

## FW356-TL-E-VB Datasheet

### N- and P-Channel 60-V (D-S) MOSFET

PRODUCT SUMMARY				
	V <sub>DS</sub> (V)	R <sub>DS(on)</sub> (Ω)	I <sub>D</sub> (A) <sup>a</sup>	Q <sub>g</sub> (Typ.)
N-Channel	60	0.026 at V <sub>GS</sub> = 10 V	5.3	6 nC
		0.029 at V <sub>GS</sub> = 4.5 V	4.7	
P-Channel	- 60	0.055 at V <sub>GS</sub> = - 10 V	- 4.9	8 nC
		0.060 at V <sub>GS</sub> = - 4.5 V	- 4.5	

#### FEATURES

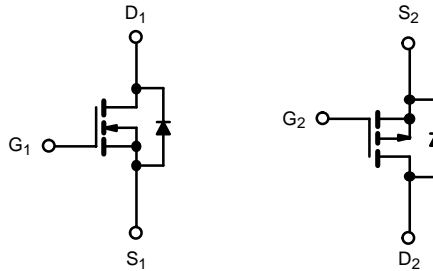
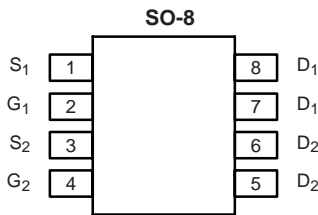
- Halogen-free According to IEC 61249-2-21 Available
- TrenchFET<sup>®</sup> Power MOSFET
- 100 % R<sub>g</sub> and UIS Tested

#### APPLICATIONS

- CCFL Inverter



**RoHS**  
COMPLIANT  
**HALOGEN**  
**FREE**  
Available



N-Channel MOSFET

P-Channel MOSFET

ABSOLUTE MAXIMUM RATINGS T <sub>A</sub> = 25 °C, unless otherwise noted				
Parameter	Symbol	N-Channel	P-Channel	Unit
Drain-Source Voltage	V <sub>DS</sub>	60	- 60	V
Gate-Source Voltage	V <sub>GS</sub>	± 20		
Continuous Drain Current (T <sub>J</sub> = 150 °C)	T <sub>C</sub> = 25 °C	5.3	- 4.9	A
	T <sub>C</sub> = 70 °C	4.3	- 4.2	
	T <sub>A</sub> = 25 °C	4.3 <sup>b, c</sup>	- 4.0 <sup>b, c</sup>	
	T <sub>A</sub> = 70 °C	3.4 <sup>b, c</sup>	- 3.4 <sup>b, c</sup>	
Pulsed Drain Current (10 μs Pulse Width)	I <sub>DM</sub>	20	- 25	A
Source Drain Current Diode Current	T <sub>C</sub> = 25 °C	2.6	- 2.8	
	T <sub>A</sub> = 25 °C	1.7 <sup>b, c</sup>	- 1.7 <sup>b, c</sup>	
Pulsed Source-Drain Current	I <sub>SM</sub>	20	- 25	mJ
Single Pulse Avalanche Current	I <sub>AS</sub>	11	15	
Single Pulse Avalanche Energy	E <sub>AS</sub>	6.1	11	W
Maximum Power Dissipation	T <sub>C</sub> = 25 °C	3.1	3.4	
	T <sub>C</sub> = 70 °C	2	2.2	
	T <sub>A</sub> = 25 °C	2 <sup>b, c</sup>	2 <sup>b, c</sup>	
	T <sub>A</sub> = 70 °C	1.3 <sup>b, c</sup>	1.3 <sup>b, c</sup>	
Operating Junction and Storage Temperature Range	T <sub>J</sub> , T <sub>stg</sub>	- 55 to 150		°C

THERMAL RESISTANCE RATINGS							
Parameter	Symbol	N-Channel		P-Channel		Unit	
		Typ.	Max.	Typ.	Max.		
Maximum Junction-to-Ambient <sup>b, d</sup>	t ≤ 10 s	R <sub>thJA</sub>	55	62.5	53	62.5	°C/W
Maximum Junction-to-Foot (Drain)	Steady State	R <sub>thJF</sub>	33	40	30	37	

Notes:

a. Based on T<sub>C</sub> = 25 °C.

b. Surface Mounted on 1" x 1" FR4 board.

c. t = 10 s.

d. Maximum under Steady State conditions is 110 °C/W for N-Channel and P-Channel.

