

## Power MOSFET



P-Channel MOSFET

### FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- Surface-mount (IRFR9220, SiHFR9220)
- Straight lead (IRFU9220, SiHFU9220)
- Available in tape and reel
- P-channel
- Fast switching
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



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

### PRODUCT SUMMARY

$V_{DS}$ (V)	-200	
$R_{DS(on)}$ ( $\Omega$ )	$V_{GS} = -10$ V	1.5
$Q_g$ (Max.) (nC)	20	
$Q_{gs}$ (nC)	3.3	
$Q_{gd}$ (nC)	11	
Configuration	Single	

### DESCRIPTION

Third power MOSFETs technology is the key to Vishay advanced line of Power MOSFET transistors. The efficient geometry and unique processing of the Power MOSFETs design achieve very low on-state resistance combined with high transconductance and extreme device ruggedness.

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.

### ORDERING INFORMATION

Package	DPAK (TO-252)	DPAK (TO-252)	DPAK (TO-252)	DPAK (TO-252)	IPAK (TO-251)
Lead (Pb)-free and halogen-free	SiHFR9220-GE3	SiHFR9220TRL-GE3 <sup>a</sup>	SiHFR9220TRR-GE3 <sup>a</sup>	SiHFR9220TR-GE3 <sup>a</sup>	SiHFU9220-GE3
	IRFR9220PbF-BE3	IRFR9220TRPbF-BE3	-	-	-
Lead (Pb)-free	IRFR9220PbF	IRFR9220TRLPbF <sup>a</sup>	IRFR9220TRRPbF <sup>a</sup>	IRFR9220TRPbF <sup>a</sup>	IRFU9220PbF

#### Note

a. See device orientation

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

PARAMETER	SYMBOL	LIMIT	UNIT
Drain-source voltage	$V_{DS}$	-200	V
Gate-source voltage	$V_{GS}$	$\pm 20$	
Continuous drain current	$V_{GS}$ at -10 V	$T_C = 25$ °C	-3.6
		$T_C = 100$ °C	-2.3
Pulsed drain current <sup>a</sup>	$I_{DM}$	-14	A
Linear derating factor		0.33	
Linear derating factor (PCB mount) <sup>e</sup>		0.020	W/°C
Single pulse avalanche energy <sup>b</sup>	$E_{AS}$	310	mJ
Repetitive avalanche current <sup>a</sup>	$I_{AR}$	-3.6	A
Repetitive avalanche energy <sup>a</sup>	$E_{AR}$	4.2	mJ
Maximum power dissipation	$P_D$	$T_C = 25$ °C	42
Maximum power dissipation (PCB mount) <sup>e</sup>		$T_A = 25$ °C	2.5
Peak diode recovery dV/dt <sup>c</sup>	$dV/dt$	-5.0	V/ns
Operating junction and storage temperature range	$T_J, T_{stg}$	-55 to +150	°C
Soldering recommendations (peak temperature) <sup>d</sup>	For 10 s	260	

#### Notes



- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- $V_{DD} = -50$  V, Starting  $T_J = 25$  °C,  $L = 35$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = -3.6$  A (see fig. 12)
- $I_{SD} \leq -3.9$  A,  $dI/dt \leq 95$  A/ $\mu$ s,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150$  °C
- 1.6 mm from case
- When mounted on 1" square PCB (FR-4 or G-10 material)



THERMAL RESISTANCE RATINGS					
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNIT
Maximum junction-to-ambient	$R_{thJA}$	-	-	110	°C/W
Maximum junction-to-ambient (PCB mount) <sup>a</sup>	$R_{thJA}$	-	-	50	
Maximum junction-to-case (drain)	$R_{thJC}$	-	-	3.0	

