

## P-Channel Enhancement Mode Power MOSFET

### Description

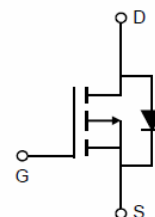
The HM2309D uses advanced trench technology and design to provide excellent  $R_{DS(ON)}$  with low gate charge. This device is well suited for use as a load switch or in PWM applications.

### General Features

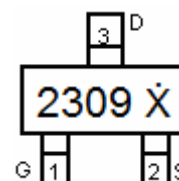
- $V_{DS} = -60V, I_D = -1.6A$   
 $R_{DS(ON)} < 330m\Omega @ V_{GS} = -10V$
- High density cell design for ultra low  $R_{dson}$
- Fully characterized avalanche voltage and current
- Excellent package for good heat dissipation

### Application

- Load switch
- PWM application



Schematic diagram



Marking and pin Assignment



SOT-23 top view

## Package Marking and Ordering Information

Device Marking	Device	Device Package	Reel Size	Tape width	Quantity
2309 X	HM2309D	SOT-23	Ø180mm	8 mm	3000 units

## Absolute Maximum Ratings ( $T_C=25^\circ C$ unless otherwise noted)

Parameter	Symbol	Limit	Unit
Drain-Source Voltage	$V_{DS}$	-60	V
Gate-Source Voltage	$V_{GS}$	$\pm 20$	V
Drain Current-Continuous	$I_D$	-1.6	A
Pulsed Drain Current	$I_{DM}$	-8	A
Maximum Power Dissipation	$P_D$	1.5	W
Operating Junction and Storage Temperature Range	$T_J, T_{STG}$	-55 To 150	$^\circ C$

## Thermal Characteristic

Thermal Resistance, Junction-to-Ambient <sup>(Note 2)</sup>	$R_{\theta JA}$	83.3	$^\circ C/W$
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## Electrical Characteristics ( $T_C=25^\circ C$ unless otherwise noted)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
<b>Off Characteristics</b>						
Drain-Source Breakdown Voltage	$BV_{DSS}$	$V_{GS}=0V, I_D=-250\mu A$	-60	-	-	V
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS}=-60V, V_{GS}=0V$	-	-	-1	$\mu A$

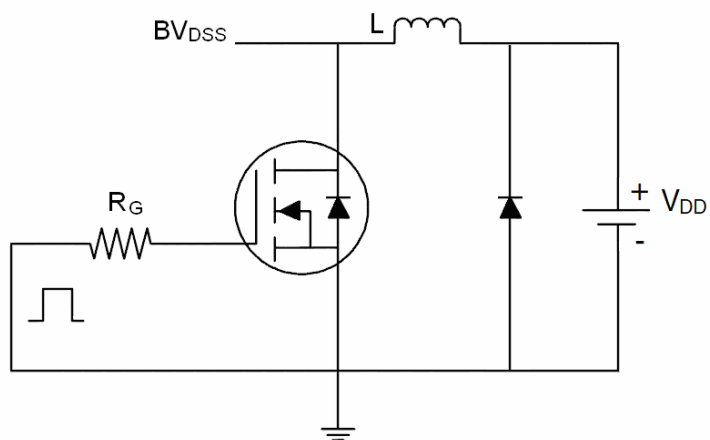
Parameter	Symbol	Condition	Min	Typ	Max	Unit
Gate-Body Leakage Current	$I_{GSS}$	$V_{GS}=\pm 20V, V_{DS}=0V$	-	-	$\pm 100$	nA
<b>On Characteristics</b> (Note 3)						
Gate Threshold Voltage	$V_{GS(th)}$	$V_{DS}=V_{GS}, I_D=-250\mu A$	-2	-2.8	-3.5	V
Drain-Source On-State Resistance	$R_{DS(ON)}$	$V_{GS}=-10V, I_D=-1.5A$	-	270	330	m $\Omega$
Forward Transconductance	$g_{FS}$	$V_{DS}=-5V, I_D=-1.5A$	-	3	-	S
<b>Dynamic Characteristics</b> (Note4)						
Input Capacitance	$C_{iss}$	$V_{DS}=-30V, V_{GS}=0V,$ $F=1.0MHz$	-	370	-	PF
Output Capacitance	$C_{oss}$		-	31.5	-	PF
Reverse Transfer Capacitance	$C_{rss}$		-	5	-	PF
<b>Switching Characteristics</b> (Note 4)						
Turn-on Delay Time	$t_{d(on)}$	$V_{DD}=-30V, I_D=1.5A,$ $V_{GS}=-10V, R_G=3\Omega$	-	40	-	nS
Turn-on Rise Time	$t_r$		-	35	-	nS
Turn-Off Delay Time	$t_{d(off)}$		-	15	-	nS
Turn-Off Fall Time	$t_f$		-	10	-	nS
Total Gate Charge	$Q_g$	$V_{DS}=-30, I_D=-1.5A,$ $V_{GS}=-10V$	-	14.3	-	nC
Gate-Source Charge	$Q_{gs}$		-	2.2	-	nC
Gate-Drain Charge	$Q_{gd}$		-	3.2	-	nC
<b>Drain-Source Diode Characteristics</b>						
Diode Forward Voltage (Note 3)	$V_{SD}$	$V_{GS}=0V, I_S=-1.5A$	-		-1.2	V
Diode Forward Current (Note 2)	$I_S$		-	-	-1.6	A
Reverse Recovery Time	$t_{rr}$	$T_J = 25^\circ C, I_F = -1.5A$ $di/dt = -100A/\mu s$ (Note3)	-	25		nS
Reverse Recovery Charge	$Q_{rr}$		-	31		nC

