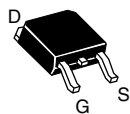
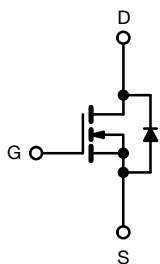
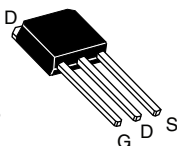


## Power MOSFET

**PAK (TO-252)**

**PAK (TO-251)**


N-Channel MOSFET

### FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- Surface-mount (IRFR310, SiHFR310)
- Straight lead (IRFU310, SiHFU310)
- Available in tape and reel
- Fast switching
- Fully avalanche rated
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



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

### DESCRIPTION

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The PAK 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 <sub>DS</sub> (V)	400	
R <sub>DS(on)</sub> (Ω)	V <sub>GS</sub> = 10 V	3.6
Q <sub>g</sub> max. (nC)	12	
Q <sub>gs</sub> (nC)	1.9	
Q <sub>gd</sub> (nC)	6.5	
Configuration	Single	

### ORDERING INFORMATION

Package	PAK (TO-252)	PAK (TO-252)	PAK (TO-252)	PAK (TO-251)
Lead (Pb)-free and halogen-free	SiHFR310-GE3	SiHFR310TRL-GE3 <sup>a</sup>	SiHFR310TR-GE3 <sup>a</sup>	SiHFU310-GE3
	SiHFR310TRR-GE3 <sup>a</sup>	IRFR310TRLPbF-BE3 <sup>a, b</sup>	IRFR310TRPbF-BE3 <sup>a, b</sup>	-
Lead (Pb)-free	IRFR310PbF	IRFR310TRLPbF <sup>a</sup>	IRFR310TRPbF <sup>a</sup>	IRFU310PbF

#### Notes

- a. See device orientation  
b. “-BE3” denotes alternate manufacturing location

### ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25 °C, unless otherwise noted)

PARAMETER	SYMBOL	LIMIT	UNIT
Drain-source voltage	V <sub>DS</sub>	400	V
Gate-source voltage	V <sub>GS</sub>	± 20	
Continuous drain current	V <sub>GS</sub> at 10 V	T <sub>C</sub> = 25 °C	A
		T <sub>C</sub> = 100 °C	
Pulsed drain current <sup>a</sup>	I <sub>DM</sub>	6.0	W/°C
Linear derating factor		0.20	
Linear derating factor (PCB mount) <sup>e</sup>		0.020	mJ
Single pulse avalanche energy <sup>b</sup>	E <sub>AS</sub>	86	
Repetitive avalanche current <sup>a</sup>	I <sub>AR</sub>	1.7	A
Repetitive avalanche energy <sup>a</sup>	E <sub>AR</sub>	2.5	mJ
Maximum power dissipation	P <sub>D</sub>	T <sub>C</sub> = 25 °C	W
Maximum power dissipation (PCB mount) <sup>e</sup>		T <sub>A</sub> = 25 °C	
Peak diode recovery dV/dt <sup>c</sup>	dV/dt	4.0	V/ns
Operating junction and storage temperature range	T <sub>J</sub> , T <sub>stg</sub>	-55 to +150	°C
Soldering recommendations (peak temperature) <sup>d</sup>	For 10 s	260	

#### Notes

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)  
b. V<sub>DD</sub> = 50 V, starting T<sub>J</sub> = 25 °C, L = 52 mH, R<sub>g</sub> = 25 Ω, I<sub>AS</sub> = 1.7 A (see fig. 12)  
c. I<sub>SD</sub> ≤ 1.7 A, dI/dt ≤ 40 A/μs, V<sub>DD</sub> ≤ V<sub>DS</sub>, T<sub>J</sub> ≤ 150 °C  
d. 1.6 mm from case  
e. When mounted on 1” square PCB (FR-4 or G-10 material)

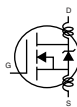

**THERMAL RESISTANCE RATINGS**

PARAMETER	SYMBOL	TYP.	MAX.	UNIT
Maximum junction-to-ambient (PCB mounted, steady-state) <sup>a</sup>	$R_{thJA}$	-	50	°C/W
Maximum junction-to-ambient	$R_{thJA}$	-	110	
Maximum junction-to-case	$R_{thJC}$	-	5.0	

