

## 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)


 Available  
**RoHS\***  
 Available

### APPLICATIONS

- Switch mode power supply (SMPS)
- Uninterruptible power supply
- High speed power switching

### APPLICABLE OFF LINE SMPS TOPOLOGIES

- Active clamped forward
- Main switch

PRODUCT SUMMARY	
$V_{DS}$ (V)	600
$R_{DS(on)}$ ( $\Omega$ )	$V_{GS} = 10\text{ V}$ 0.75
$Q_g$ max. (nC)	49
$Q_{gs}$ (nC)	13
$Q_{gd}$ (nC)	20
Configuration	Single


ORDERING INFORMATION	
Package	TO-220AB
Lead (Pb)-free	IRFB9N60APbF
Lead (Pb)-free and halogen-free	IRFB9N60APbF-BE3

ABSOLUTE MAXIMUM RATINGS ( $T_C = 25\text{ }^\circ\text{C}$ , 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	$I_D$	$T_C = 25\text{ }^\circ\text{C}$	9.2	A
			$T_C = 100\text{ }^\circ\text{C}$	5.8	
Pulsed drain current <sup>a</sup>		$I_{DM}$	37		
Linear derating factor			1.3	W/ $^\circ\text{C}$	
Single pulse avalanche energy <sup>b</sup>		$E_{AS}$	290	mJ	
Repetitive avalanche current <sup>a</sup>		$I_{AR}$	9.2	A	
Repetitive avalanche energy <sup>a</sup>		$E_{AR}$	17	mJ	
Maximum power dissipation	$T_C = 25\text{ }^\circ\text{C}$	$P_D$	170	W	
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	$^\circ\text{C}$	
Soldering recommendations (peak temperature) <sup>d</sup>	For 10 s		300		
Mounting torque	6-32 or M3 screw		10		lbf · in
			1.1	N · m	

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- Starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 6.8\text{ mH}$ ,  $R_g = 25\text{ }^\circ\Omega$ ,  $I_{AS} = 9.2\text{ A}$  (see fig. 12)
- $I_{SD} \leq 9.2\text{ A}$ ,  $dI/dt \leq 50\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$
- 1.6 mm from case

THERMAL RESISTANCE RATINGS				
PARAMETER	SYMBOL	TYP.	MAX.	UNIT
Maximum junction-to-ambient	$R_{thJA}$	-	62	°C/W
Case-to-sink, flat, greased surface	$R_{thCS}$	0.50	-	
Maximum junction-to-case (drain)	$R_{thJC}$	-	0.75	

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	$\Delta V_{DS}/T_J$	Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$		-	660	-	mV/°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	$I_{GSS}$	$V_{GS} = \pm 30\text{ V}$		-	-	$\pm 100$	nA
Zero gate voltage drain current	$I_{DSS}$	$V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$		-	-	25	$\mu\text{A}$
		$V_{DS} = 480\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$		-	-	250	
Drain-source on-state resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}$	$I_D = 5.5\text{ A}^b$	-	-	0.75	$\Omega$
Forward transconductance	$g_{fs}$	$V_{DS} = 50\text{ V}, I_D = 5.5\text{ A}$		5.5	-	-	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		-	1400	-	pF
Output capacitance	$C_{oss}$			-	180	-	
Reverse transfer capacitance	$C_{rss}$			-	7.1	-	
Output capacitance	$C_{oss}$	$V_{GS} = 0\text{ V}$	$V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$	-	1957	-	pF
Effective output capacitance	$C_{oss\text{ eff.}}$		$V_{DS} = 480\text{ V}, f = 1.0\text{ MHz}$	-	49	-	
Total gate charge	$Q_g$	$V_{GS} = 10\text{ V}$	$I_D = 9.2\text{ A}, V_{DS} = 400\text{ V}$ see fig. 6 and 13 <sup>b</sup>	-	-	49	nC
Gate-source charge	$Q_{gs}$			-	-	13	
Gate-drain charge	$Q_{gd}$			-	-	20	
Turn-on delay time	$t_{d(on)}$	$V_{DD} = 300\text{ V}, I_D = 9.2\text{ A}$ $R_g = 9.1\text{ }\Omega, R_D = 35.5\text{ }\Omega,$ see fig. 10 <sup>b</sup>		-	13	-	ns
Rise time	$t_r$			-	25	-	
Turn-off delay time	$t_{d(off)}$			-	30	-	
Fall time	$t_f$			-	22	-	
Gate input resistance	$R_g$	$f = 1\text{ MHz},$ open drain		0.5	-	3.2	$\Omega$
<b>Drain-Source Body Diode Characteristics</b>							
Continuous source-drain diode current	$I_S$	MOSFET symbol showing the integral reverse p-n junction diode 		-	-	9.2	A
Pulsed diode forward current <sup>a</sup>	$I_{SM}$			-	-	37	
Body diode voltage	$V_{SD}$	$T_J = 25\text{ }^\circ\text{C}, I_S = 9.2\text{ A}, V_{GS} = 0\text{ V}^b$		-	-	1.5	V
Body diode reverse recovery time	$t_{rr}$	$T_J = 25\text{ }^\circ\text{C}, I_F = 9.2\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$		-	530	800	ns
Body diode reverse recovery charge	$Q_{rr}$			-	3.0	4.4	$\mu\text{C}$
Forward turn-on time	$t_{on}$	Intrinsic turn-on time is negligible (turn-on is dominated by $L_S$ and $L_D$ )					