**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
<b>Static</b>							
Drain-source breakdown voltage	$V_{DS}$	$V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$		- 200	-	-	V
$V_{DS}$ temperature coefficient	$\Delta V_{DS}/T_J$	Reference to $25\text{ }^\circ\text{C}$ , $I_D = -1\text{ mA}$		-	- 0.22	-	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	$I_{GSS}$	$V_{GS} = \pm 20\text{ V}$		-	-	$\pm 100$	nA
Zero gate voltage drain current	$I_{DSS}$	$V_{DS} = -200\text{ V}, V_{GS} = 0\text{ V}$		-	-	- 100	$\mu\text{A}$
		$V_{DS} = -160\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$		-	-	- 500	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS} = -10\text{ V}$	$I_D = -2.2\text{ A}^b$	-	-	1.5	$\Omega$
Forward transconductance	$g_{fs}$	$V_{DS} = -50\text{ V}, I_D = -2.2\text{ A}$		1.1	-	-	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		-	340	-	pF
Output capacitance	$C_{oss}$			-	110	-	
Reverse transfer capacitance	$C_{rss}$			-	33	-	
Total gate charge	$Q_g$	$V_{GS} = -10\text{ V}$	$I_D = -3.9\text{ A}, V_{DS} = -160\text{ V}$ , see fig. 6 and 13 <sup>b</sup>	-	-	20	nC
Gate-source charge	$Q_{gs}$			-	-	3.3	
Gate-drain charge	$Q_{gd}$			-	-	11	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = -100\text{ V}, I_D = -3.9\text{ A}, R_g = 18\text{ }\Omega, R_D = 24\text{ }\Omega$ , see fig. 10 <sup>b</sup>		-	8.8	-	ns
Rise time	$t_r$			-	27	-	
Turn-off delay time	$t_{d(off)}$			-	7.3	-	
Fall time	$t_f$			-	19	-	
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 		-	-	- 3.6	A
Pulsed diode forward current <sup>a</sup>	$I_{SM}$			-	-	- 14	
Body diode voltage	$V_{SD}$	$T_J = 25\text{ }^\circ\text{C}, I_S = -3.6\text{ A}, V_{GS} = 0\text{ V}^b$		-	-	- 6.3	V
Body diode reverse recovery time	$t_{rr}$	$T_J = 25\text{ }^\circ\text{C}, I_F = -3.9\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$		-	150	300	ns
Body diode reverse recovery charge	$Q_{rr}$			-	0.97	2.0	$\mu\text{C}$
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  $\leq 2\text{ }\%$