**Note**

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

**SPECIFICATIONS** ( $T_J = 25\text{ °C}$ , 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 $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$		-	0.47	-	V/ $^\circ\text{C}$
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	$I_{DSS}$	$V_{DS} = 400\text{ V}$ , $V_{GS} = 0\text{ V}$		-	-	25	$\mu\text{A}$
		$V_{DS} = 320\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^\circ\text{C}$		-	-	250	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}$	$I_D = 1.0\text{ A}^b$	-	-	3.6	$\Omega$
Forward transconductance	$g_{fs}$	$V_{DS} = 50\text{ V}$ , $I_D = 1.0\text{ A}^b$		0.97	-	-	S
Dynamic							
Input capacitance	$C_{iss}$	$V_{GS} = 0\text{ V}$ , $V_{DS} = 25\text{ V}$ , $f = 1.0\text{ MHz}$ , see fig. 5 $^\circ$		-	170	-	pF
Output capacitance	$C_{oss}$			-	34	-	
Reverse transfer capacitance	$C_{rss}$			-	6.3	-	
Total gate charge	$Q_g$	$V_{GS} = 10\text{ V}$	$I_D = 2.0\text{ A}$ , $V_{DS} = 320\text{ V}$ , see fig. 6 and 13 $^b, ^c$	-	-	12	nC
Gate-source charge	$Q_{gs}$			-	-	1.9	
Gate-drain charge	$Q_{gd}$			-	-	6.5	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 200\text{ V}$ , $I_D = 2.0\text{ A}$ , $R_g = 24\text{ }\Omega$ , $R_D = 95\text{ }\Omega$ , see fig. 10 $^b, ^c$		-	7.9	-	ns
Rise time	$t_r$			-	9.9	-	
Turn-off delay time	$t_{d(off)}$			-	21	-	
Fall time	$t_f$			-	11	-	
Gate input resistance	$R_g$	$f = 1\text{ MHz}$ , open drain		1.7	-	11.2	$\Omega$
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	-	
Drain-Source Body Diode Characteristics							
Continuous source-drain diode current	$I_S$	MOSFET symbol showing the integral reverse p - n junction diode 		-	-	1.7	A
Pulsed diode forward current <sup>a</sup>	$I_{SM}$			-	-	6.0	
Body diode voltage	$V_{SD}$	$T_J = 25\text{ }^\circ\text{C}$ , $I_S = 1.7\text{ A}$ , $V_{GS} = 0\text{ V}^b$		-	-	1.6	V
Body diode reverse recovery time	$t_{rr}$	$T_J = 25\text{ }^\circ\text{C}$ , $I_F = 2.0\text{ A}$ , $dI/dt = 100\text{ A}/\mu\text{s}^b$		-	240	540	ns
Body diode reverse recovery charge	$Q_{rr}$			-	0.85	1.6	$\mu\text{C}$
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)