<b>SPECIFICATIONS</b> $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted								
Parameter	Symbol	Test Conditions		Min.	Typ. <sup>a</sup>	Max.	Unit	
<b>Static</b>								
Drain-Source Breakdown Voltage	$V_{DS}$	$V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$	N-Ch	60			V	
		$V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$	P-Ch	-60				
$V_{DS}$ Temperature Coefficient	$\Delta V_{DS}/T_J$	$I_D = 250\text{ }\mu\text{A}$	N-Ch		55		mV	
		$I_D = -250\text{ }\mu\text{A}$	P-Ch		-50			
$V_{GS(th)}$ Temperature Coefficient	$\Delta V_{GS(th)}/T_J$	$I_D = 250\text{ }\mu\text{A}$	N-Ch		-6		mV	
		$I_D = -250\text{ }\mu\text{A}$	P-Ch		4			
Gate Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	N-Ch	1		3	V	
		$V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$	P-Ch	-1		-3		
Gate-Body Leakage	$I_{GSS}$	$V_{DS} = 0\text{ V}, V_{GS} = \pm 20\text{ V}$	N-Ch			100	nA	
			P-Ch			-100		
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}$	N-Ch			1	$\mu\text{A}$	
			P-Ch			-1		
		$V_{DS} = 60\text{ V}, V_{GS} = 0\text{ V}, T_J = 55\text{ }^\circ\text{C}$	N-Ch			10		
			P-Ch			-10		
On-State Drain Current <sup>b</sup>	$I_{D(on)}$	$V_{DS} \geq 5\text{ V}, V_{GS} = 10\text{ V}$	N-Ch	20			A	
		$V_{DS} \leq -5\text{ V}, V_{GS} = -10\text{ V}$	P-Ch	-25				
Drain-Source On-State Resistance <sup>b</sup>	$R_{DS(on)}$	$V_{GS} = 10\text{ V}, I_D = 4.3\text{ A}$	N-Ch		0.026		$\Omega$	
		$V_{GS} = -10\text{ V}, I_D = -3.1\text{ A}$	P-Ch		0.055			
		$V_{GS} = 4.5\text{ V}, I_D = 3.9\text{ A}$	N-Ch		0.029			
		$V_{GS} = -4.5\text{ V}, I_D = -0.2\text{ A}$	P-Ch		0.060			
Forward Transconductance <sup>b</sup>	$g_{fs}$	$V_{DS} = 15\text{ V}, I_D = 4.3\text{ A}$	N-Ch		15		S	
		$V_{DS} = -15\text{ V}, I_D = -3.1\text{ A}$	P-Ch		8.5			
<b>Dynamic<sup>a</sup></b>								
Input Capacitance	$C_{iss}$	N-Channel $V_{DS} = 15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	N-Ch		665		$\mu\text{F}$	
			P-Ch		650			
Output Capacitance	$C_{oss}$		P-Channel $V_{DS} = -15\text{ V}, V_{GS} = 0\text{ V}, f = 1\text{ MHz}$	N-Ch		75		
				P-Ch		95		
Reverse Transfer Capacitance	$C_{rss}$			N-Ch		40		
				P-Ch		60		
Total Gate Charge	$Q_g$		$V_{DS} = 30\text{ V}, V_{GS} = 10\text{ V}, I_D = 4.3\text{ A}$	N-Ch		13	20	nC
				P-Ch		14.5	22	
		$V_{DS} = 30\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 4.3\text{ A}$	N-Ch		6	9		
			P-Ch		8	12		
Gate-Source Charge	$Q_{gs}$	$V_{DS} = 30\text{ V}, V_{GS} = 4.5\text{ V}, I_D = 4.3\text{ A}$	N-Ch		2.3			
P-Ch			2.2					
Gate-Drain Charge	$Q_{gd}$	$V_{DS} = -30\text{ V}, V_{GS} = -4.5\text{ V}, I_D = -3.1\text{ A}$	N-Ch		2.6			
			P-Ch		3.7			
Gate Resistance	$R_g$		$f = 1\text{ MHz}$	N-Ch		2	3	$\Omega$
				P-Ch		14	20	

