

## SI2309DS-T1-GE3-VB Datasheet P-Channel 60-V (D-S) MOSFET

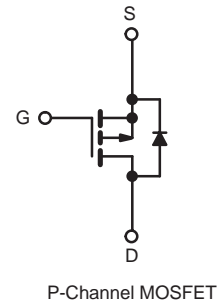
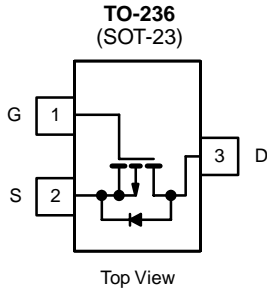
PRODUCT SUMMARY		
$V_{DS}$ (V)	- 60	
$R_{DS(on)}$ ( $\Omega$ )	$V_{GS} = - 10$ V	0.05
$Q_g$ (Max.) (nC)	12	
$Q_{gs}$ (nC)	3.8	
$Q_{gd}$ (nC)	5.1	
Configuration	Single	

### FEATURES

- Isolated Package
- High Voltage Isolation = 2.5 kV<sub>RMS</sub> (t = 60 s; f = 60 Hz)
- Sink to Lead Creepage Distance = 4.8 mm
- P-Channel
- 175 °C Operating Temperature
- Dynamic dV/dt Rating
- Low Thermal Resistance
- Lead (Pb)-free Available



Available  
**RoHS\***  
COMPLIANT


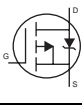


ABSOLUTE MAXIMUM RATINGS $T_C = 25\text{ }^\circ\text{C}$ , unless otherwise noted					
PARAMETER		SYMBOL	LIMIT	UNIT	
Drain-Source Voltage		$V_{DS}$	- 60	V	
Gate-Source Voltage		$V_{GS}$	$\pm 20$		
Continuous Drain Current	$V_{GS}$ at - 10 V	$I_D$	$T_C = 25\text{ }^\circ\text{C}$	- 5.2	A
			$T_C = 100\text{ }^\circ\text{C}$	- 3.8	
Pulsed Drain Current <sup>a</sup>		$I_{DM}$	- 21		
Linear Derating Factor			0.18	W/ $^\circ\text{C}$	
Single Pulse Avalanche Energy <sup>b</sup>		$E_{AS}$	120	mJ	
Repetitive Avalanche Current <sup>a</sup>		$I_{AR}$	- 5.2	A	
Repetitive Avalanche Energy <sup>a</sup>		$E_{AR}$	2.7	mJ	
Maximum Power Dissipation	$T_C = 25\text{ }^\circ\text{C}$	$P_D$	27	W	
Peak Diode Recovery dV/dt <sup>c</sup>		dV/dt	- 4.5	V/ns	
Operating Junction and Storage Temperature Range		$T_J, T_{stg}$	- 55 to + 175	$^\circ\text{C}$	
Soldering Recommendations (Peak Temperature)	for 10 s		300 <sup>d</sup>		
Mounting Torque	6-32 or M3 screw		10		lbf · in
			1.1	N · m	

### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{DD} = - 25$  V, starting  $T_J = 25\text{ }^\circ\text{C}$ , L = 5.0 mH,  $R_G = 25\text{ }\Omega$ ,  $I_{AS} = - 5.3$  A (see fig. 12).
- $I_{SD} \leq - 6.7$  A,  $dI/dt \leq 90$  A/ $\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 175\text{ }^\circ\text{C}$ .
- 1.6 mm from case.

THERMAL RESISTANCE RATINGS				
PARAMETER	SYMBOL	TYP.	MAX.	UNIT
Maximum Junction-to-Ambient	$R_{thJA}$	-	65	°C/W
Maximum Junction-to-Case (Drain)	$R_{thJC}$	-	5.5	

