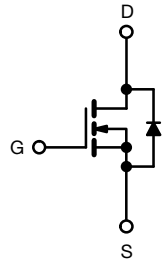
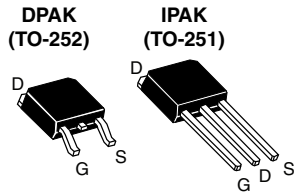


## Power MOSFET



N-Channel MOSFET

### FEATURES

- Low gate charge  $Q_g$  results in simple drive requirement
- Improved gate, avalanche and dynamic  $dV/dt$  ruggedness
- Fully characterized capacitance and avalanche voltage and current
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



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

### APPLICATIONS

- Switch mode power supply (SMPS)
- Uninterruptible power supply
- Power factor correction

### TYPICAL SMPS TOPOLOGIES

- Low power single transistor flyback

PRODUCT SUMMARY	
$V_{DS}$ (V)	600
$R_{DS(on)}$ max. ( $\Omega$ )	$V_{GS} = 10$ V   7.0
$Q_g$ max. (nC)	14
$Q_{gs}$ (nC)	2.7
$Q_{gd}$ (nC)	8.1
Configuration	Single

ORDERING INFORMATION				
Package	DPAK (TO-252)	DPAK (TO-252)	DPAK (TO-252)	IPAK (TO-251)
Lead (Pb)-free and halogen-free	SiHFR1N60A-GE3	SiHFR1N60ATRL-GE3 <sup>a</sup>	SiHFR1N60ATR-GE3 <sup>a</sup>	SiHFU1N60A-GE3
	IRFR1N60APbF-BE3 <sup>ab</sup>	IRFR1N60ATRPbF-BE3 <sup>ab</sup>	SiHFR1N60ATRR-GE3 <sup>a</sup>	-
Lead (Pb)-free	IRFR1N60APbF	IRFR1N60ATRLPbF <sup>a</sup>	IRFR1N60ATRPbF <sup>a</sup>	IRFU1N60APbF

#### Notes

- See device orientation
- "-BE3" denotes alternate manufacturing location

ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °C, unless otherwise noted)					
PARAMETER	SYMBOL		LIMIT	UNIT	
Drain-source voltage	$V_{DS}$		600	V	
Gate-source voltage	$V_{GS}$		$\pm 30$		
Continuous drain current	$V_{GS}$ at 10 V	$T_C = 25$ °C	1.4	A	
		$T_C = 100$ °C	0.89		
Pulsed drain current <sup>a</sup>	$I_{DM}$		5.6		
Linear derating factor			0.28	W/°C	
Single pulse avalanche energy <sup>b</sup>	$E_{AS}$		93	mJ	
Repetitive avalanche current <sup>a</sup>	$I_{AR}$		1.4	A	
Repetitive avalanche energy <sup>a</sup>	$E_{AR}$		3.6	mJ	
Maximum power dissipation	$T_A = 25$ °C		$P_D$	36	W
Peak diode recovery $dV/dt$ <sup>c</sup>	$dV/dt$		3.8	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		300		

#### Notes


- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- Starting  $T_J = 25$  °C,  $L = 95$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 1.4$  A (see fig. 12)
- $I_{SD} \leq 1.4$  A,  $dI/dt \leq 180$  A/ $\mu$ s,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150$  °C
- 1.6 mm from case



THERMAL RESISTANCE RATINGS				
PARAMETER	SYMBOL	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)	$R_{thJC}$	-	3.5	