<b>SPECIFICATIONS</b> $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted							
Parameter	Symbol	Test Conditions	Min.	Typ. <sup>a</sup>	Max.	Unit	
<b>Dynamic<sup>a</sup></b>							
Turn-On Delay Time	$t_{d(on)}$	N-Channel $V_{DD} = 30\text{ V}$ , $R_L = 8.8\ \Omega$ $I_D \cong 3.4\text{ A}$ , $V_{GEN} = 4.5\text{ V}$ , $R_g = 1\ \Omega$	N-Ch		15	25	ns
			P-Ch		30	45	
Rise Time	$t_r$		N-Ch		65	100	
			P-Ch		70	105	
Turn-Off Delay Time	$t_{d(off)}$	P-Channel $V_{DD} = -30\text{ V}$ , $R_L = 12.5\ \Omega$ $I_D \cong -2.4\text{ A}$ , $V_{GEN} = -4.5\text{ V}$ , $R_g = 1\ \Omega$	N-Ch		15	25	
			P-Ch		40	60	
Fall Time	$t_f$		N-Ch		10	15	
			P-Ch		30	45	
Turn-On Delay Time	$t_{d(on)}$	N-Channel $V_{DD} = 30\text{ V}$ , $R_L = 8.8\ \Omega$ $I_D \cong 3.4\text{ A}$ , $V_{GEN} = 10\text{ V}$ , $R_g = 1\ \Omega$	N-Ch		10	15	
			P-Ch		10	15	
Rise Time	$t_r$		N-Ch		15	25	
			P-Ch		13	20	
Turn-Off Delay Time	$t_{d(off)}$	P-Channel $V_{DD} = -30\text{ V}$ , $R_L = 12.5\ \Omega$ $I_D \cong -2.4\text{ A}$ , $V_{GEN} = -10\text{ V}$ , $R_g = 1\ \Omega$	N-Ch		20	30	
			P-Ch		35	55	
Fall Time	$t_f$		N-Ch		10	15	
			P-Ch		30	45	
<b>Drain-Source Body Diode Characteristics</b>							
Continuous Source-Drain Diode Current	$I_S$	$T_C = 25\text{ }^\circ\text{C}$	N-Ch			2.6	A
			P-Ch			-2.8	
Pulse Diode Forward Current <sup>a</sup>	$I_{SM}$		N-Ch			20	A
			P-Ch			-25	
Body Diode Voltage	$V_{SD}$	$I_S = 1.7\text{ A}$	N-Ch		0.8	1.2	V
		$I_S = -2\text{ A}$	P-Ch		-0.8	-1.2	
Body Diode Reverse Recovery Time	$t_{rr}$	N-Channel $I_F = 1.7\text{ A}$ , $di/dt = 100\text{ A}/\mu\text{s}$ , $T_J = 25\text{ }^\circ\text{C}$	N-Ch		30	60	ns
			P-Ch		30	50	
Body Diode Reverse Recovery Charge	$Q_{rr}$	P-Channel $I_F = -2\text{ A}$ , $di/dt = -100\text{ A}/\mu\text{s}$ , $T_J = 25\text{ }^\circ\text{C}$	N-Ch		32	50	nC
			P-Ch		35	60	
Reverse Recovery Fall Time	$t_a$		N-Ch		25		ns
			P-Ch		16		
Reverse Recovery Rise Time	$t_b$		N-Ch		5		
			P-Ch		14		

Notes:

- a. Guaranteed by design, not subject to production testing.  
 b. Pulse test; pulse width  $\leq 300\ \mu\text{s}$ , duty cycle  $\leq 2\%$ .

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**N-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



