

Power MOSFET



P-Channel MOSFET

FEATURES

- Advanced process technology
- Fully avalanche rated
- Surface-mount (IRFR9310, SiHFR9310)
- Straight lead (IRFU9310, SiHFU9310)
- P-channel
- Fast switching
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT
HALOGEN
FREE
Available

DESCRIPTION

Third generation power MOSFETs from Vishay utilize advanced processing techniques to achieve low on-resistance per silicon area. This benefit, combined with the fast switching speed and ruggedized device design that power MOSFETs are well known for, provides the designer with an extremely efficient and reliable device for use in a wide variety of applications.

The DPAK is designed for surface mounting using vapor phase, infrared, or wave soldering techniques. The straight lead version (IRFU/SiHFU series) is for through-hole mounting applications. Power dissipation levels up to 1.5 W are possible in typical surface-mount applications.

PRODUCT SUMMARY

V_{DS} (V)	-400	
$R_{DS(on)}$ (Ω)	$V_{GS} = -10$ V	7.0
Q_g (Max.) (nC)	13	
Q_{gs} (nC)	3.2	
Q_{gd} (nC)	5.0	
Configuration	Single	

ORDERING INFORMATION

Package	DPAK (TO-252)	DPAK (TO-252)	DPAK (TO-252)	DPAK (TO-252)	IPAK (TO-251)
Lead (Pb)-free and halogen-free	SiHFR9310-GE3	SiHFR9310TRL-GE3	SiHFR9310TR-GE3	SiHFR9310TRR-GE3	SiHFU9310-GE3
Lead (Pb)-free	IRFR9310PbF	IRFR9310TRLPbF ^a	IRFR9310TRPbF ^a	IRFR9310TRRPbF ^a	IRFU9310PbF

Note

- a. See device orientation

ABSOLUTE MAXIMUM RATINGS ($T_C = 25$ °C, unless otherwise noted)

PARAMETER	SYMBOL	LIMIT	UNIT	
Drain-source voltage	V_{DS}	-400	V	
Gate-source voltage	V_{GS}	± 20		
Continuous drain current	V_{GS} at -10 V	$T_C = 25$ °C	A	
		$T_C = 100$ °C		
Pulsed drain current ^a	I_{DM}	-7.2		
Linear derating factor		0.40	W/°C	
Single pulse avalanche energy ^b	E_{AS}	92	mJ	
Repetitive avalanche current ^a	I_{AR}	-1.8	A	
Repetitive avalanche energy ^a	E_{AR}	5.0	mJ	
Maximum power dissipation	$T_C = 25$ °C	P_D	50	W
Peak diode recovery dV/dt ^c	dV/dt	-24	V/ns	
Operating junction and storage temperature range	T_J, T_{stg}	-55 to +150	°C	
Soldering recommendations (peak temperature) ^d	For 10 s	300		

Notes

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
 b. Starting $T_J = 25$ °C, $L = 57$ mH, $R_g = 25$ Ω , $I_{AS} = -1.8$ A (see fig. 12)
 c. $I_{SD} \leq -1.1$ A, $dI/dt \leq 450$ A/ μ s, $V_{DD} \leq V_{DS}$, $T_J \leq 150$ °C
 d. 1.6 mm from case



THERMAL RESISTANCE RATINGS					
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Maximum junction-to-ambient	R_{thJA}	-	-	110	°C/W
Maximum junction-to-ambient (PCB mount) ^a	R_{thJA}	-	-	50	
Maximum junction-to-case (drain)	R_{thJC}	-	-	2.5	

Note

a. When mounted on 1" square PCB (FR-4 or G-10 material)