**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	
<b>Static</b>							
Drain-source breakdown voltage	$V_{DS}$	$V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$	600	-	-	V	
$V_{DS}$ temperature coefficient	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	2.0	-	4.0		
Gate-source threshold voltage	$I_{GSS}$	$V_{GS} = \pm 30\text{ V}$	-	-	$\pm 100$	nA	
Gate-source leakage	$I_{DSS}$	$V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$	-	-	25	$\mu\text{A}$	
Zero gate voltage drain current		$V_{DS} = 480\text{ V}, V_{GS} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	-	250		
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}, I_D = 0.84\text{ A}^b$	-	-	7.0	$\Omega$	
Drain-source on-state resistance	$g_{fs}$	$V_{DS} = 50\text{ V}, I_D = 0.84\text{ A}$	0.88	-	-	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	-	229	-	pF	
Output capacitance	$C_{oss}$		-	32.6	-		
Reverse transfer capacitance	$C_{rss}$		-	2.4	-		
Output capacitance	$C_{oss}$	$V_{GS} = 0\text{ V}$	$V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$	-	320	-	
Effective output capacitance			$C_{oss\text{ eff.}}$	$V_{DS} = 480\text{ V}, f = 1.0\text{ MHz}$	-	11.5	-
Total gate charge	$Q_g$	$V_{GS} = 10\text{ V}$	$I_D = 1.4\text{ A}, V_{DS} = 400\text{ V}$ , see fig. 6 and 13 <sup>b</sup>	-	-	14	nC
Gate-source charge	$Q_{gs}$			-	-	2.7	
Gate-drain charge	$Q_{gd}$			-	-	8.1	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 250\text{ V}, I_D = 1.4\text{ A}, R_g = 2.15\text{ }\Omega, R_D = 178\text{ }\Omega$ , see fig. 10 <sup>b</sup>	-	9.8	-	ns	
Rise time	$t_r$		-	14	-		
Turn-off delay time	$t_{d(off)}$		-	18	-		
Fall time	$t_f$		-	20	-		
<b>Drain-source body diode characteristics</b>							
Continuous source-drain diode current	$I_S$	MOSFET symbol showing the integral reverse p - n junction diode 	-	-	1.4	A	
Pulsed diode forward current <sup>a</sup>	$I_{SM}$		-	-	5.6		
Body diode voltage	$V_{SD}$	$T_J = 25\text{ }^\circ\text{C}, I_S = 1.4\text{ A}, V_{GS} = 0\text{ V}^b$	-	-	1.6	V	
Body diode reverse recovery time	$t_{rr}$	$T_J = 25\text{ }^\circ\text{C}, I_F = 1.4\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$	-	290	440	ns	
Body diode reverse recovery charge	$Q_{rr}$		-	510	760	$\mu\text{C}$	
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  $\leq 2\%$
- c.  $C_{oss\text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 to 80 %  $V_{DS}$