**Notes**

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\text{ }\%$
- $C_{oss}$  effective 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)

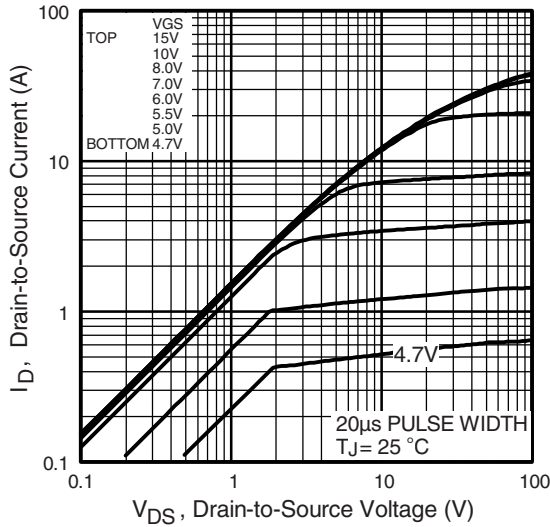


Fig. 1 - Typical Output Characteristics

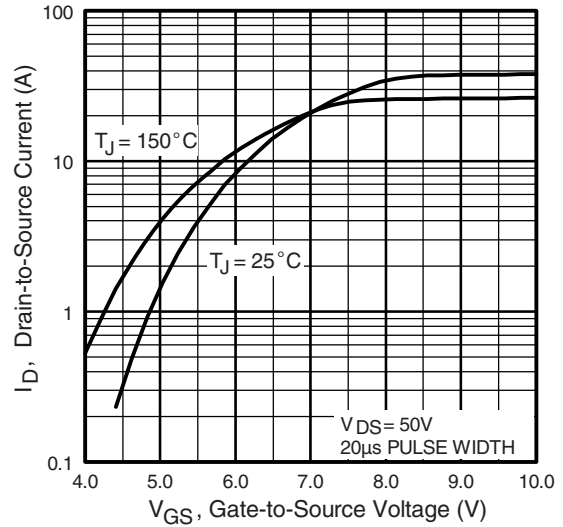


Fig. 3 - Typical Transfer Characteristics

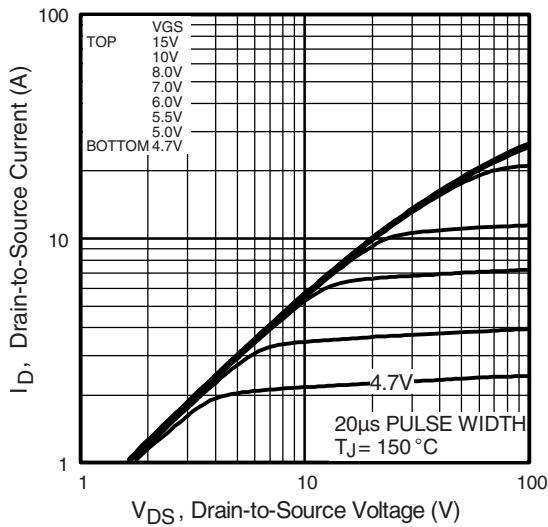


Fig. 2 - Typical Output Characteristics

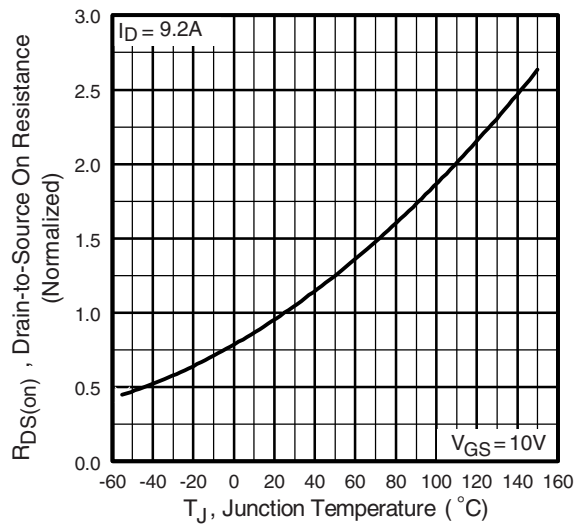


Fig. 4 - Normalized On-Resistance vs. Temperature