SPECIFICATIONS $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted						
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
<b>Static</b>						
Drain-Source Breakdown Voltage	$V_{DS}$	$V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$	-60	-	-	V
$V_{DS}$ Temperature Coefficient	$\Delta V_{DS}/T_J$	Reference to $25\text{ }^\circ\text{C}$ , $I_D = -1\text{ mA}$	-	-0.060	-	V/°C
Gate-Source Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$	-1.0	-	-2.5	V
Gate-Source Leakage	$I_{GSS}$	$V_{GS} = \pm 20\text{ V}$	-	-	$\pm 100$	nA
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = -60\text{ V}, V_{GS} = 0\text{ V}$	-	-	-100	$\mu\text{A}$
		$V_{DS} = -48\text{ V}, V_{GS} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	-	-500	
Drain-Source On-State Resistance	$R_{DS(on)}$	$V_{GS} = -10\text{ V}, I_D = -3.2\text{ A}^b$	-	0.05	-	$\Omega$
Forward Transconductance	$g_{fs}$	$V_{DS} = -25\text{ V}, I_D = -3.2\text{ A}^b$	1.6	-	-	S
<b>Dynamic</b>						
Input Capacitance	$C_{iss}$	$V_{GS} = 0\text{ V}, V_{DS} = -25\text{ V}, f = 1.0\text{ MHz}$ , see fig. 5	-	270	-	pF
Output Capacitance	$C_{oss}$		-	170	-	
Reverse Transfer Capacitance	$C_{rss}$		-	31	-	
Drain to Sink Capacitance	$C$	$f = 1.0\text{ MHz}$	-	12	-	
Total Gate Charge	$Q_g$	$V_{GS} = -10\text{ V}, I_D = -4.7\text{ A}, V_{DS} = -48\text{ V}$ , see fig. 6 and 13 <sup>b</sup>	-	-	12	nC
Gate-Source Charge	$Q_{gs}$		-	-	3.8	
Gate-Drain Charge	$Q_{gd}$		-	-	5.1	
Turn-On Delay Time	$t_{d(on)}$	$V_{DD} = -30\text{ V}, I_D = -4.7\text{ A}, R_G = 24\text{ }\Omega, R_D = 4.0\text{ }\Omega$ , see fig. 10 <sup>b</sup>	-	11	-	ns
Rise Time	$t_r$		-	63	-	
Turn-Off Delay Time	$t_{d(off)}$		-	9.6	-	
Fall Time	$t_f$		-	31	-	
Internal Drain Inductance	$L_D$	Between lead, 6 mm (0.25") from package and center of die contact 	-	4.5	-	nH
Internal Source Inductance	$L_S$		-	7.5	-	
<b>Drain-Source Body Diode Characteristics</b>						
Continuous Source-Drain Diode Current	$I_S$	MOSFET symbol showing the integral reverse p-n junction diode 	-	-	-5.2	A
Pulsed Diode Forward Current <sup>a</sup>	$I_{SM}$		-	-	-21	
Body Diode Voltage	$V_{SD}$	$T_J = 25\text{ }^\circ\text{C}, I_S = -5.2\text{ A}, V_{GS} = 0\text{ V}^b$	-	-	-5.5	V
Body Diode Reverse Recovery Time	$t_{rr}$	$T_J = 25\text{ }^\circ\text{C}, I_F = -4.7\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$	-	80	160	ns
Body Diode Reverse Recovery Charge	$Q_{rr}$		-	0.096	0.19	$\mu\text{C}$
Forward Turn-On Time	$t_{on}$	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$ )				

**Notes**

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).  
 b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted