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



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

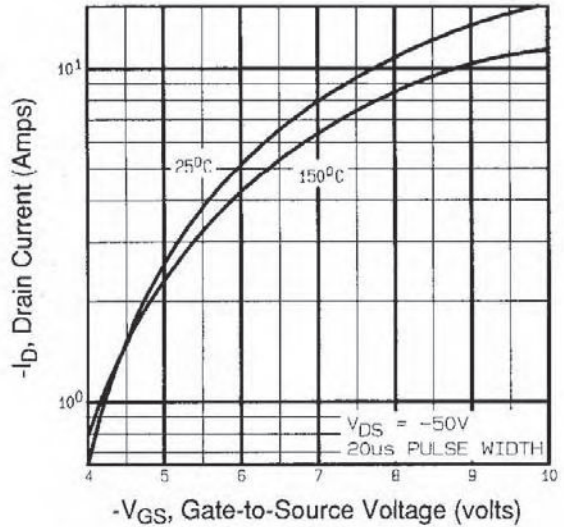


Fig. 2 - Typical Transfer Characteristics

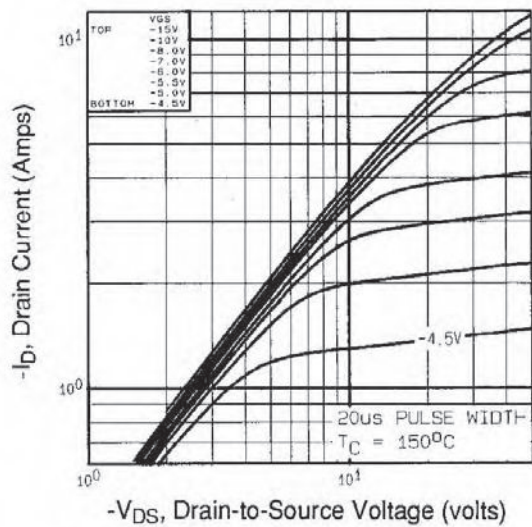


Fig. 1 - Typical Output Characteristics,  $T_C = 150\text{ }^\circ\text{C}$

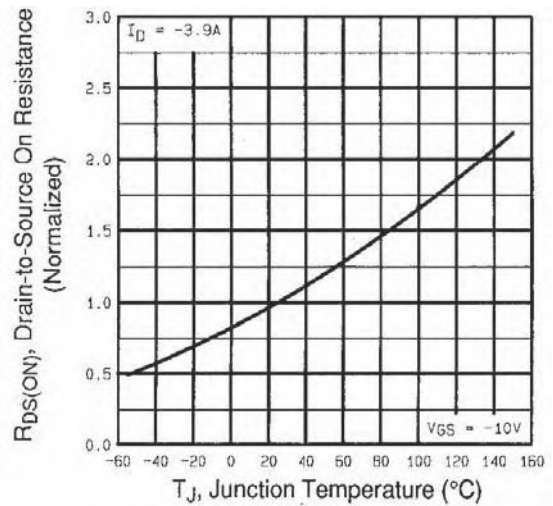


Fig. 3 - Normalized On-Resistance vs. Temperature



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

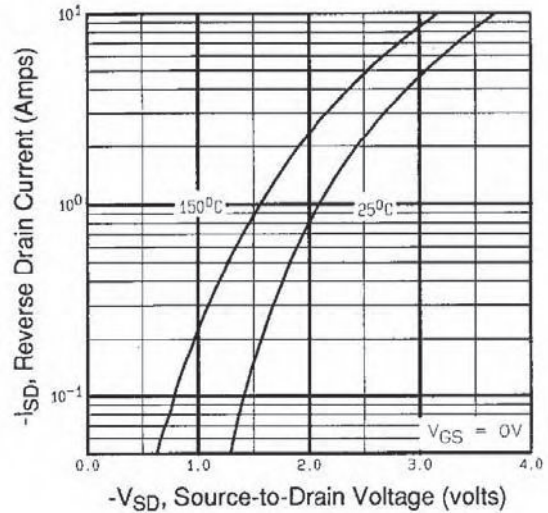


Fig. 6 - Typical Source-Drain Diode Forward Voltage

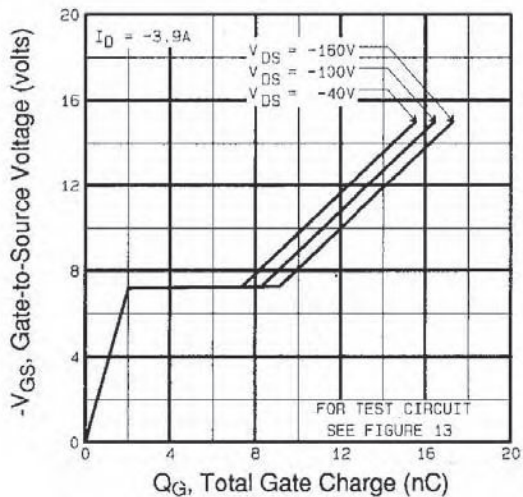


Fig. 5 - Typical Gate Charge vs. Gate-to-Source Voltage