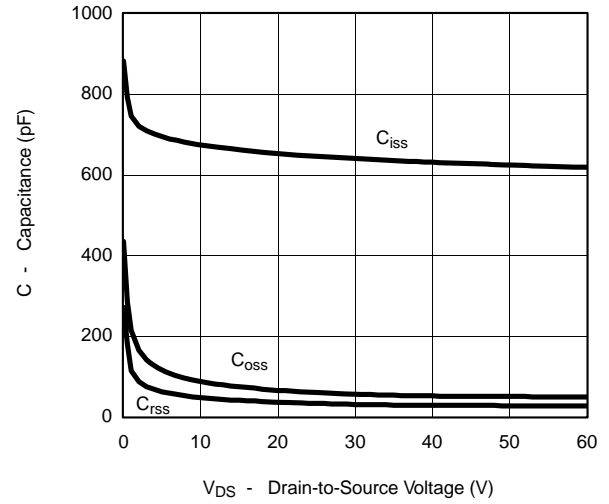
**Output Characteristics**



**Transfer Characteristics**



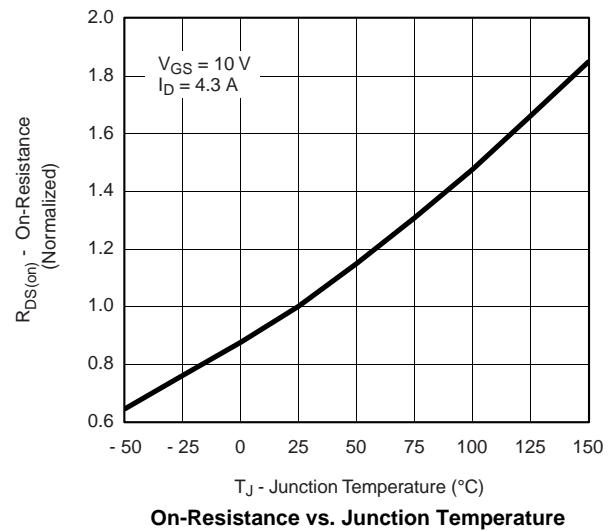
**On-Resistance vs. Drain Current and Gate Voltage**



**Capacitance**

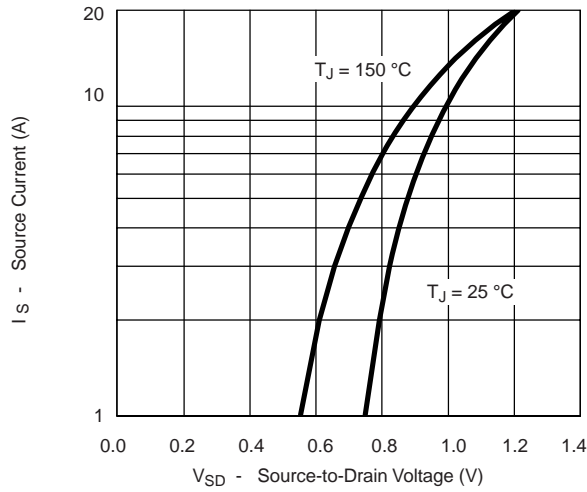


**Gate Charge**



**On-Resistance vs. Junction Temperature**

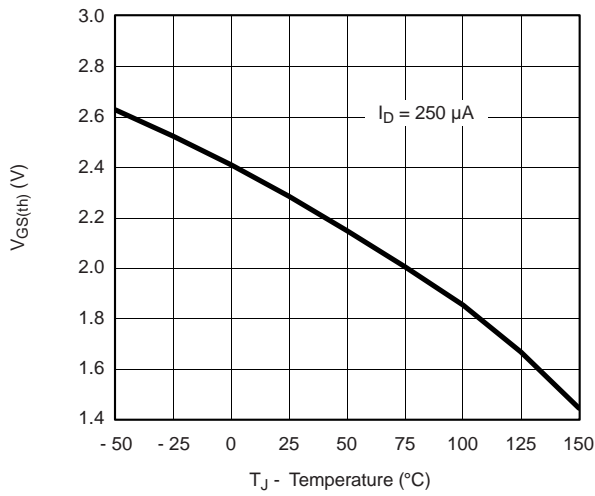
**N-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