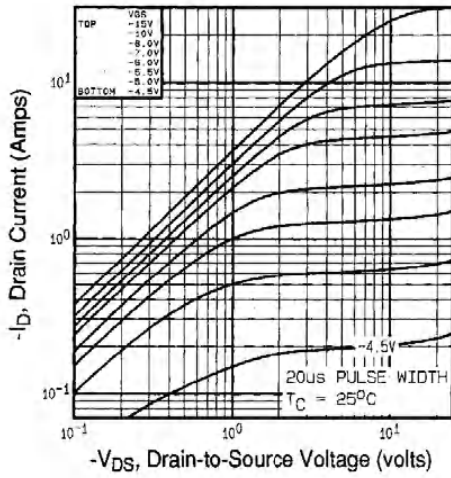


Fig. 1 - Typical Output Characteristics,  $T_C = 25\text{ }^\circ\text{C}$

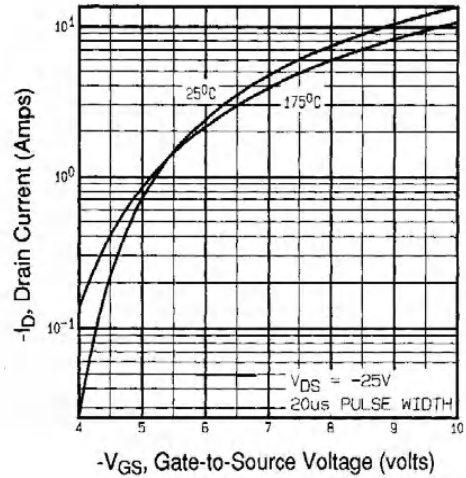


Fig. 3 - Typical Transfer Characteristics

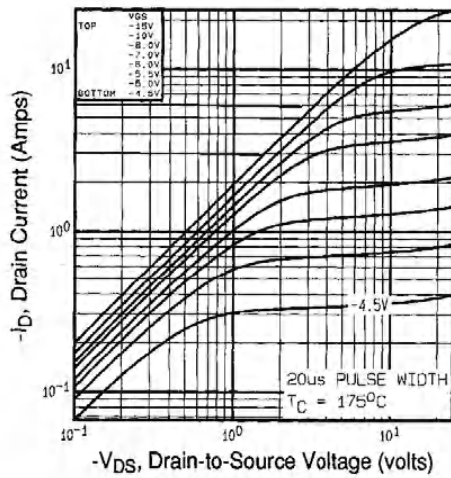


Fig. 2 - Typical Output Characteristics,  $T_C = 175\text{ }^\circ\text{C}$

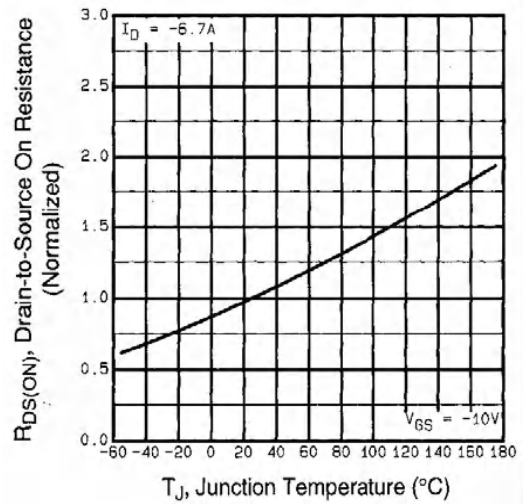


Fig. 4 - Normalized On-Resistance vs. Temperature



Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

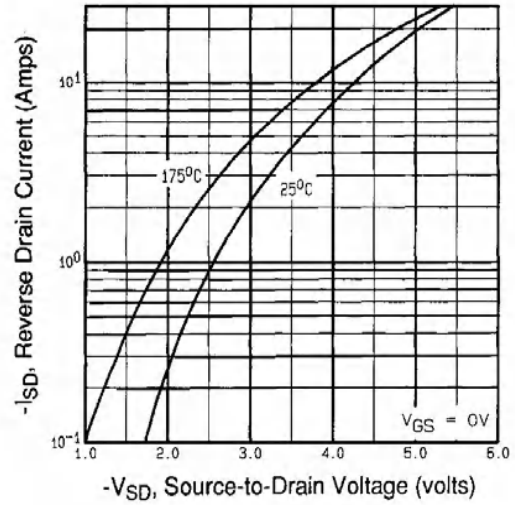