SPECIFICATIONS ($T_J = 25\text{ }^\circ\text{C}$, unless otherwise noted)							
PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
Static							
Drain-source breakdown voltage	V_{DS}	$V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$		-400	-	-	V
V_{DS} temperature coefficient	$\Delta V_{DS}/T_J$	Reference to $25\text{ }^\circ\text{C}$, $I_D = -1\text{ mA}$		-	-0.41	-	V/°C
Gate-source threshold voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = -250\text{ }\mu\text{A}$		-2.0	-	-4.0	V
Gate-source leakage	I_{GSS}	$V_{GS} = \pm 20\text{ V}$		-	-	± 100	nA
Zero gate voltage drain current	I_{DSS}	$V_{DS} = -400\text{ V}, V_{GS} = 0\text{ V}$		-	-	-100	μA
		$V_{DS} = -320\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$		-	-	-500	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS} = -10\text{ V}$	$I_D = -1.1\text{ A}^b$	-	-	7.0	Ω
Forward transconductance	g_{fs}	$V_{DS} = -50\text{ V}, I_D = -1.1\text{ A}$		0.91	-	-	S
Dynamic							
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}			-	50	-	
Reverse transfer capacitance	C_{rss}			-	8.0	-	
Total gate charge	Q_g	$V_{GS} = -10\text{ V}$	$I_D = -1.1\text{ A}, V_{DS} = -320\text{ V}$, see fig. 6 and 13 ^b	-	-	13	nC
Gate-source charge	Q_{gs}			-	-	3.2	
Gate-drain charge	Q_{gd}			-	-	5.0	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = -200\text{ V}, I_D = -1.1\text{ A}, R_g = 21\text{ }\Omega, R_D = 180\text{ }\Omega$, see fig. 10 ^b		-	11	-	ns
Rise time	t_r			-	10	-	
Turn-off delay time	$t_{d(off)}$			-	25	-	
Fall time	t_f			-	24	-	
Internal drain inductance	L_D	Between lead, 6 mm (0.25") from package and center of die contact ^c		-	4.5	-	nH
Internal source inductance	L_S			-	7.5	-	
Drain-Source Body Diode Characteristics							
Continuous source-drain diode current	I_S	MOSFET symbol showing the integral reverse p-n junction diode		-	-	-1.9	A
Pulsed diode forward current ^a	I_{SM}			-	-	-7.6	
Body diode voltage	V_{SD}	$T_J = 25\text{ }^\circ\text{C}, I_S = -1.1\text{ A}, V_{GS} = 0\text{ V}^b$		-	-	-4.0	V
Body diode reverse recovery time	t_{rr}	$T_J = 25\text{ }^\circ\text{C}, I_F = -1.1\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$		-	170	260	ns
Body diode reverse recovery charge	Q_{rr}			-	640	960	nC
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 $\leq 2\%$
- c. This is applied for IPAK, L_S of DPAK is measured between lead and center of die contact



TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

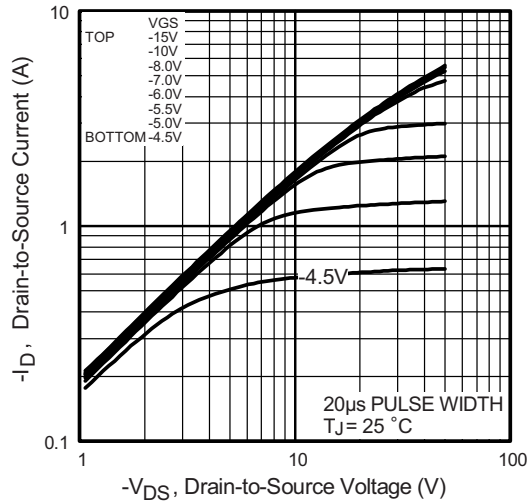


Fig. 1 - Typical Output Characteristics



Fig. 2 - Typical Transfer Characteristics

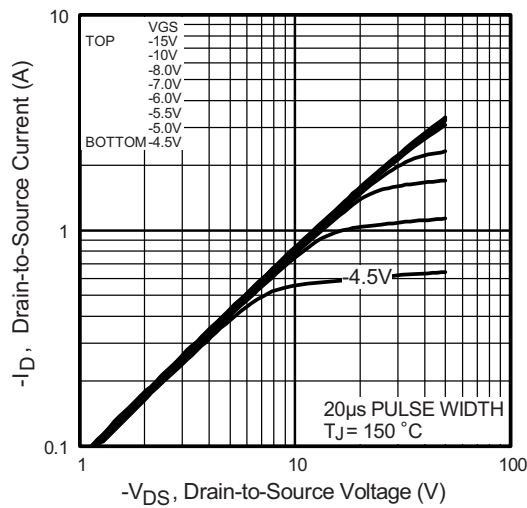


Fig. 1 - Typical Output Characteristics

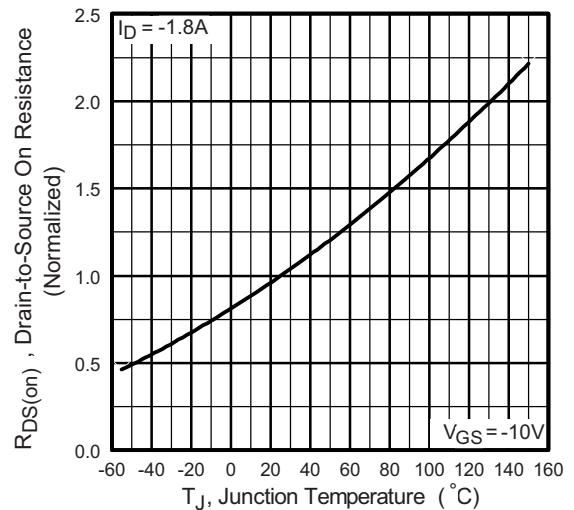


Fig. 3 - Normalized On-Resistance vs. Temperature

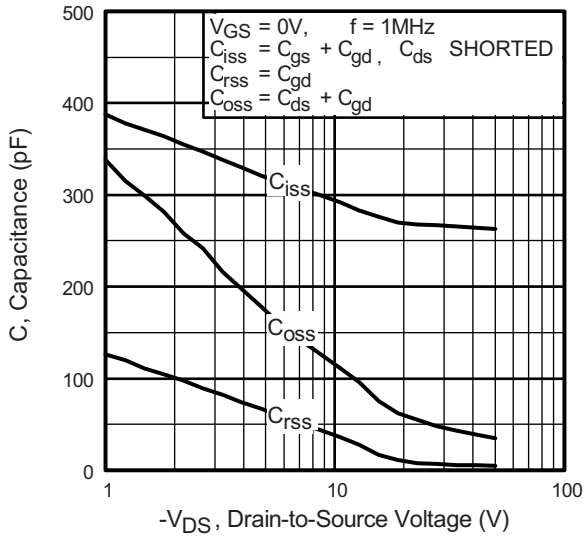


Fig. 4 - Typical Capacitance vs. Drain-to-Source Voltage

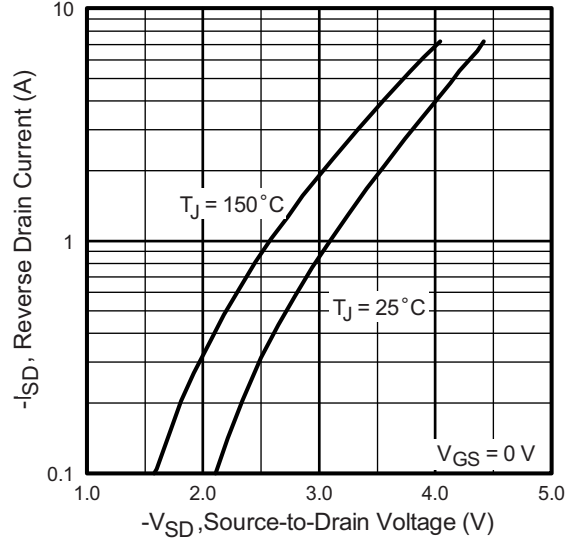


Fig. 6 - Typical Source-Drain Diode Forward Voltage

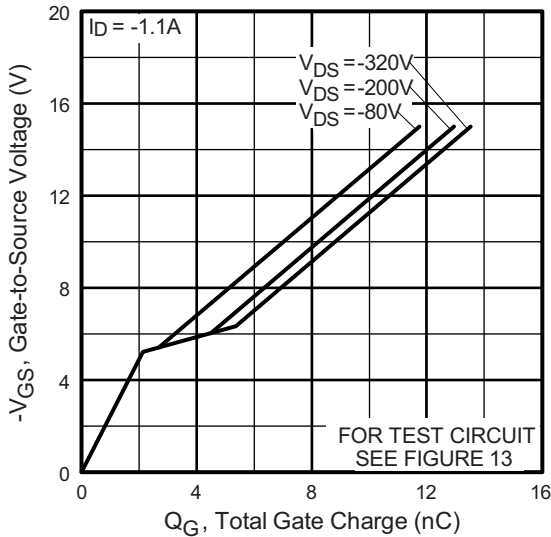


Fig. 5 - Typical Gate Charge vs. Gate-to-Source Voltage

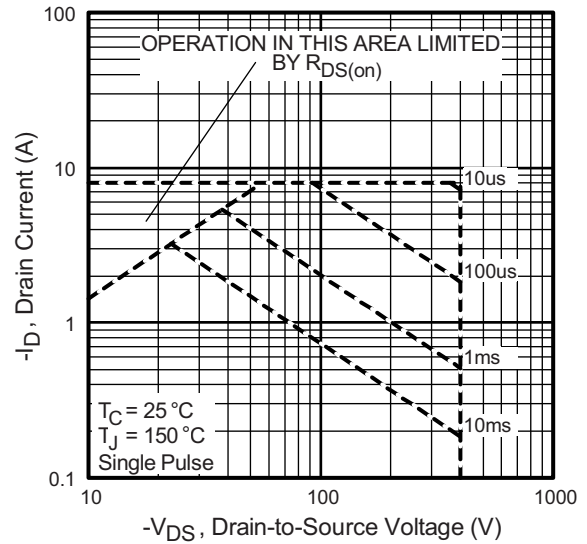