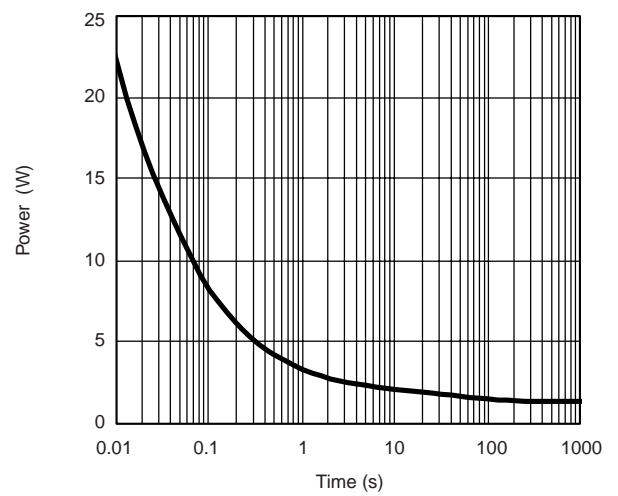
**Source-Drain Diode Forward Voltage**



**On-Resistance vs. Gate-to-Source Voltage**



**Threshold Voltage**



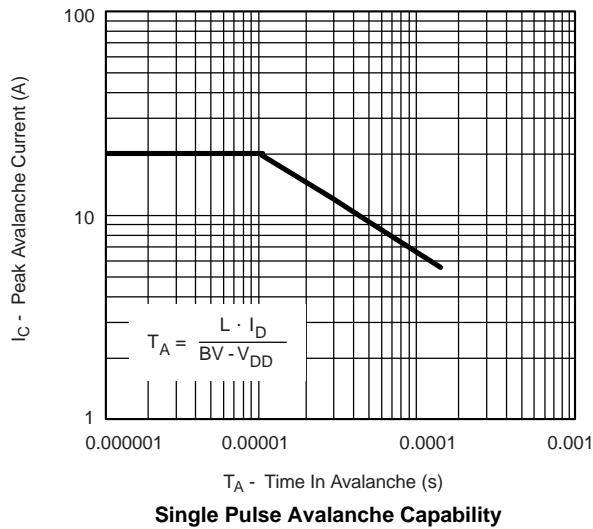
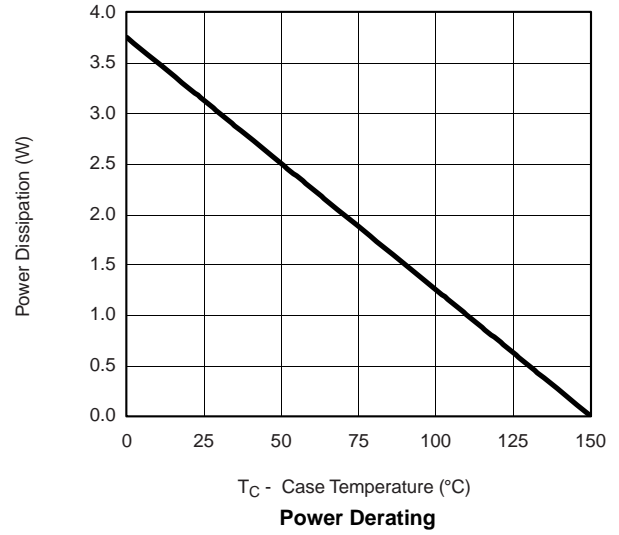
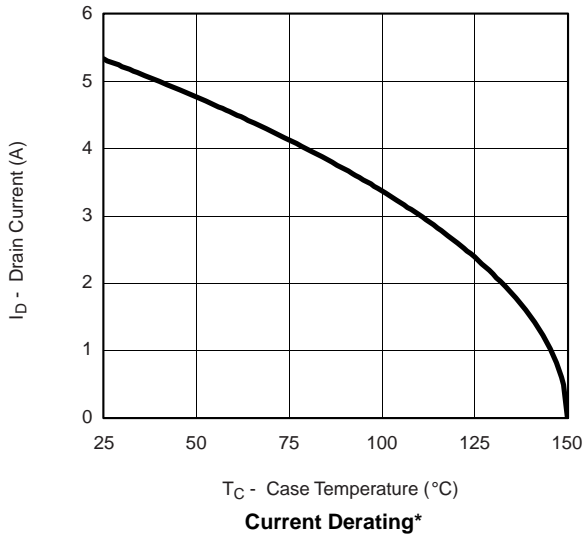
**Single Pulse Power, Junction-to-Ambient**



\*  $V_{GS} >$  minimum  $V_{GS}$  at which  $R_{DS(on)}$  is specified

**Safe Operating Area**

**N-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



\* The power dissipation  $P_D$  is based on  $T_{J(max)} = 150$  °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit.