Fig. 7 - Typical Source-Drain Diode Forward Voltage



Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

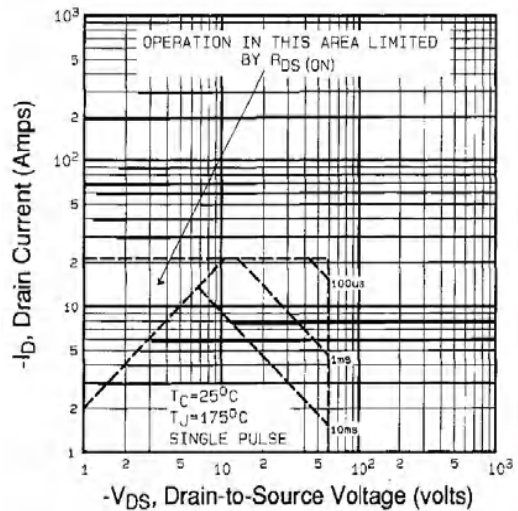


Fig. 8 - Maximum Safe Operating Area

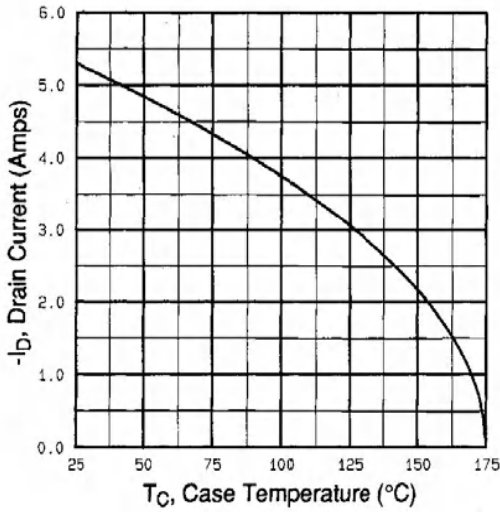


Fig. 9 - Maximum Drain Current vs. Case Temperature

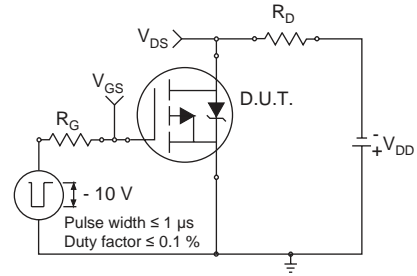


Fig. 10a - Switching Time Test Circuit

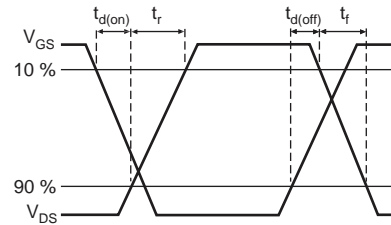


Fig. 10b - Switching Time Waveforms



Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