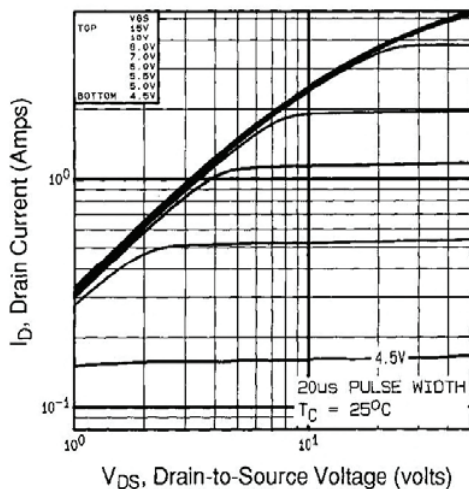


Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$

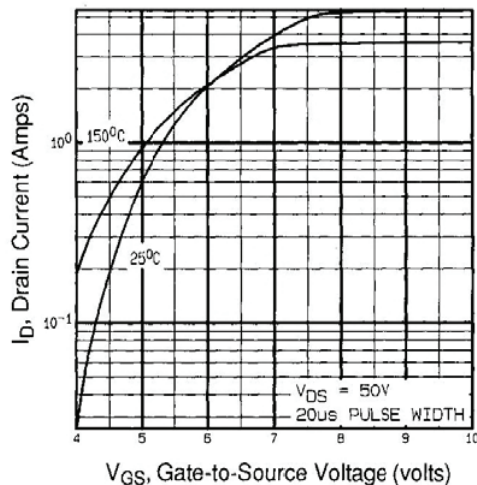


Fig. 3 - Typical Transfer Characteristics

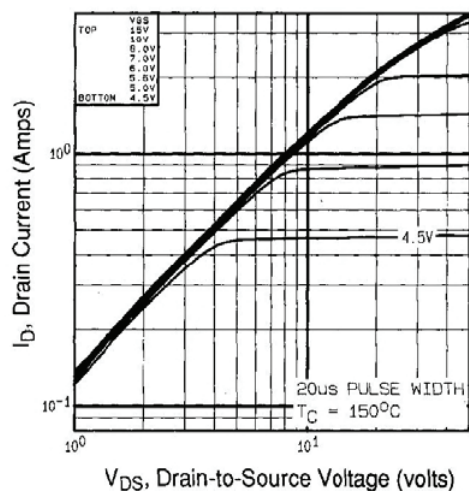


Fig. 2 - Typical Output Characteristics,  $T_C = 150^\circ\text{C}$

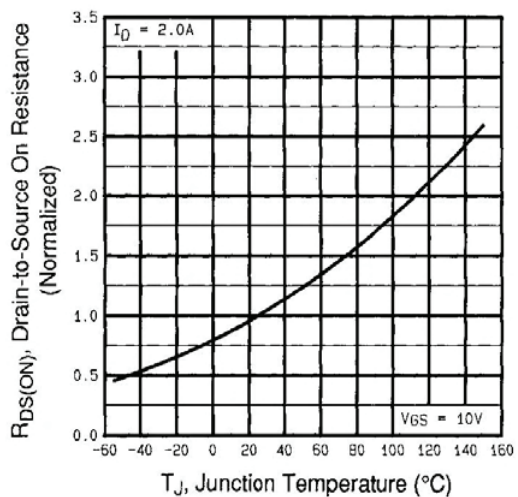
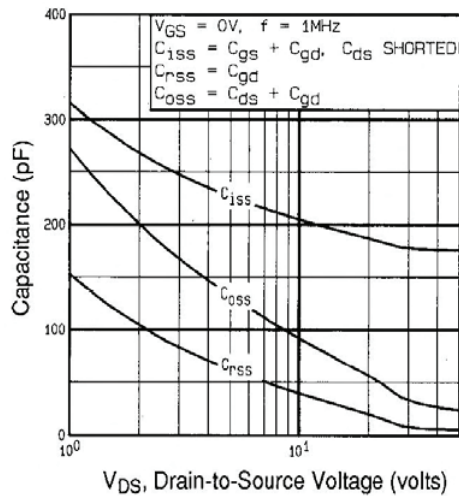
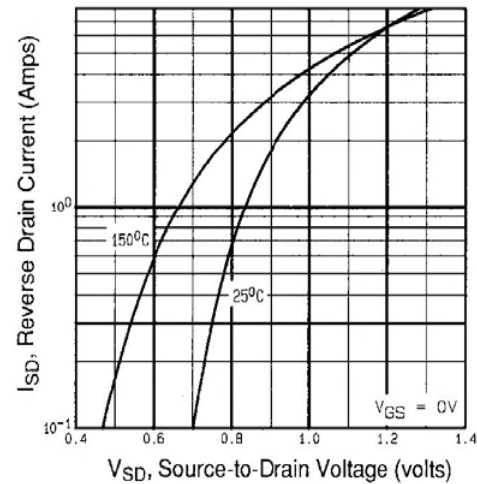
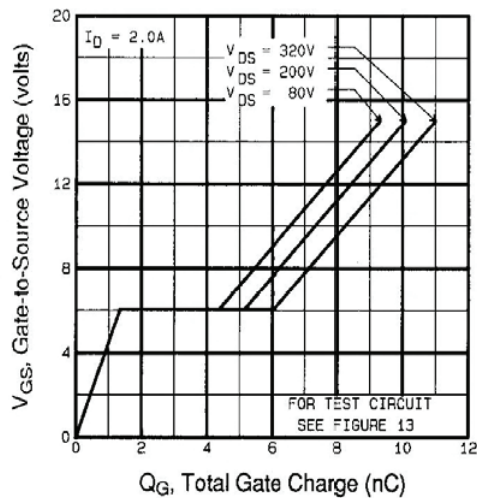
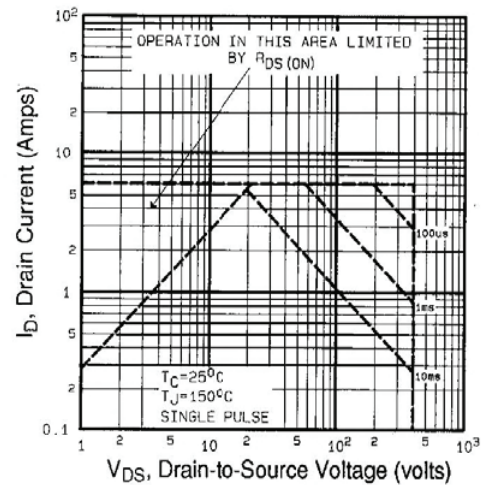