**N-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



**P-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



**Output Characteristics**



**Transfer Characteristics**



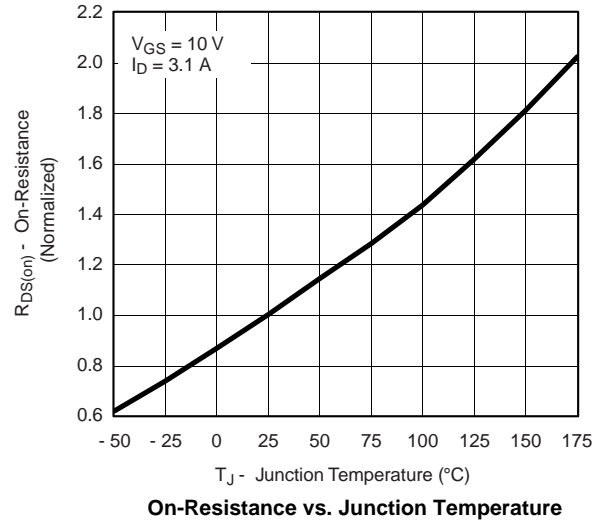
**On-Resistance vs. Drain Current**



**Capacitance**



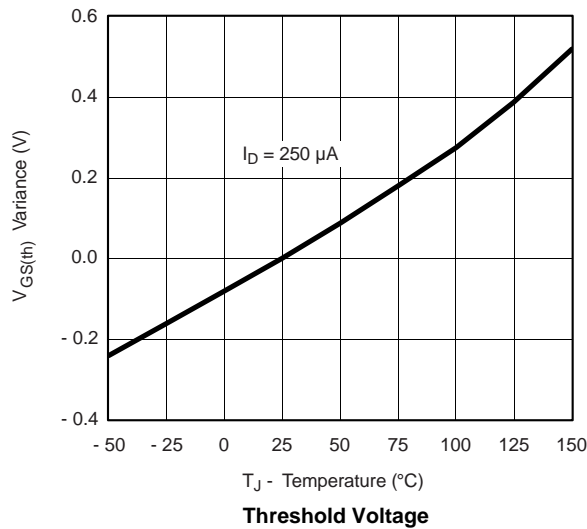
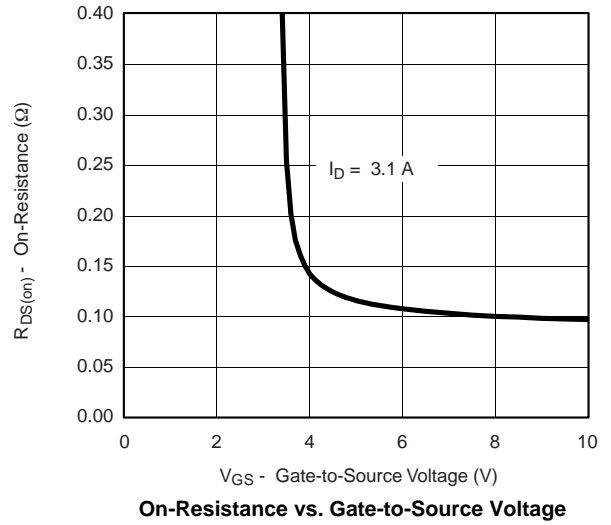
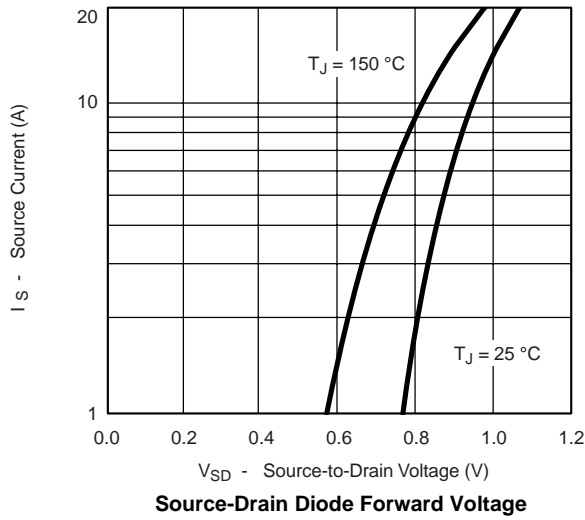
**Gate Charge**