**Notes:**

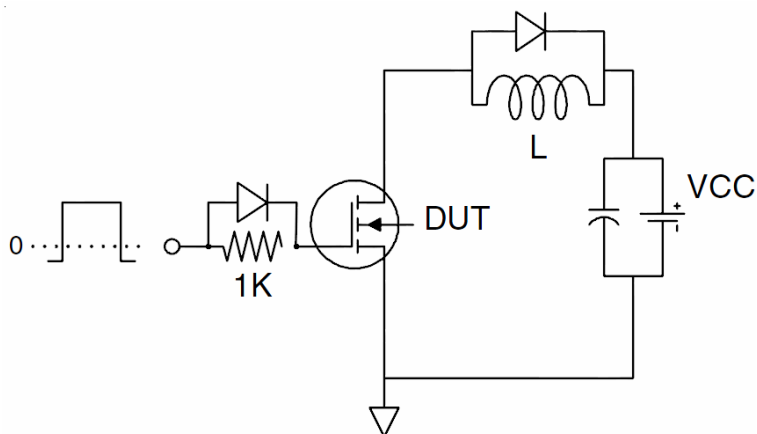
1. Repetitive Rating: Pulse width limited by maximum junction temperature.
2. Surface Mounted on FR4 Board,  $t \leq 10$  sec.
3. Pulse Test: Pulse Width  $\leq 300\mu s$ , Duty Cycle  $\leq 2\%$ .
4. Guaranteed by design, not subject to production

**Test Circuit**

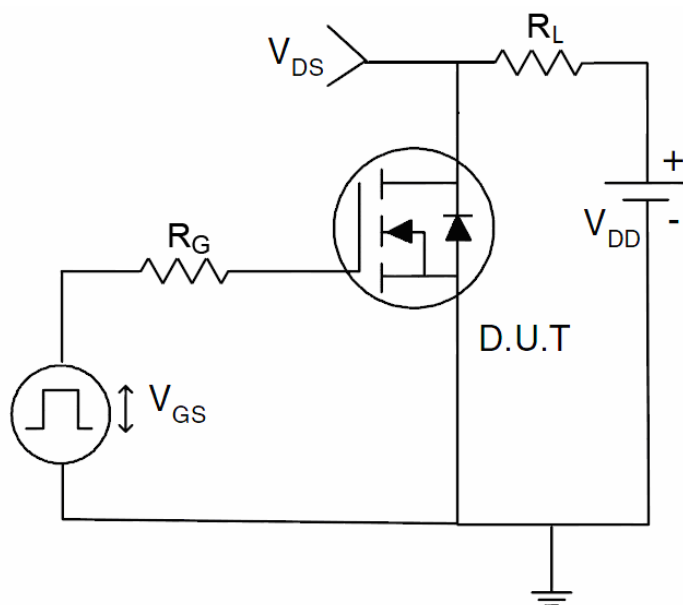
1)  $E_{AS}$  test Circuit



2) Gate charge test Circuit



3) Switch Time Test Circuit



Typical Electrical and Thermal Characteristics (Curves)