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

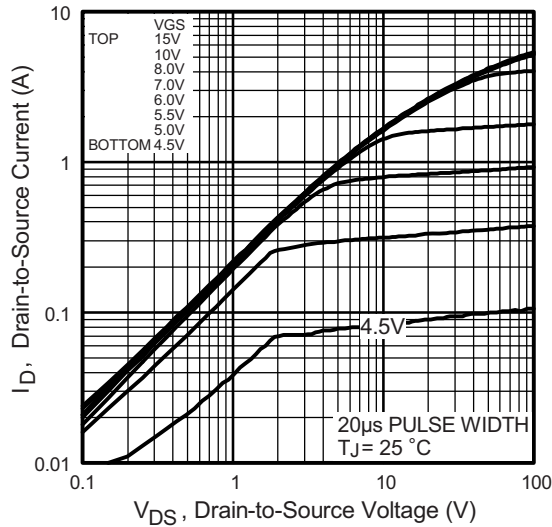


Fig. 1 - Typical Output Characteristics

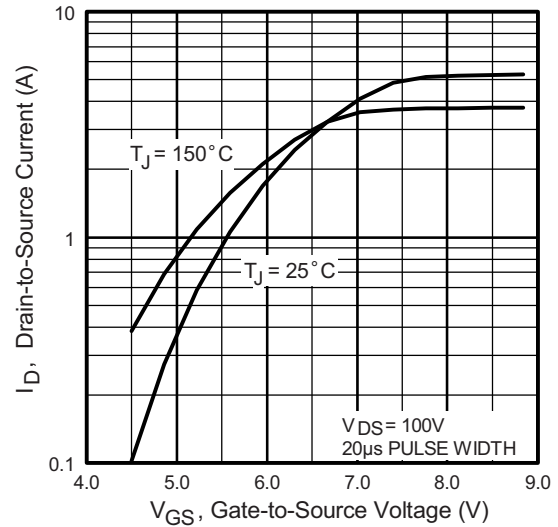


Fig. 2 - Typical Transfer Characteristics

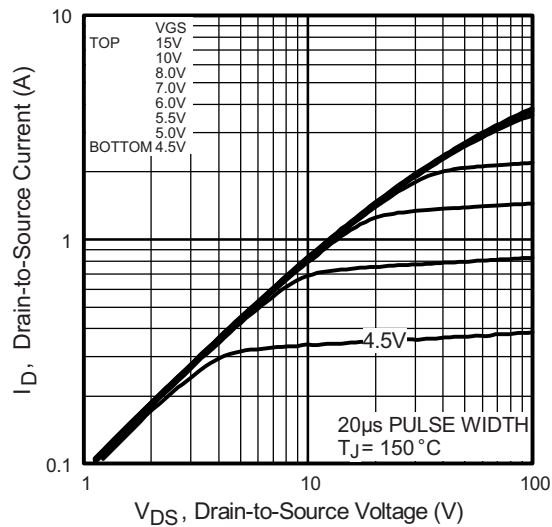


Fig. 1 - Typical Output Characteristics

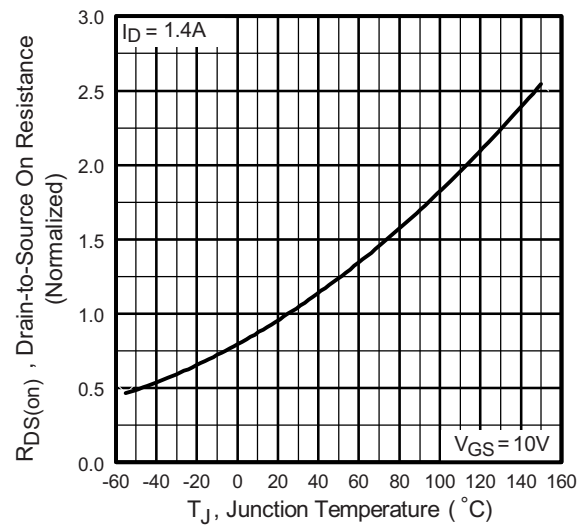


Fig. 3 - Normalized On-Resistance vs. Temperature

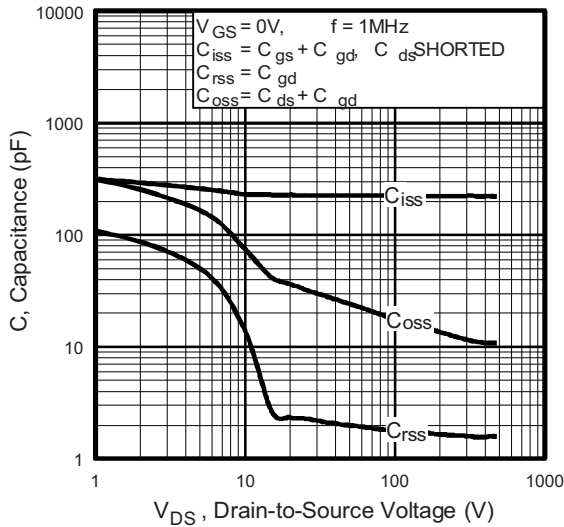


Fig. 4 - Typical Capacitance vs. Drain-to-Source Voltage

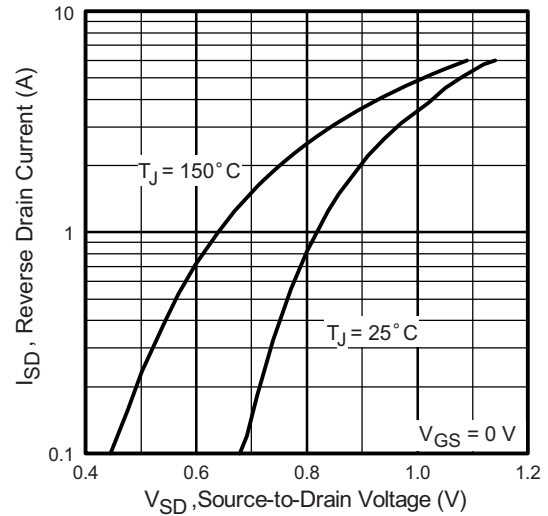


Fig. 6 - Typical Source-Drain Diode Forward Voltage

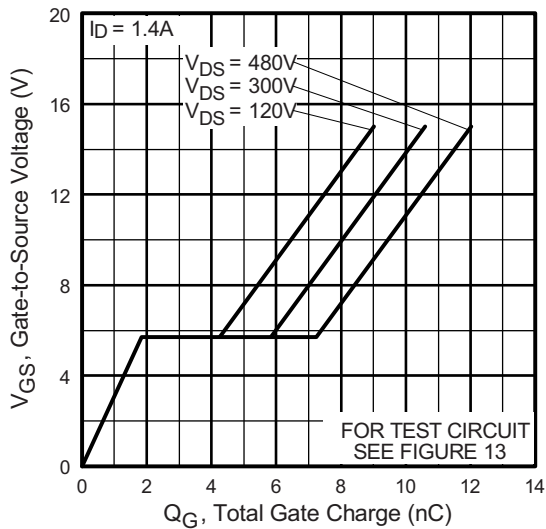


Fig. 5 - Typical Gate Charge vs. Gate-to-Source Voltage