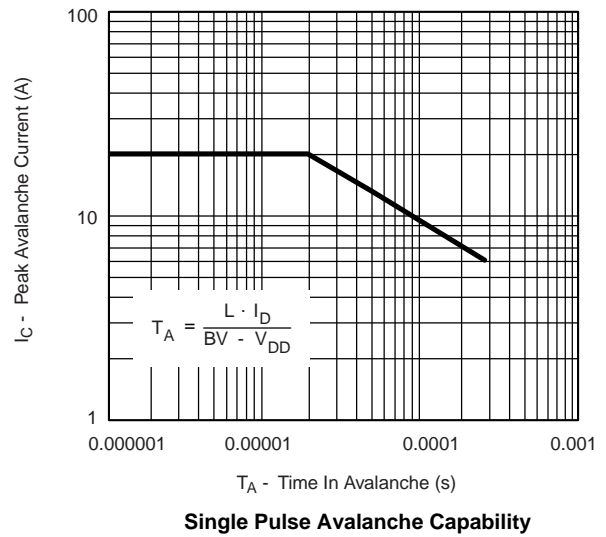
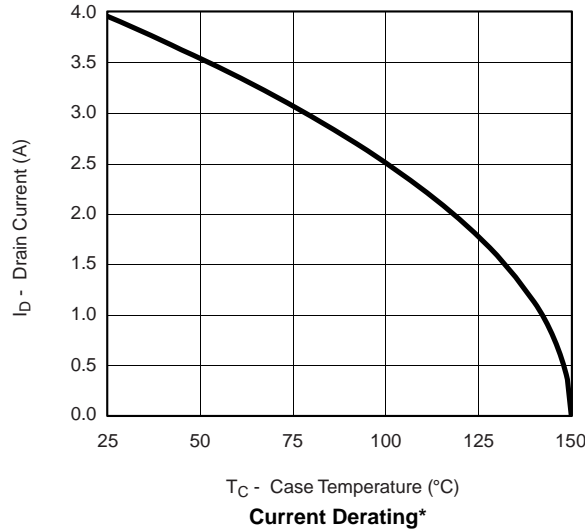
**On-Resistance vs. Junction Temperature**



**P-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted

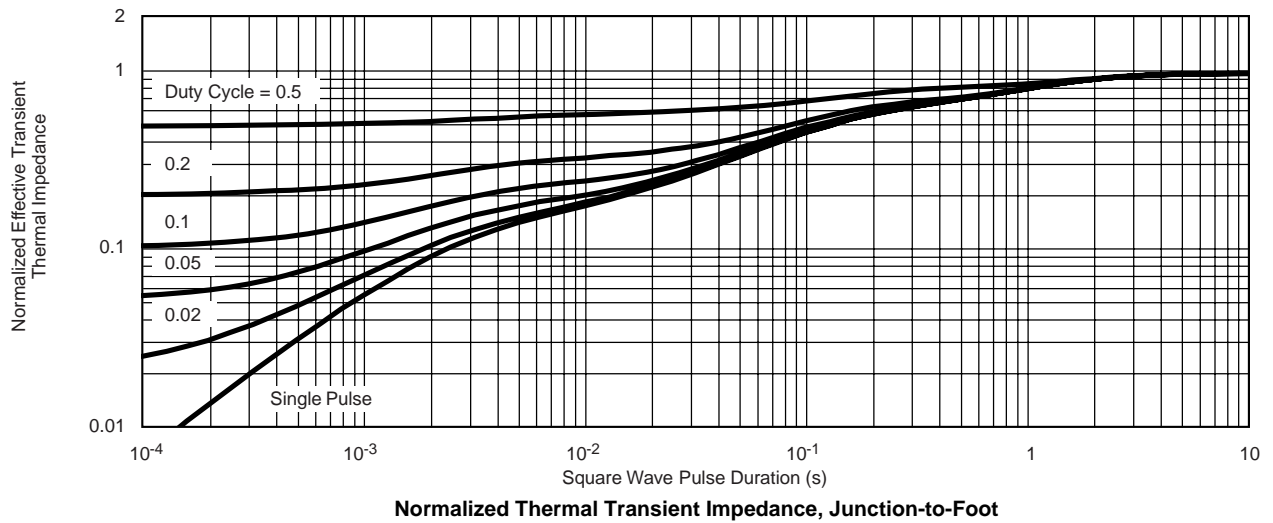
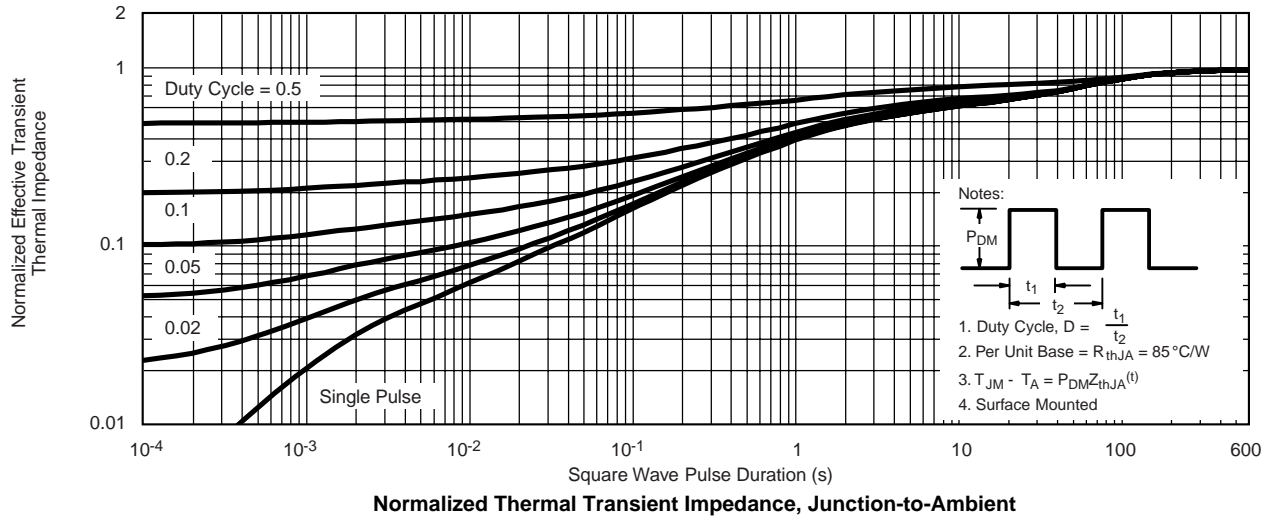