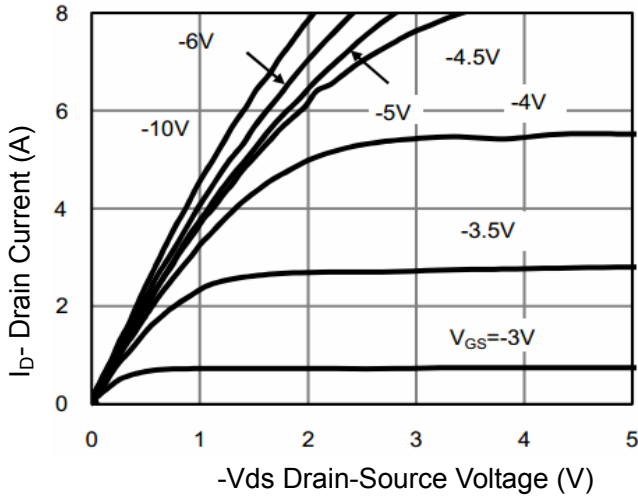


Figure 1 Output Characteristics

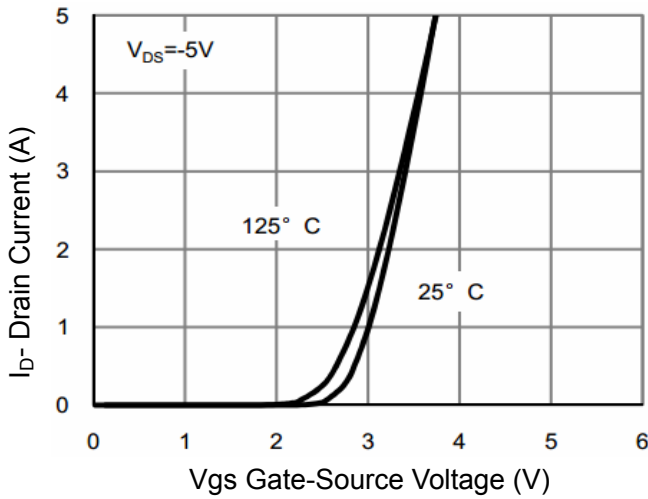


Figure 2 Transfer Characteristics

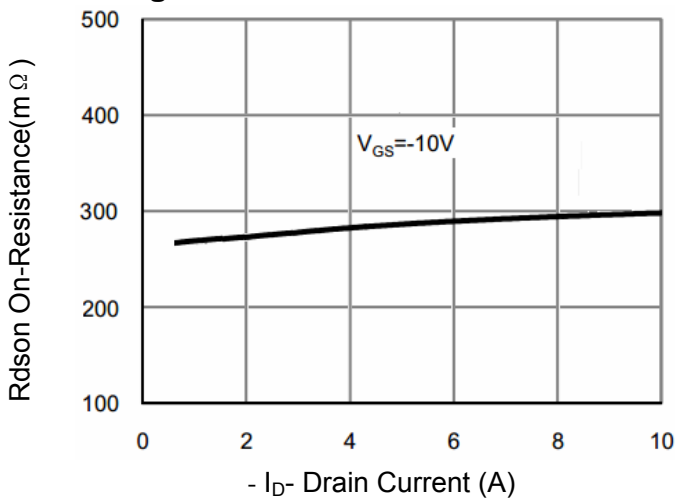


Figure 3  $R_{DS(on)}$ - Drain Current