Fig. 7 - Maximum Safe Operating Area

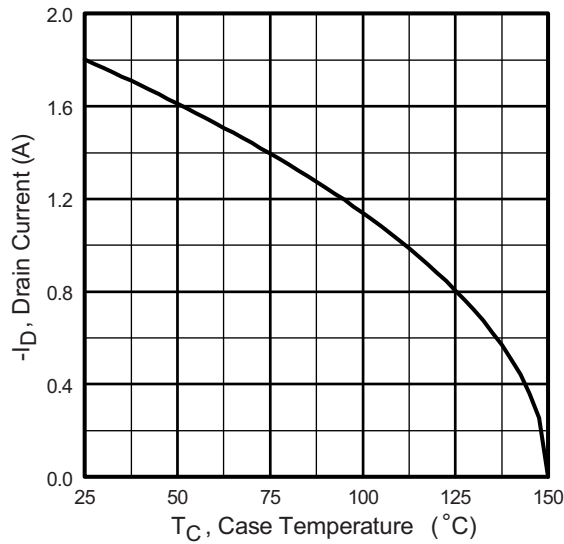


Fig. 8 - Maximum Drain Current vs. Case Temperature



Fig. 10a - Switching Time Test Circuit



Fig. 10b - Switching Time Waveforms

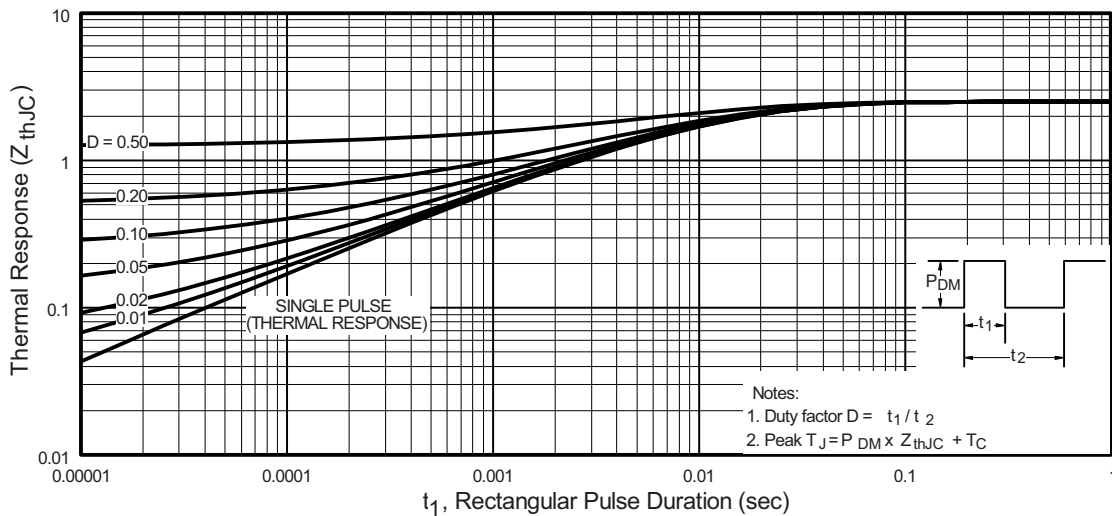


Fig. 9 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

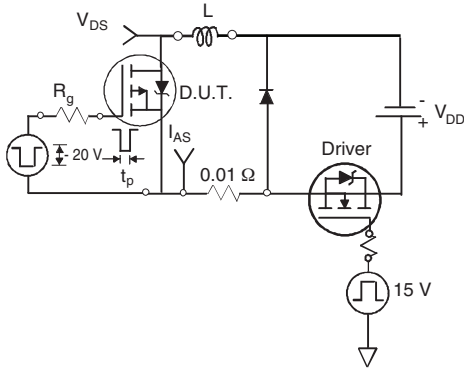


Fig. 12a - Unclamped Inductive Test Circuit

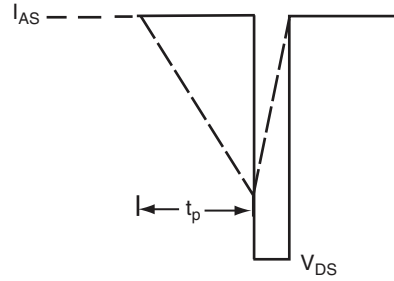


Fig. 12b - Unclamped Inductive Waveforms

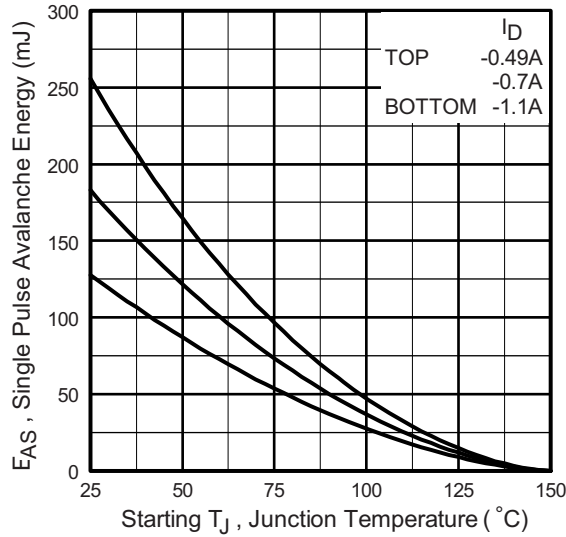


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

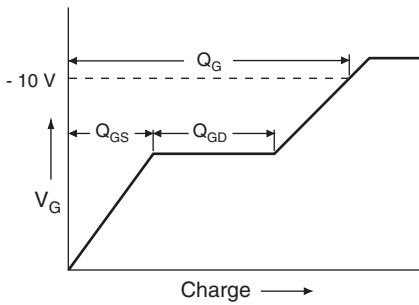


Fig. 13a - Basic Gate Charge Waveform