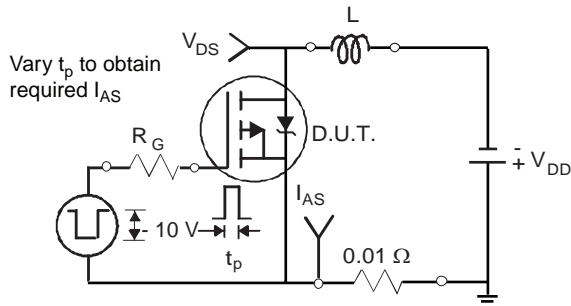


Fig. 12a - Unclamped Inductive Test Circuit

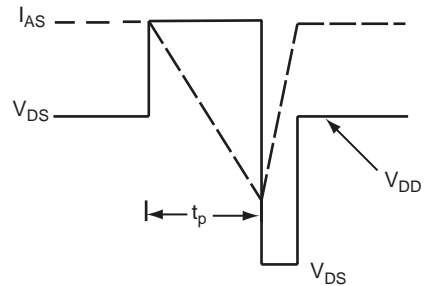


Fig. 12b - Unclamped Inductive Waveforms

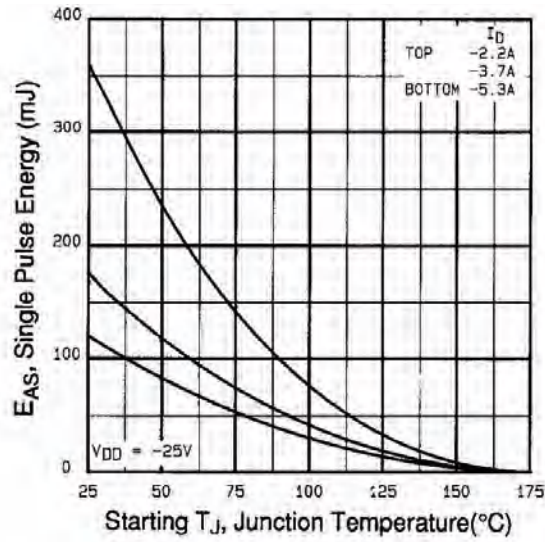


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

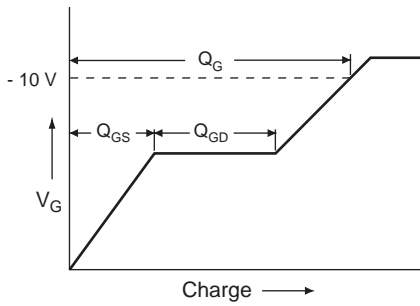


Fig. 13a - Basic Gate Charge Waveform

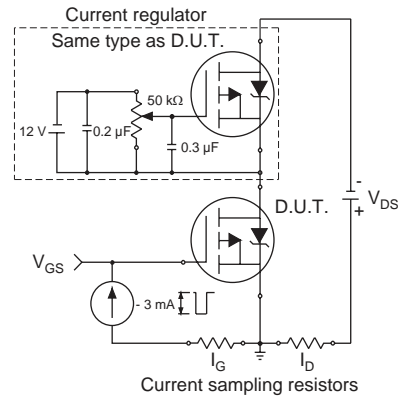
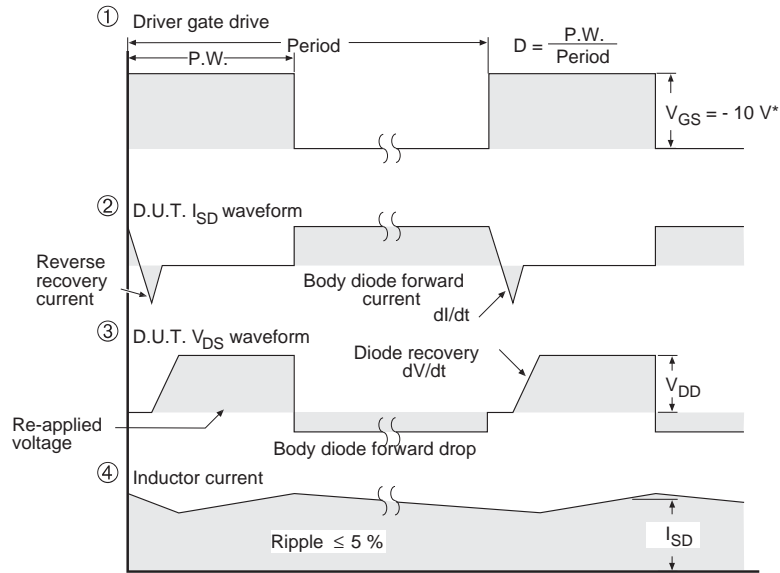
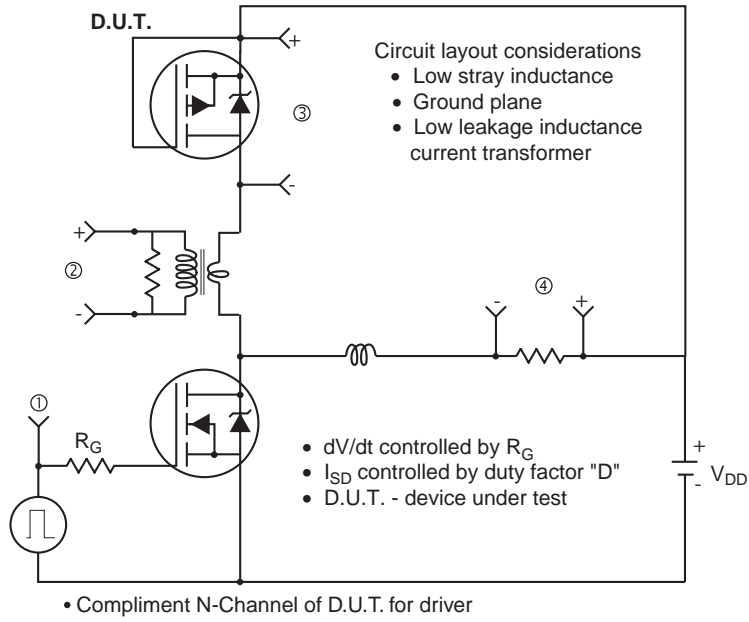