Fig. 4 - Normalized On-Resistance vs. Temperature


**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**

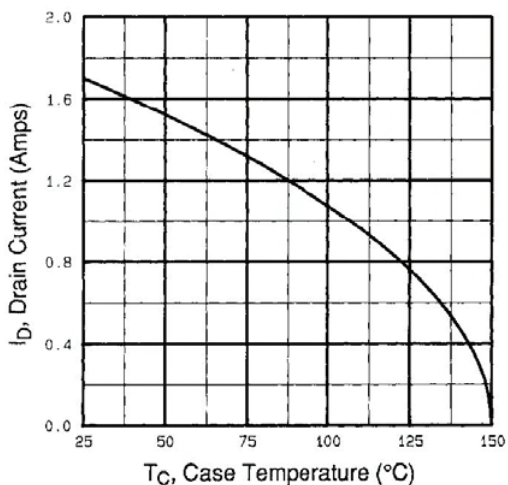


Fig. 9 - Maximum Drain Current vs. Case Temperature

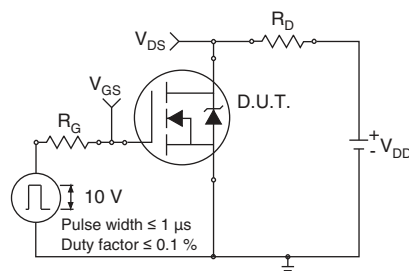


Fig. 10a - Switching Time Test Circuit



Fig. 10b - Switching Time Waveforms

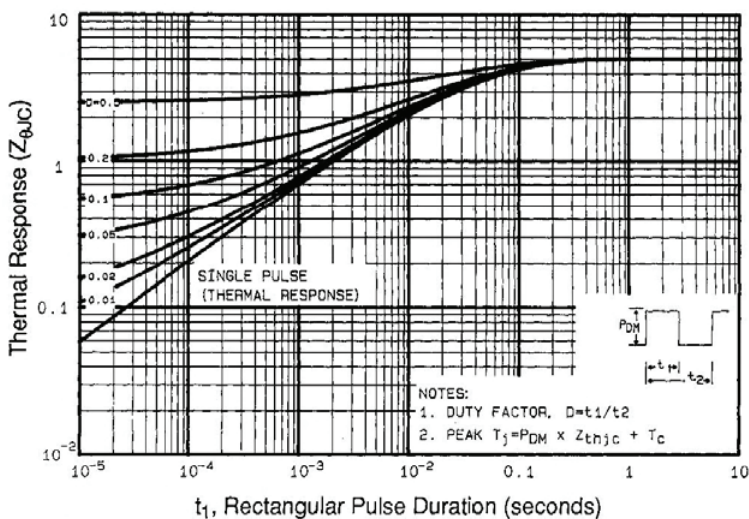


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