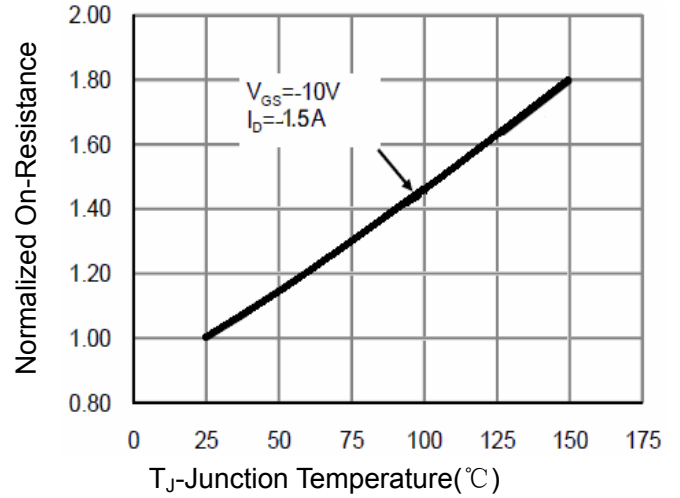


Figure 4  $R_{DS(on)}$ -Junction Temperature

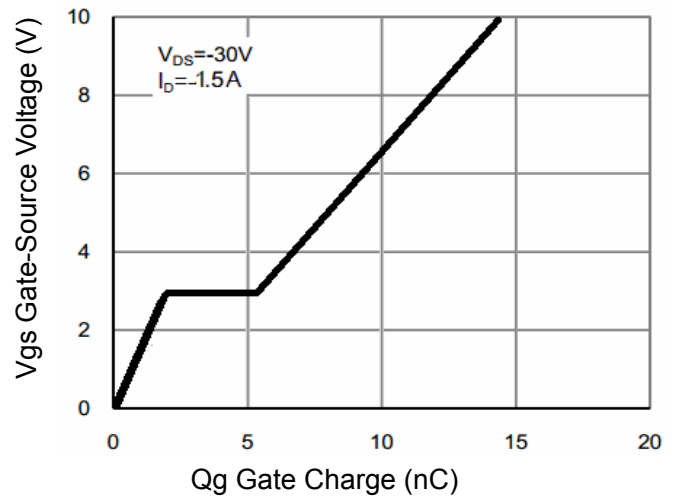


Figure 5 Gate Charge

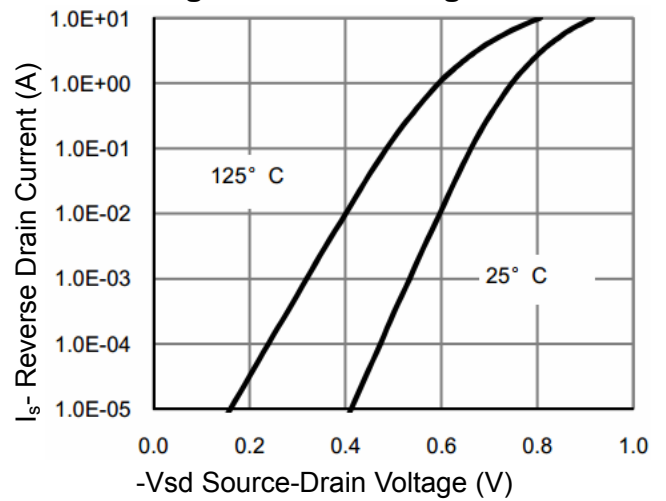
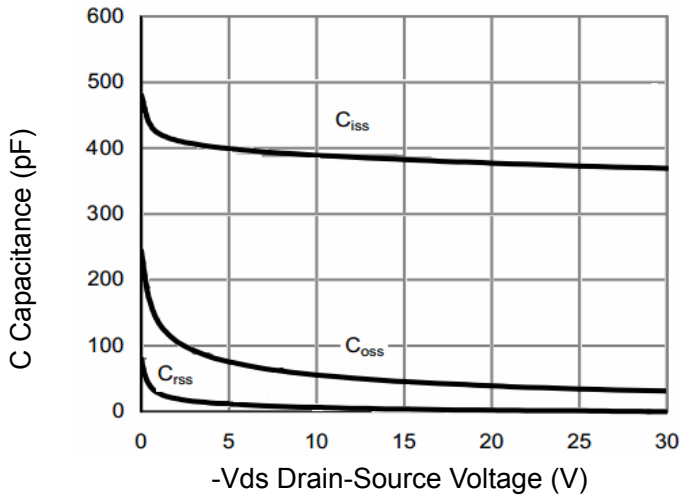
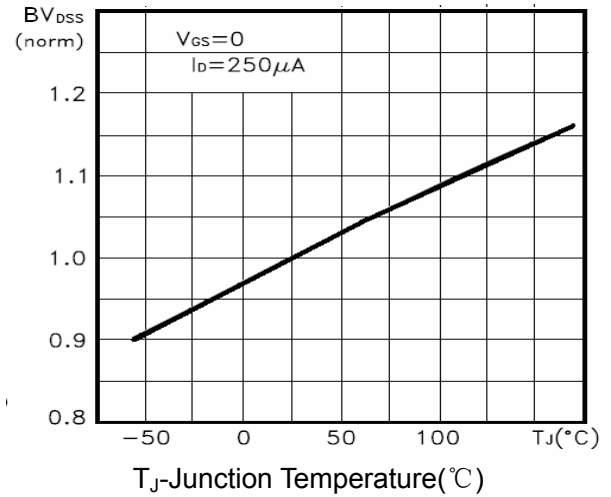