Fig. 13b - Gate Charge Test Circuit

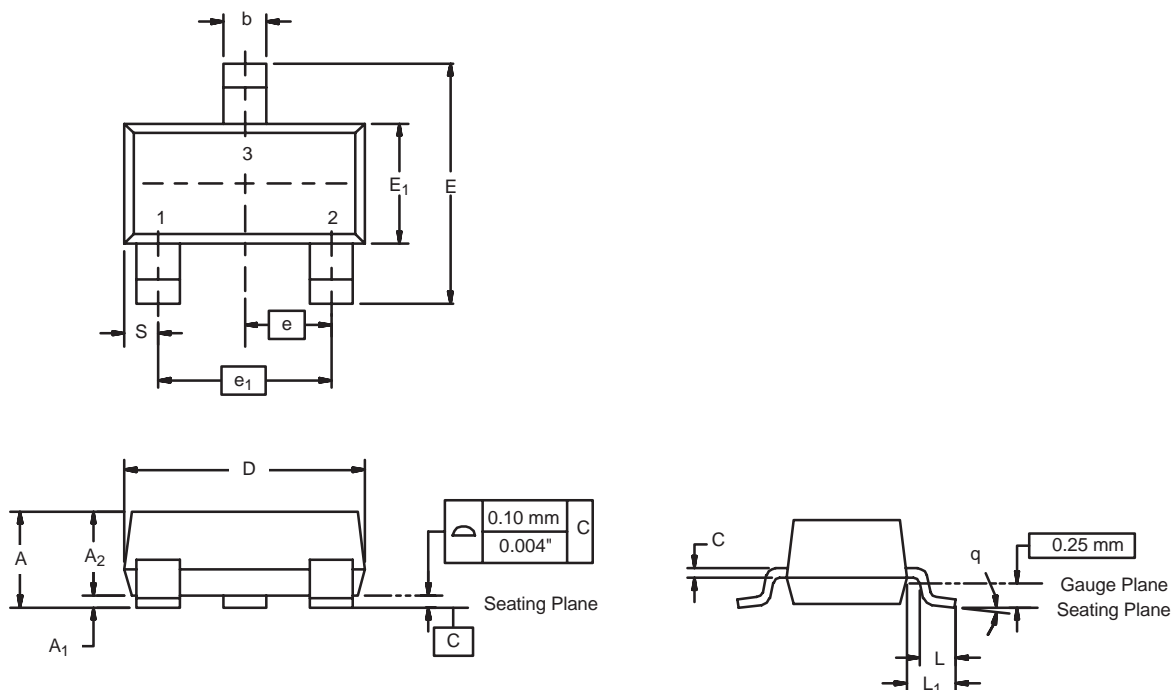
### Peak Diode Recovery dV/dt Test Circuit



\*  $V_{GS} = -5\text{ V}$  for logic level and  $-3\text{ V}$  drive devices

**Fig. 14 - For P-Channel**

**SOT-23 (TO-236): 3-LEAD**

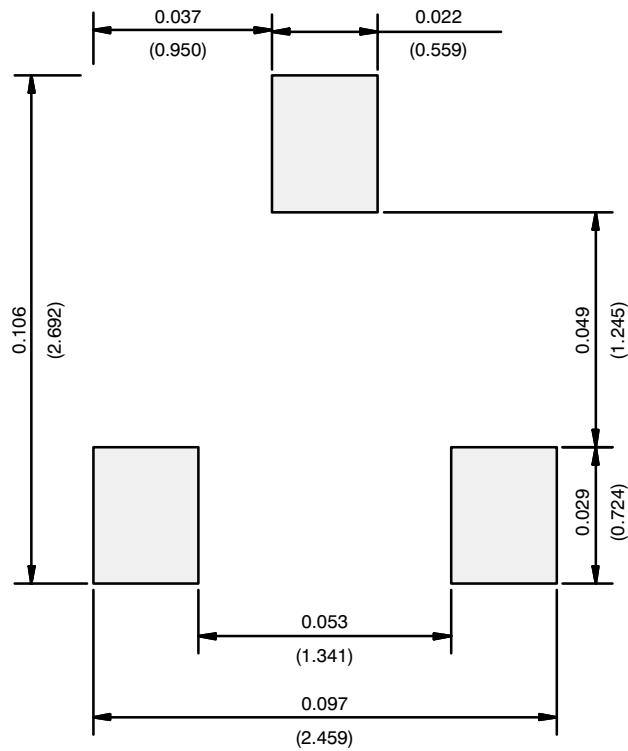


Dim	MILLIMETERS		INCHES	
	Min	Max	Min	Max
A	0.89	1.12	0.035	0.044
A <sub>1</sub>	0.01	0.10	0.0004	0.004
A <sub>2</sub>	0.88	1.02	0.0346	0.040
b	0.35	0.50	0.014	0.020
c	0.085	0.18	0.003	0.007
D	2.80	3.04	0.110	0.120
E	2.10	2.64	0.083	0.104
E <sub>1</sub>	1.20	1.40	0.047	0.055
e	0.95 BSC		0.0374 Ref	
e <sub>1</sub>	1.90 BSC		0.0748 Ref	
L	0.40	0.60	0.016	0.024
L <sub>1</sub>	0.64 Ref		0.025 Ref	
S	0.50 Ref		0.020 Ref	
q	3°	8°	3°	8°

ECN: S-03946-Rev. K, 09-Jul-01  
DWG: 5479



RECOMMENDED MINIMUM PADS FOR SOT-23



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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