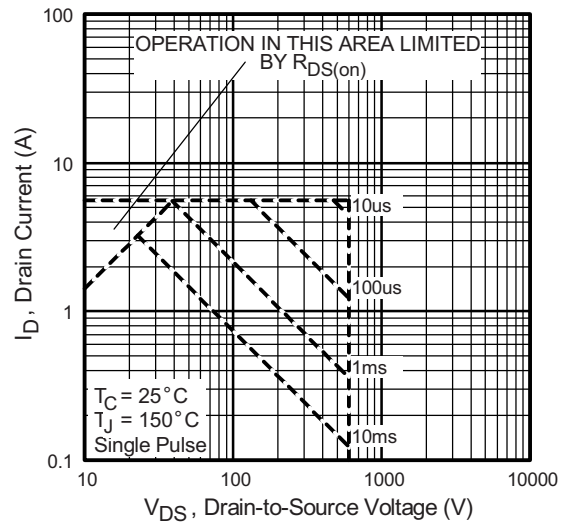


Fig. 7 - Maximum Safe Operating Area

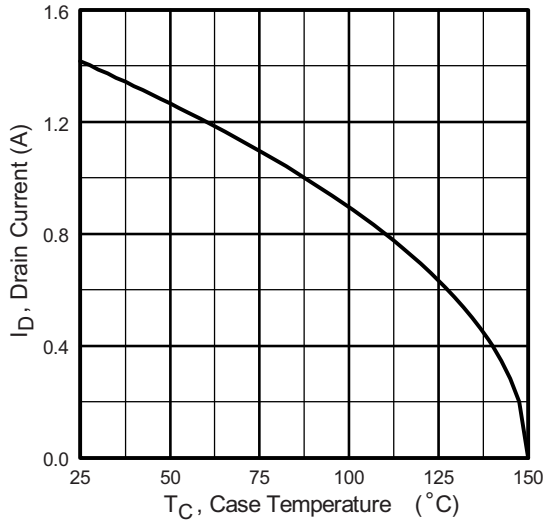


Fig. 8 - Maximum Drain Current vs. Case Temperature

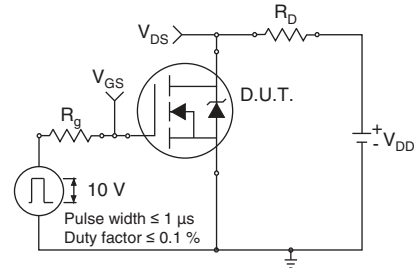


Fig. 10a - Switching Time Test Circuit

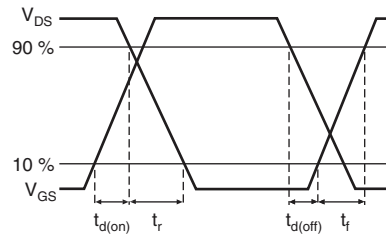


Fig. 10b - Switching Time Waveforms

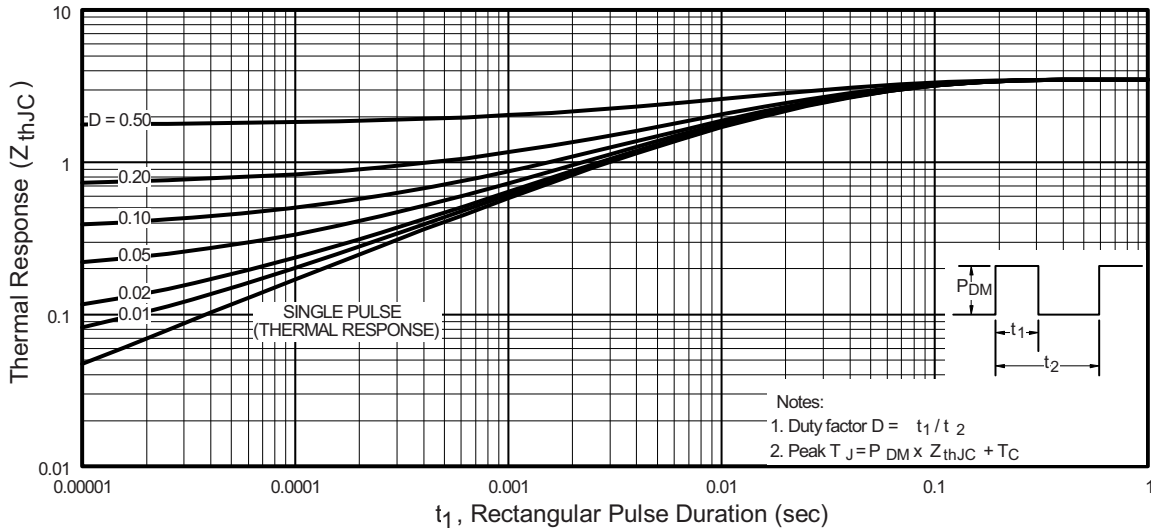


Fig. 9 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

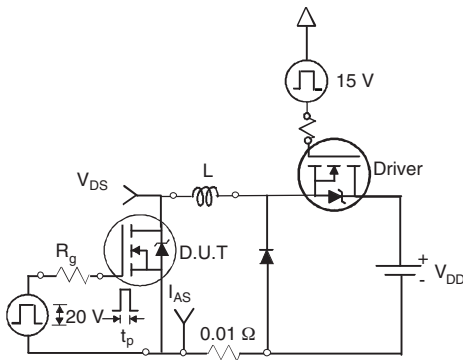


Fig. 12a - Unclamped Inductive Test Circuit

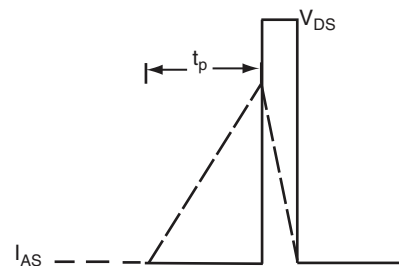


Fig. 12b - Unclamped Inductive Waveforms

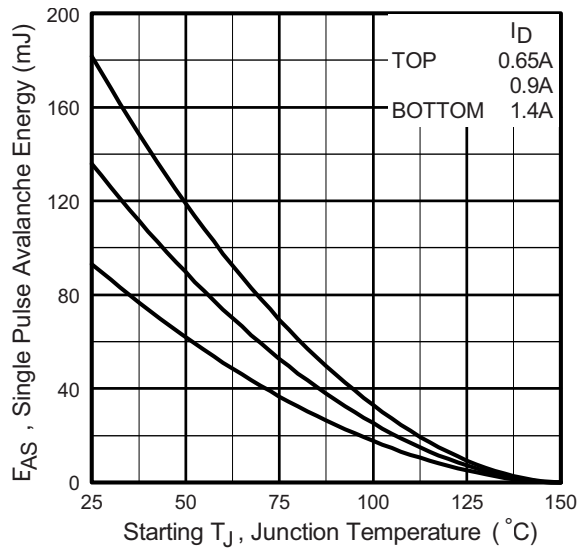


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