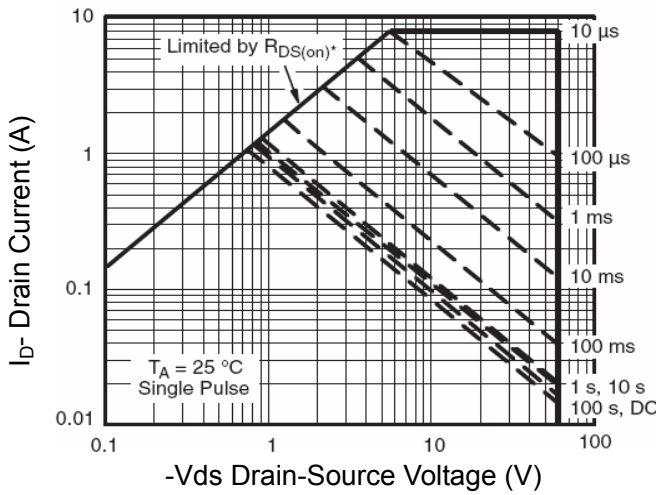
Figure 6 Source- Drain Diode Forward



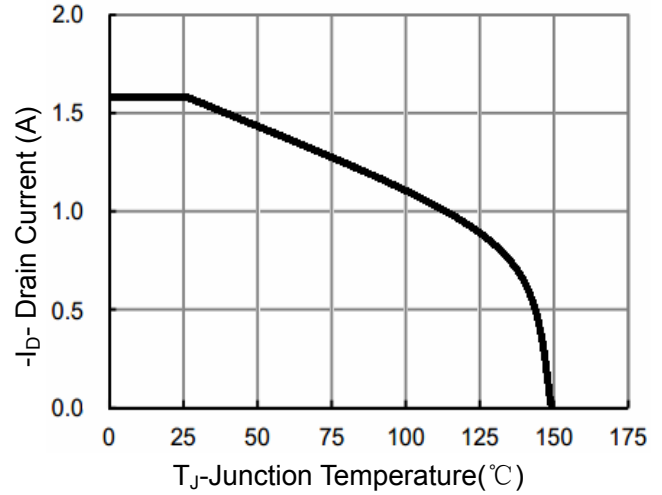
**Figure 7 Capacitance vs Vds**



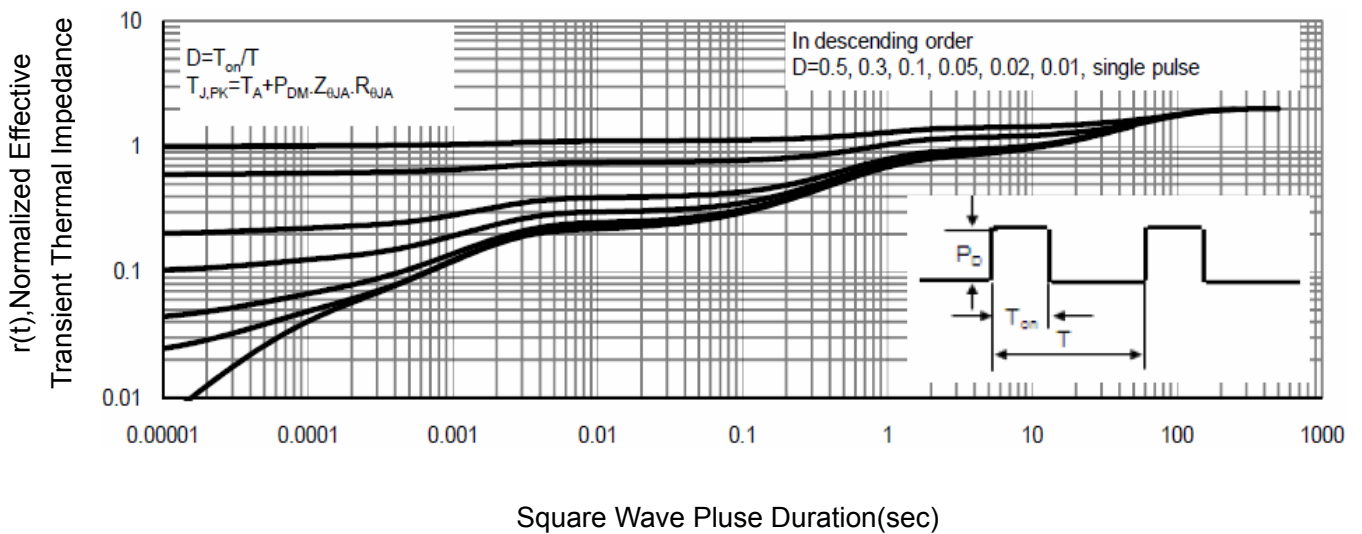
**Figure 9  $BV_{DSS}$  vs Junction Temperature**



