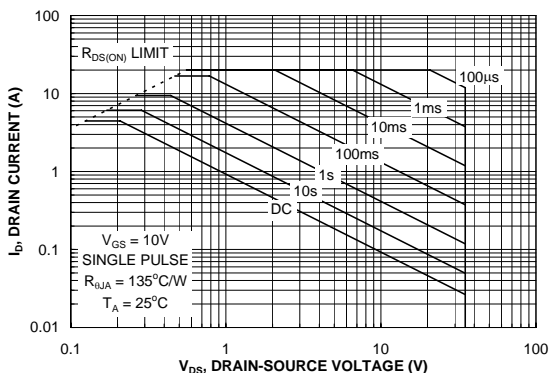


Figure 9. Maximum Safe Operating Area.

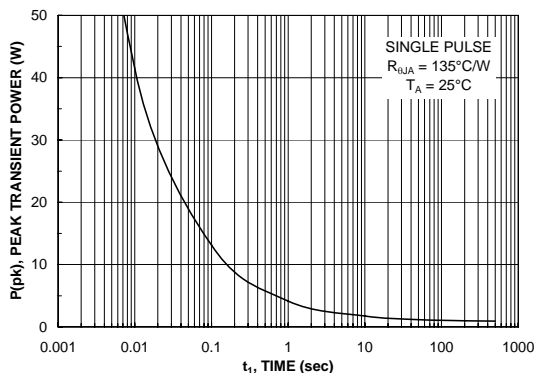


Figure 10. Single Pulse Maximum Power Dissipation.

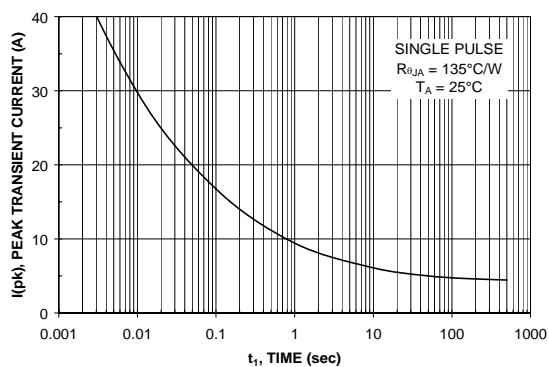


Figure 11. Single Pulse Maximum Peak Current

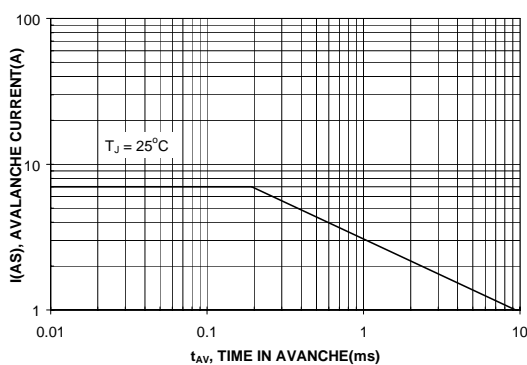
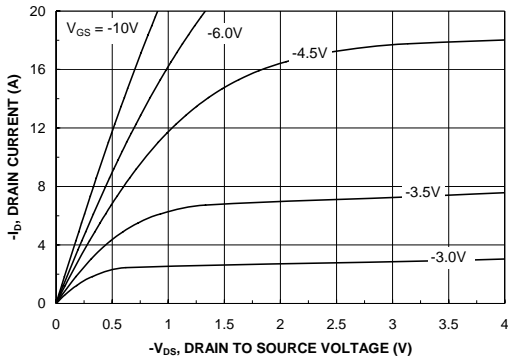
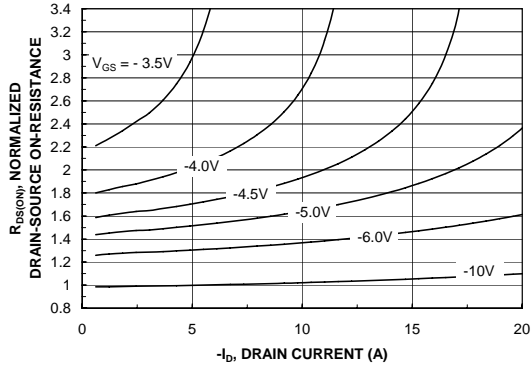