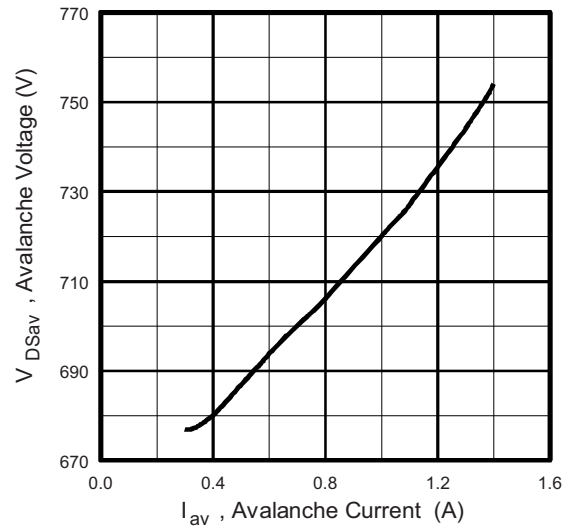


Fig. 12d - Basic Gate Charge Waveform

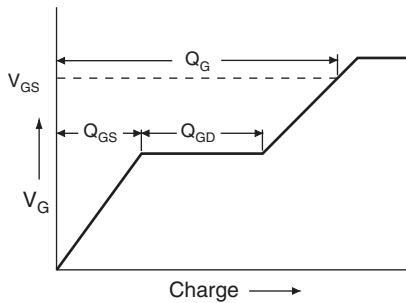


Fig. 13a - Maximum Avalanche Energy vs. Drain Current

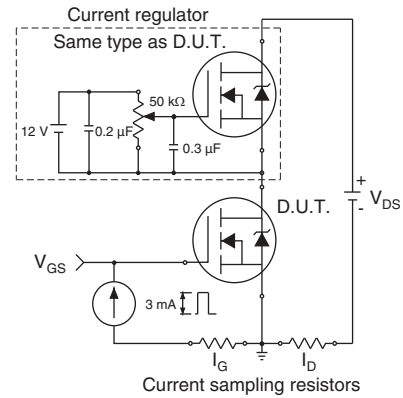
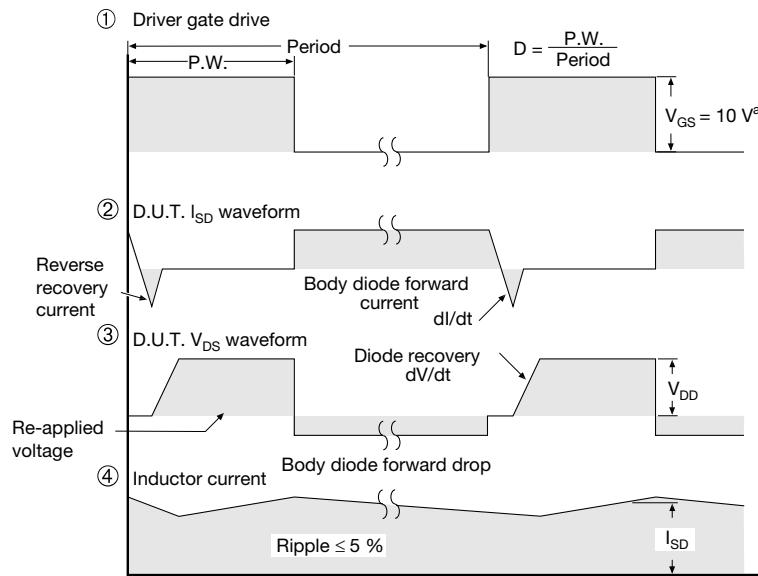
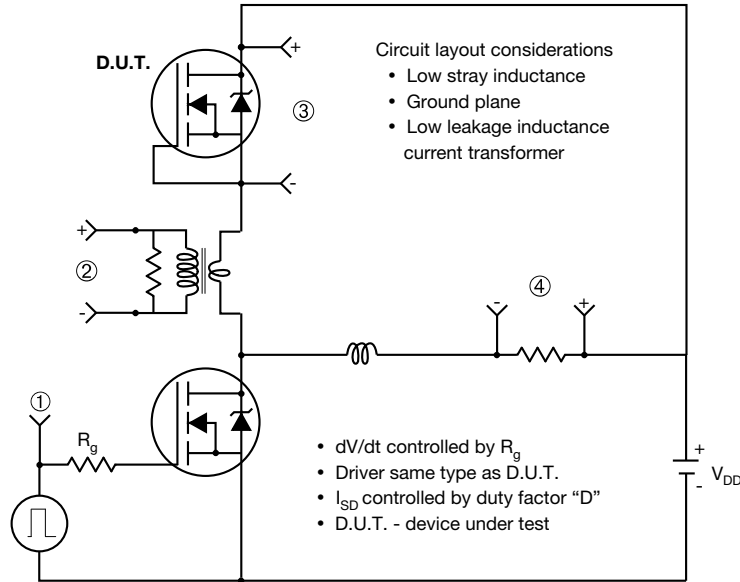


Fig. 13b - Gate Charge Test Circuit

### Peak Diode Recovery dV/dt Test Circuit



**Note**

a.  $V_{GS} = 5\text{ V}$  for logic level devices

**Fig. 10 - For N-Channel**

Vishay Siliconix maintains worldwide manufacturing capability. Products may be manufactured at one of several qualified locations. Reliability data for Silicon Technology and Package Reliability represent a composite of all qualified locations. For related documents such as package/tape drawings, part marking, and reliability data, see [www.vishay.com/ppg?91267](http://www.vishay.com/ppg?91267).



# 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: E19-0649-Rev. Q, 16-Dec-2019  
 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
theta1	0'	15'	0'	15'
theta2	25'	35'	25'	35'

ECN: E21-0605-Rev. B, 25-Oct-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.	MAX.	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.	MAX.	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: E21-0605-Rev. B, 25-Oct-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)

[Return to Index](#)



## Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.