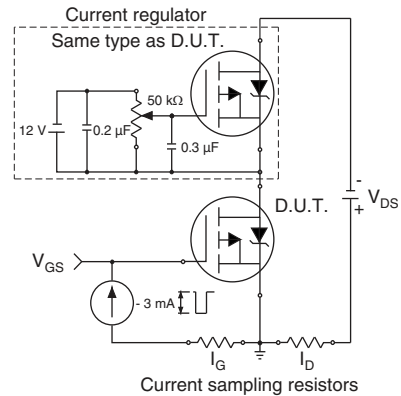
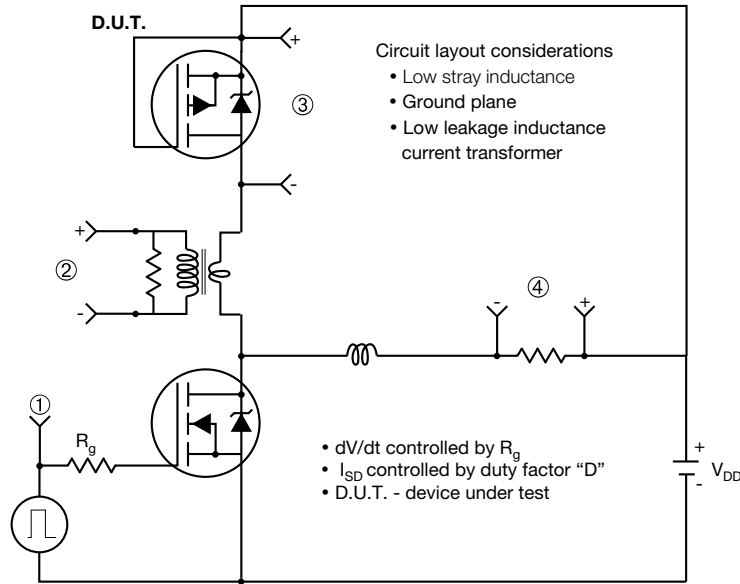


Fig. 13b - Gate Charge Test Circuit

Peak Diode Recovery dV/dt Test Circuit



Note
• Compliment N-Channel of D.U.T. for driver



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

Fig. 10 - For P-Channel

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TO-252AA Case Outline

VERSION 1: FACILITY CODE = Y



MILLIMETERS		
DIM.	MIN.	MAX.
A	2.18	2.38
A1	-	0.127
b	0.64	0.88
b2	0.76	1.14
b3	4.95	5.46
C	0.46	0.61
C2	0.46	0.89
D	5.97	6.22
D1	4.10	-
E	6.35	6.73
E1	4.32	-
H	9.40	10.41
e	2.28 BSC	
e1	4.56 BSC	
L	1.40	1.78
L3	0.89	1.27
L4	-	1.02
L5	1.01	1.52

Note

- Dimension L3 is for reference only



VERSION 2: FACILITY CODE = N



MILLIMETERS		
DIM.	MIN.	MAX.
A	2.18	2.39
A1	-	0.13
b	0.65	0.89
b1	0.64	0.79
b2	0.76	1.13
b3	4.95	5.46
c	0.46	0.61
c1	0.41	0.56
c2	0.46	0.60
D	5.97	6.22
D1	5.21	-
E	6.35	6.73
E1	4.32	-
e	2.29 BSC	
H	9.94	10.34

MILLIMETERS		
DIM.	MIN.	MAX.
L	1.50	1.78
L1	2.74 ref.	
L2	0.51 BSC	
L3	0.89	1.27
L4	-	1.02
L5	1.14	1.49
L6	0.65	0.85
θ	0°	10°
θ1	0°	15°
θ2	25°	35°

Notes

- Dimensioning and tolerance confirm to ASME Y14.5M-1994
- All dimensions are in millimeters. Angles are in degrees
- Heat sink side flash is max. 0.8 mm
- Radius on terminal is optional

ECN: E22-0399-Rev. R, 03-Oct-2022
 DWG: 5347

Case Outline for TO-251AA (High Voltage)

OPTION 1:



DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	2.18	2.39	0.086	0.094
A1	0.89	1.14	0.035	0.045
b	0.64	0.89	0.025	0.035
b1	0.65	0.79	0.026	0.031
b2	0.76	1.14	0.030	0.045
b3	0.76	1.04	0.030	0.041
b4	4.95	5.46	0.195	0.215
c	0.46	0.61	0.018	0.024
c1	0.41	0.56	0.016	0.022
c2	0.46	0.86	0.018	0.034
D	5.97	6.22	0.235	0.245

DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
D1	5.21	-	0.205	-
E	6.35	6.73	0.250	0.265
E1	4.32	-	0.170	-
e	2.29 BSC		2.29 BSC	
L	8.89	9.65	0.350	0.380
L1	1.91	2.29	0.075	0.090
L2	0.89	1.27	0.035	0.050
L3	1.14	1.52	0.045	0.060
θ1	0°	15°	0°	15°
θ2	25°	35°	25°	35°

ECN: E21-0682-Rev. C, 27-Dec-2021
DWG: 5968

Notes

- Dimensioning and tolerancing per ASME Y14.5M-1994
- Dimension are shown in inches and millimeters
- Dimension D and E do not include mold flash. Mold flash shall not exceed 0.13 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body
- Thermal pad contour optional with dimensions b4, L2, E1 and D1
- Lead dimension uncontrolled in L3
- Dimension b1, b3 and c1 apply to base metal only
- Outline conforms to JEDEC® outline TO-251AA



OPTION 2: FACILITY CODE = N



DIM.	MIN.	NOM.	MAX.
A	2.180	2.285	2.390
A1	0.890	1.015	1.140
b	0.640	0.765	0.890
b1	0.640	0.715	0.790
b2	0.760	0.950	1.140
b3	0.760	0.900	1.040
b4	4.950	5.205	5.460
c	0.460	-	0.610
c1	0.410	-	0.560
c2	0.460	-	0.610
D	5.970	6.095	6.220
D1	4.300	-	-

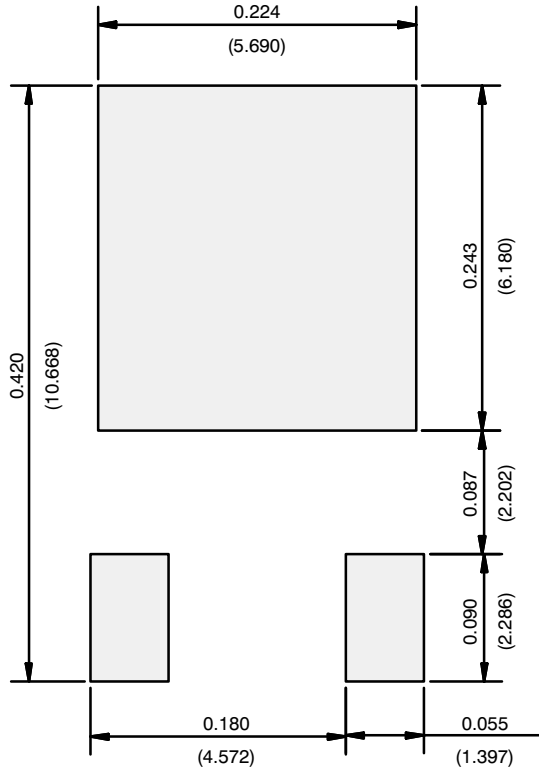
DIM.	MIN.	NOM.	MAX.
D2	5.380	-	-
E	6.350	6.540	6.730
E1	4.32	-	-
e	2.29 BSC		
L	8.890	9.270	9.650
L1	1.910	2.100	2.290
L2	0.890	1.080	1.270
L3	1.140	1.330	1.520
L4	1.300	1.400	1.500
theta 1	0°	7.5°	15°
theta 2	4°	-	-

ECN: E21-0682-Rev. C, 27-Dec-2021
DWG: 5968

Notes

- Dimensioning and tolerancing per ASME Y14.5M-1994
- All dimension are in millimeters, angles are in degrees
- Heat sink side flash is max. 0.8 mm

RECOMMENDED MINIMUM PADS FOR DPAK (TO-252)



Recommended Minimum Pads
Dimensions in Inches/(mm)

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