**P-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



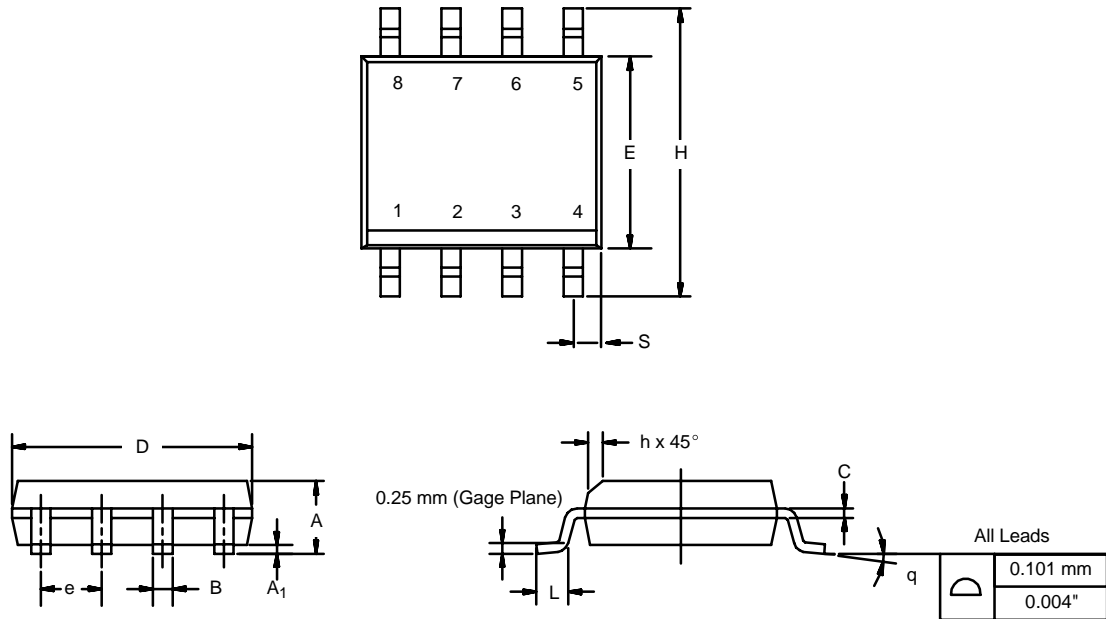
\* The power dissipation  $P_D$  is based on  $T_{J(max)} = 150$  °C, using junction-to-case thermal resistance, and is more useful in settling the upper dissipation limit for cases where additional heatsinking is used. It is used to determine the current rating, when this rating falls below the package limit.

**P-CHANNEL TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



**SOIC (NARROW): 8-LEAD**

JEDEC Part Number: MS-012



DIM	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A <sub>1</sub>	0.10	0.20	0.004	0.008
B	0.35	0.51	0.014	0.020
C	0.19	0.25	0.0075	0.010
D	4.80	5.00	0.189	0.196
E	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
h	0.25	0.50	0.010	0.020
L	0.50	0.93	0.020	0.037
q	0°	8°	0°	8°
S	0.44	0.64	0.018	0.026
ECN: C-06527-Rev. I, 11-Sep-06				
DWG: 5498				

RECOMMENDED MINIMUM PADS FOR SO-8



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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