Figure 12. Unclamped Inductive Switching Capability

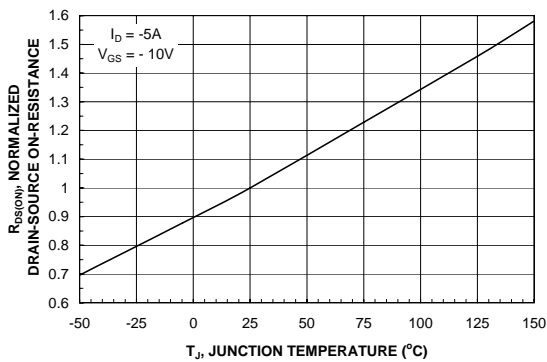
**Typical Characteristics: Q2 (P-Channel)**



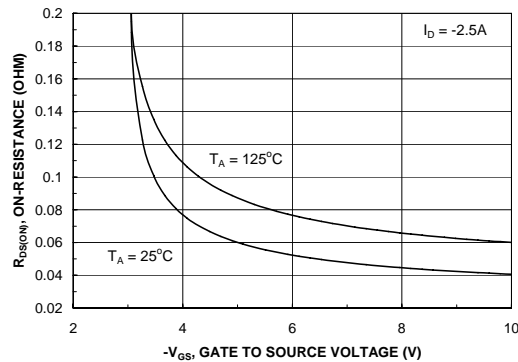
**Figure 13. On-Region Characteristics.**



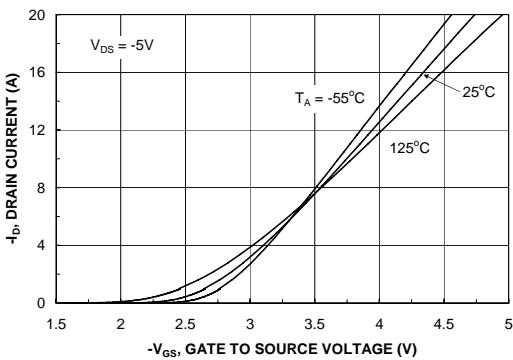
**Figure 14. On-Resistance Variation with Drain Current and Gate Voltage.**



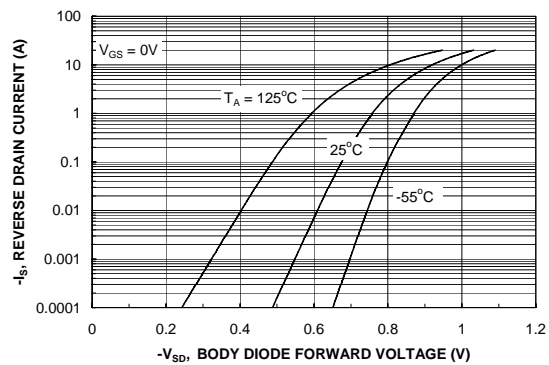
**Figure 15. On-Resistance Variation with Temperature.**



**Figure 16. On-Resistance Variation with Gate-to-Source Voltage.**



**Figure 17. Transfer Characteristics.**



**Figure 18. Body Diode Forward Voltage Variation with Source Current and Temperature.**

### Typical Characteristics: Q2 (P-Channel)

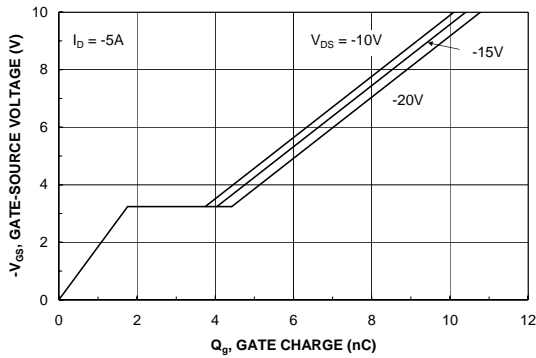


Figure 19. Gate Charge Characteristics.

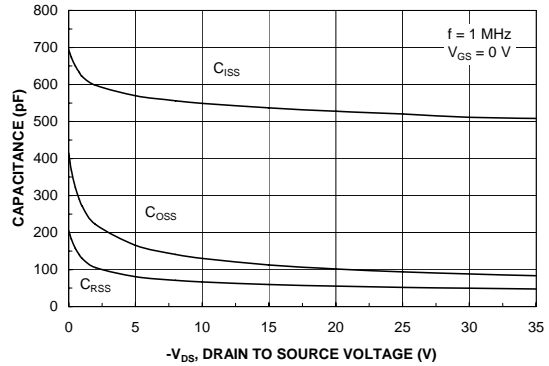


Figure 20. Capacitance Characteristics.