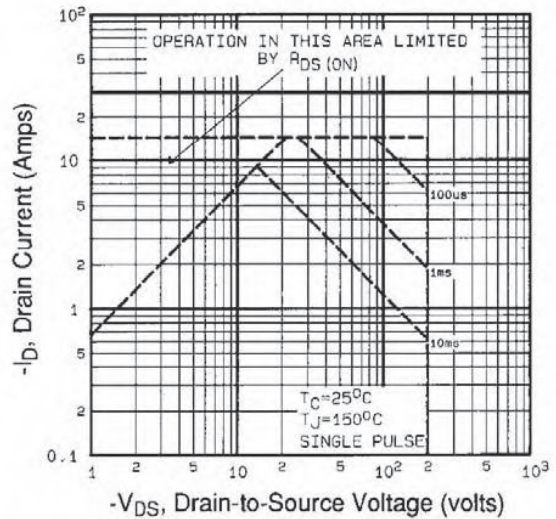


Fig. 7 - Maximum Safe Operating Area

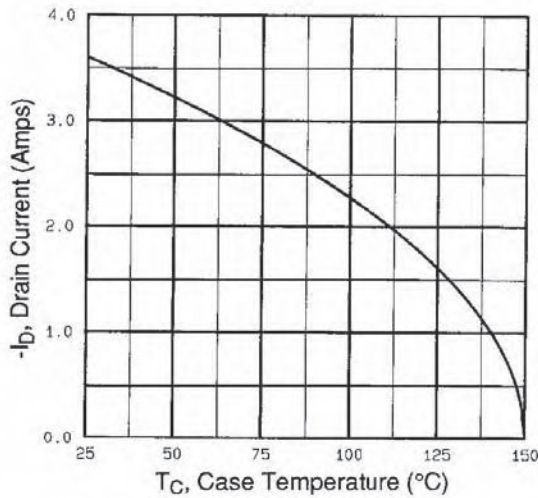


Fig. 8 - Maximum Drain Current vs. Case Temperature

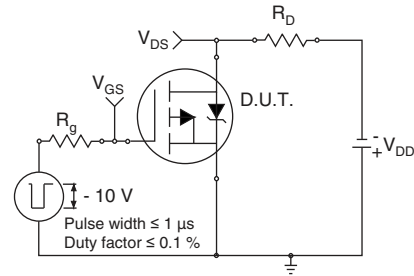


Fig. 10a - Switching Time Test Circuit

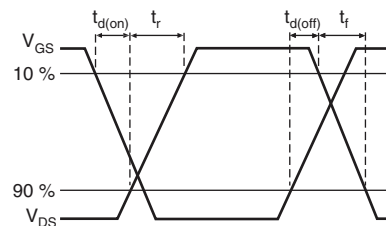


Fig. 10b - Switching Time Waveforms

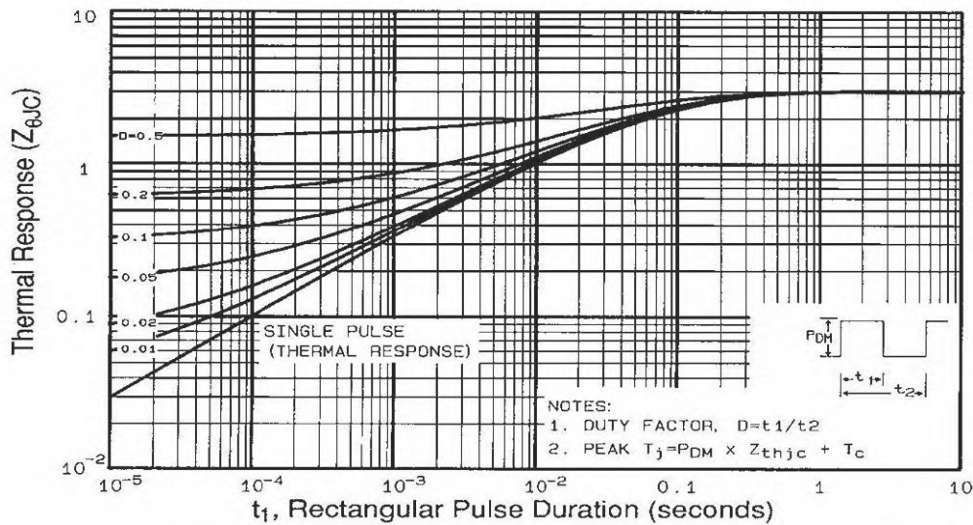


Fig. 9 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

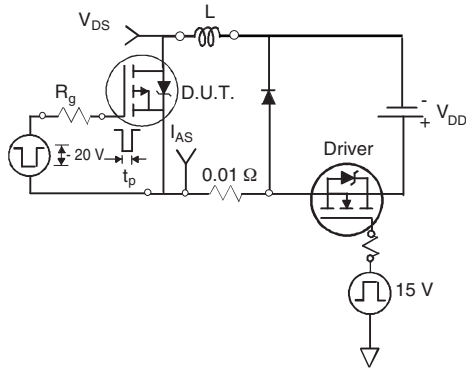


Fig. 12a - Unclamped Inductive Test Circuit

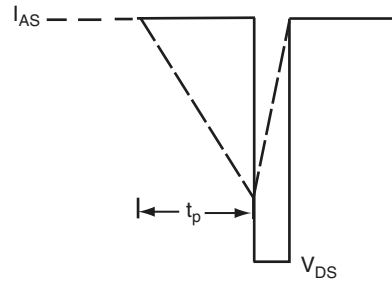


Fig. 12b - Unclamped Inductive Waveforms