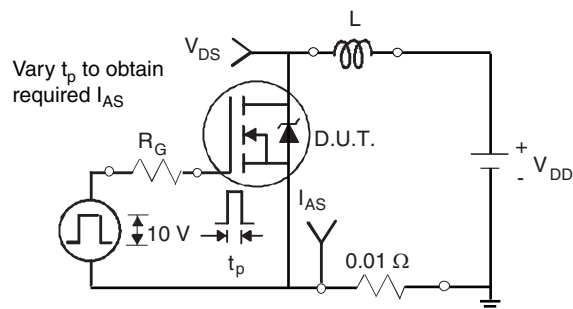


Fig. 12a - Unclamped Inductive Test Circuit

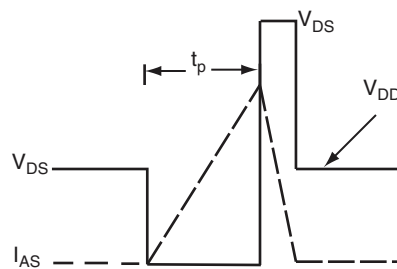


Fig. 12b - Unclamped Inductive Waveforms

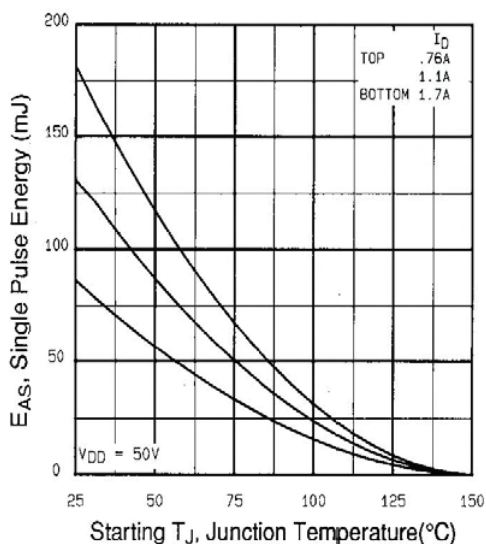


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

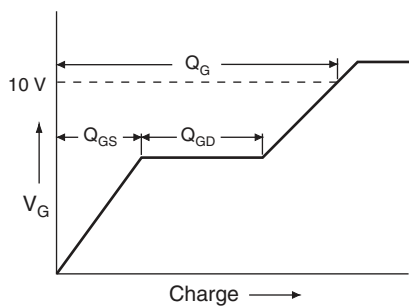


Fig. 13a - Basic Gate Charge Waveform

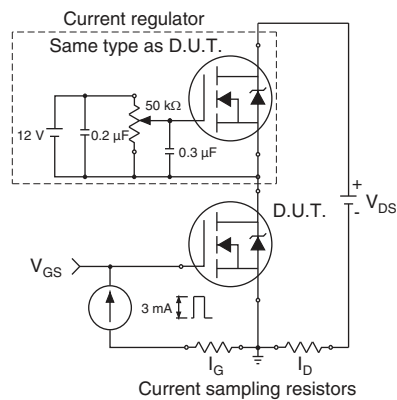
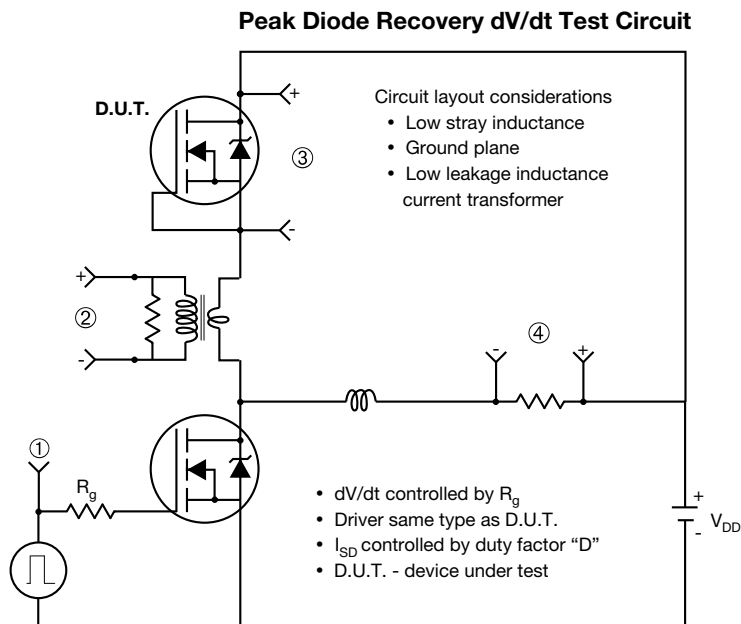