**Figure 8 Safe Operation Area**

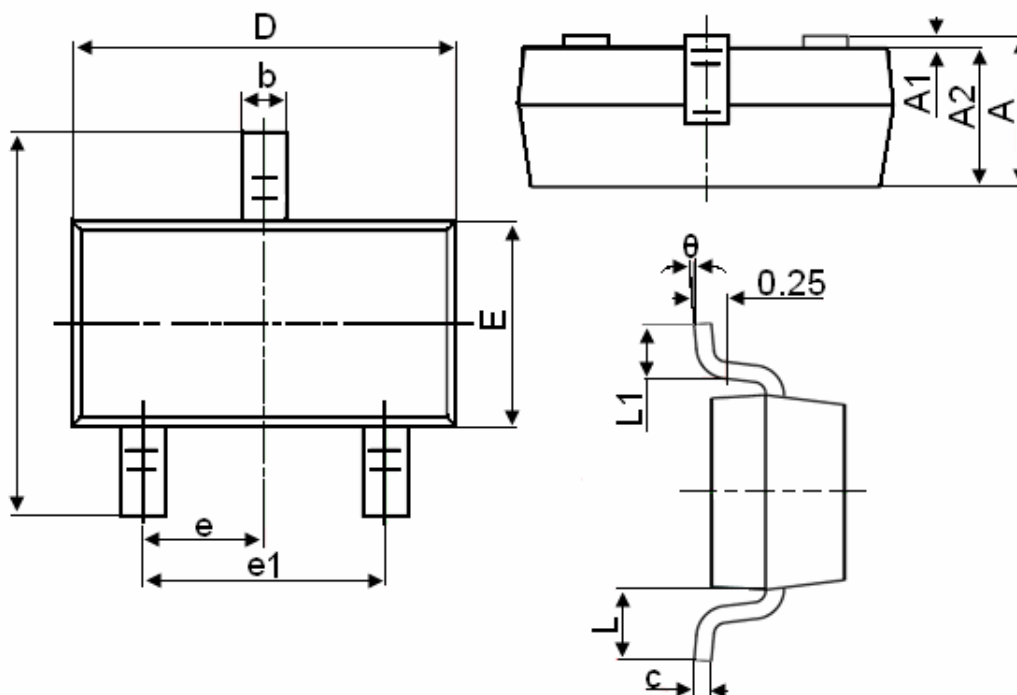


**Figure 10 ID Current De-rating**



**Figure 11 Normalized Maximum Transient Thermal Impedance**

## SOT-23 Package Information



Symbol	Dimensions in Millimeters	
	MIN.	MAX.
A	0.900	1.150
A1	0.000	0.100
A2	0.900	1.050
b	0.300	0.500
c	0.080	0.150
D	2.800	3.000
E	1.200	1.400
E1	2.250	2.550
e	0.950TYP	
e1	1.800	2.000
L	0.550REF	
L1	0.300	0.500
$\theta$	0°	8°

### Notes

- All dimensions are in millimeters.
- Tolerance  $\pm 0.10\text{mm}$  (4 mil) unless otherwise specified
- Package body sizes exclude mold flash and gate burrs. Mold flash at the non-lead sides should be less than 5 mils.
- Dimension L is measured in gauge plane.
- Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.