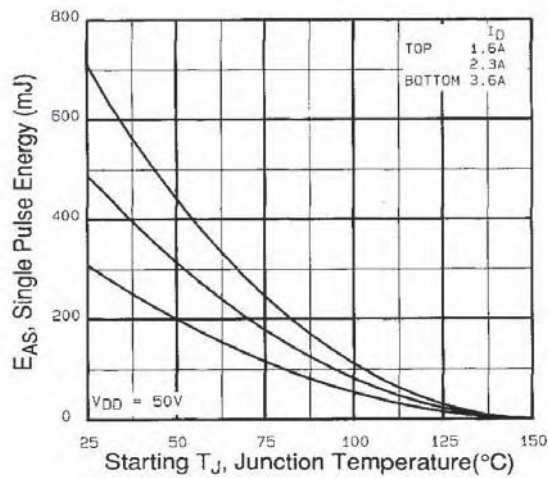


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

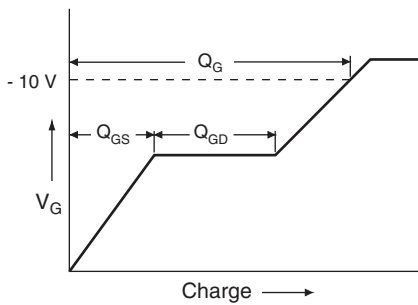


Fig. 13a - Basic Gate Charge Waveform

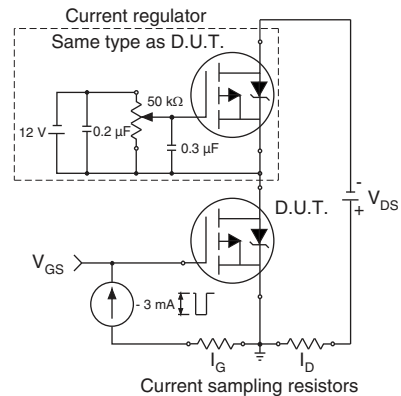
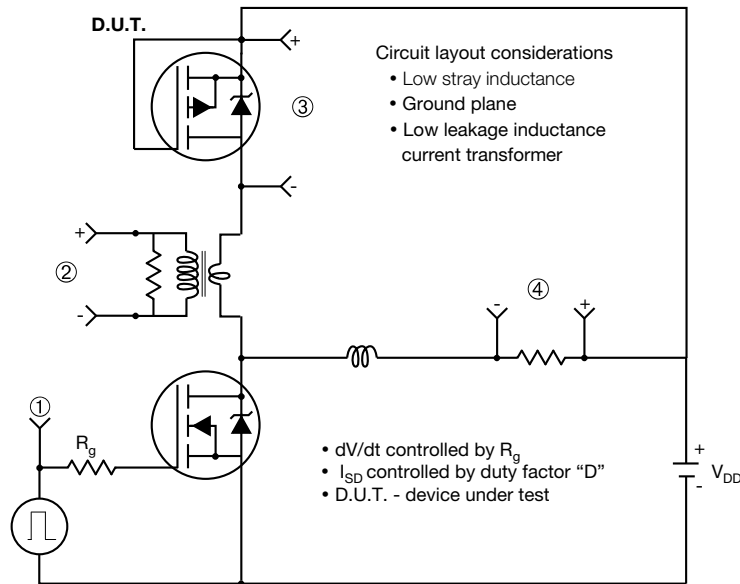
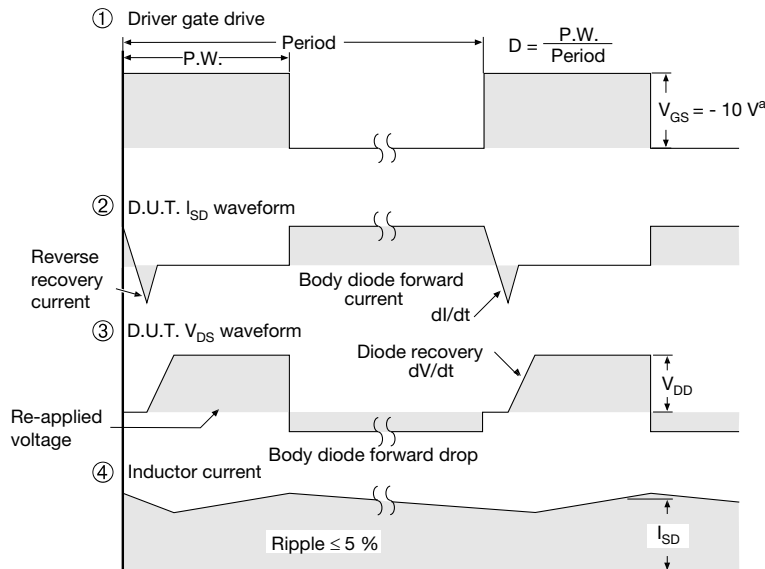


Fig. 13b - Gate Charge Test Circuit

### 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  $-3\text{ V}$  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



DIM.	MILLIMETERS	
	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

DIM.	MILLIMETERS	
	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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