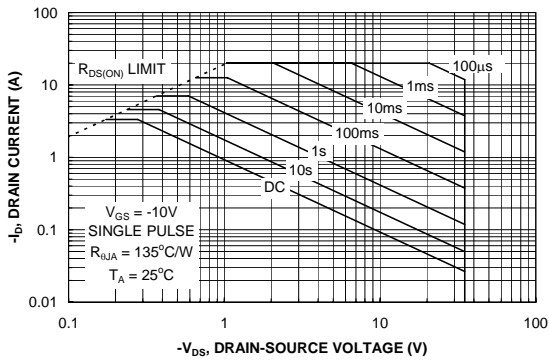


Figure 21. Maximum Safe Operating Area.

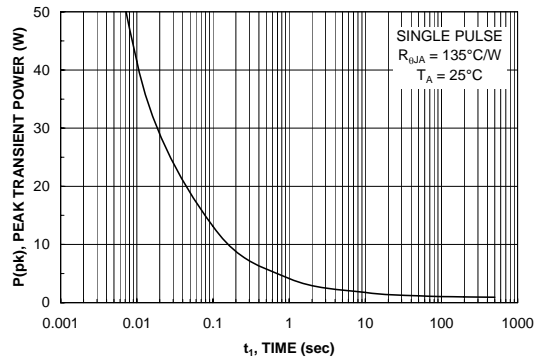


Figure 22. Single Pulse Maximum Power Dissipation.

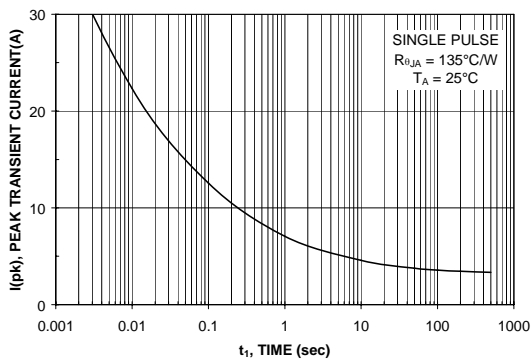


Figure 23. Single Pulse Maximum Peak Current

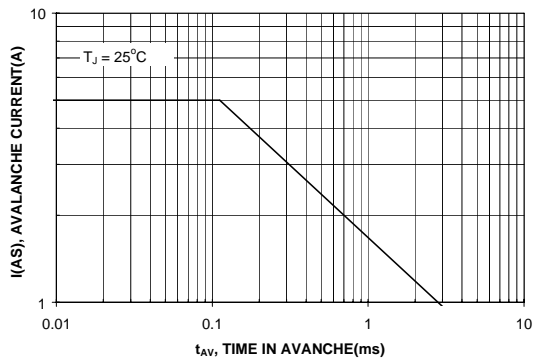
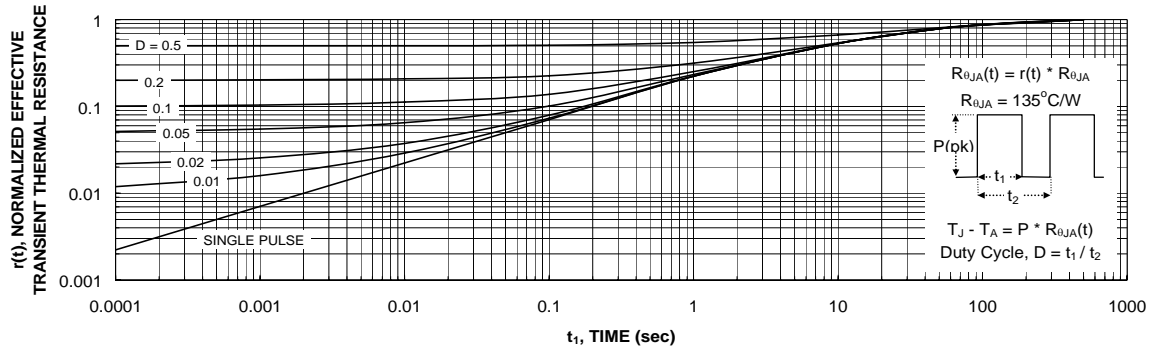


Figure 24. Unclamped Inductive Switching Capability



### Typical Characteristics



**Figure 25. Transient Thermal Response Curve.**

Thermal characterization performed using the conditions described in Note 1c.

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