Fig. 13b - Gate Charge Test Circuit



**Note**

a. V<sub>GS</sub> = 5 V for logic level devices

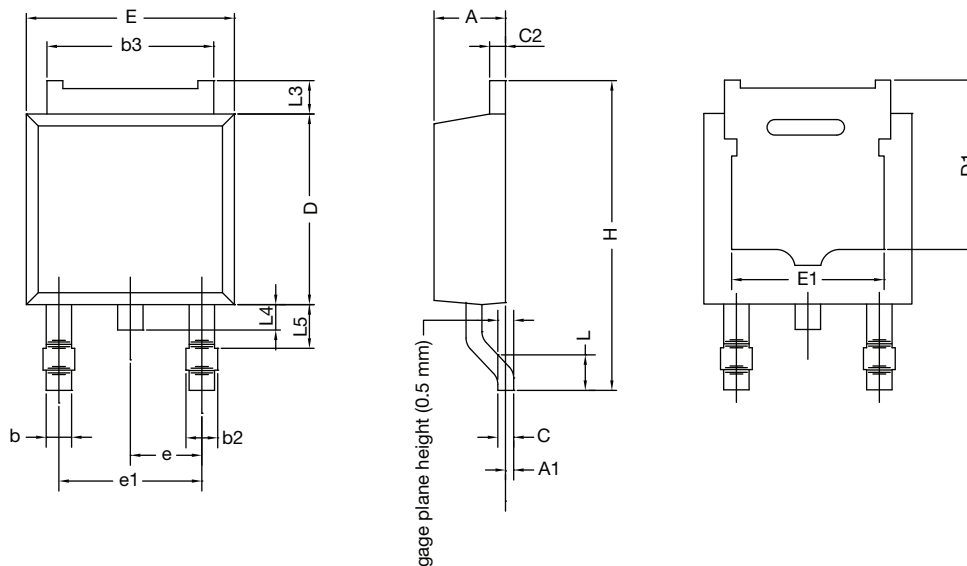
**Fig. 14 - For N-Channel**

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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	-	-

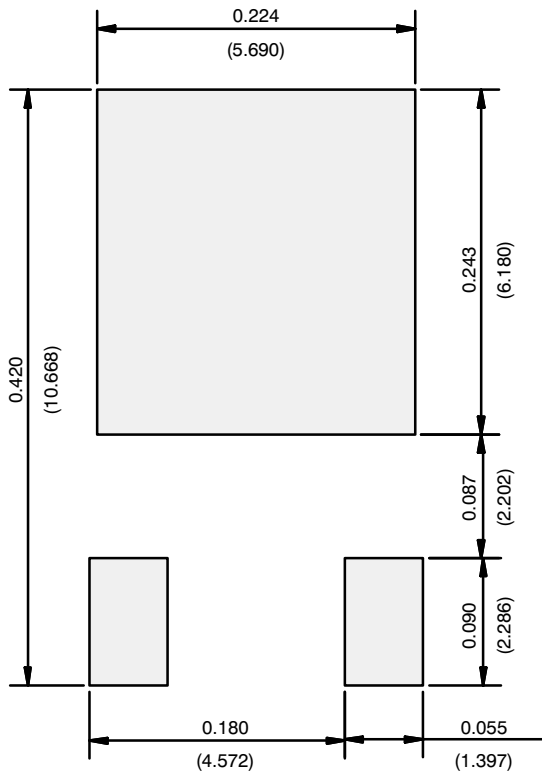
DIM.	MIN.	NOM.	MAX.
D2	5.380	-	-
E	6.350	6.540	6.730
E1	4.32	-	-
e	2.29 BSC		
L	8.890	9.270	9.650
L1	1.910	2.100	2.290
L2	0.890	1.080	1.270
L3	1.140	1.330	1.520
L4	1.300	1.400	1.500
theta1	0°	7.5°	15°
theta2	4°	-	-

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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