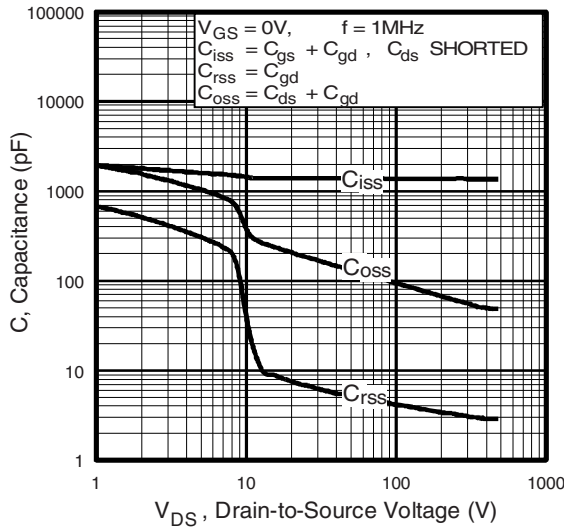


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

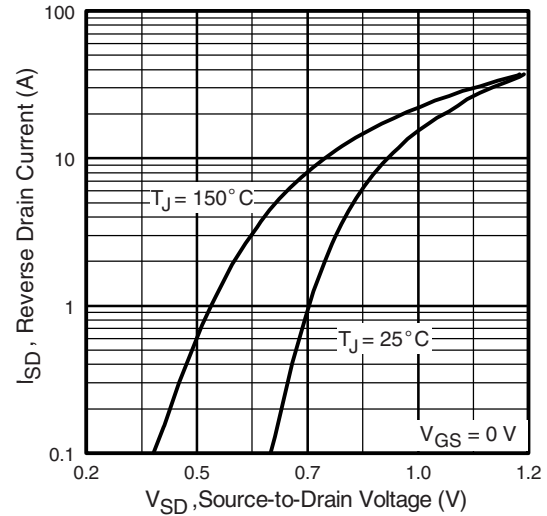


Fig. 7 - Typical Source-Drain Diode Forward Voltage

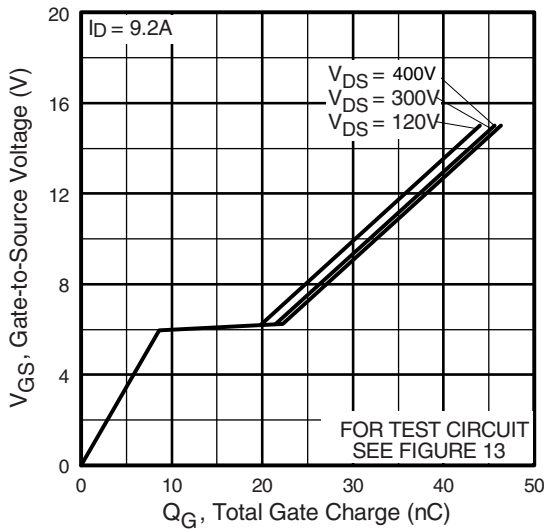


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

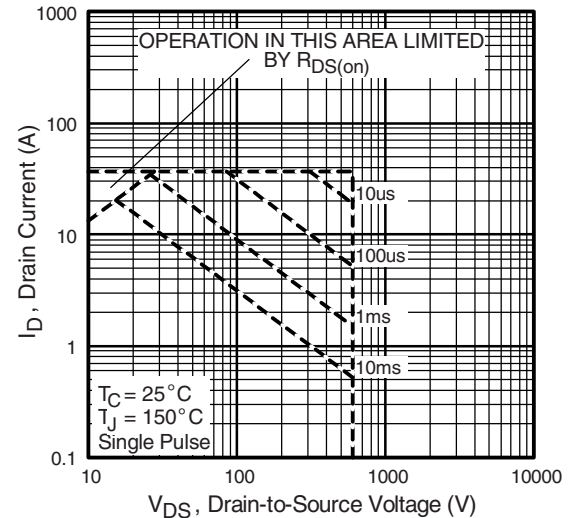


Fig. 8 - Maximum Safe Operating Area

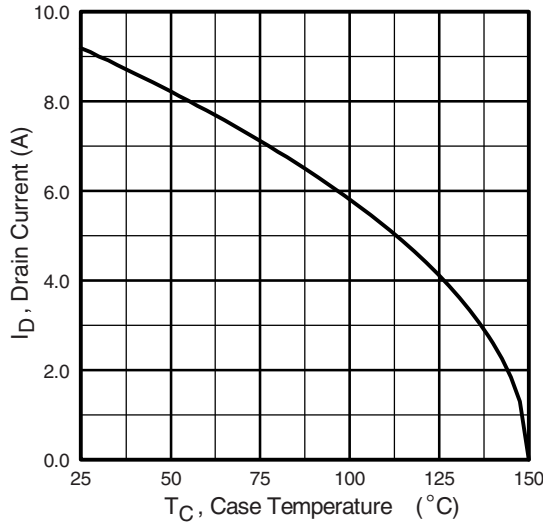


Fig. 9 - Maximum Drain Current vs. Case Temperature

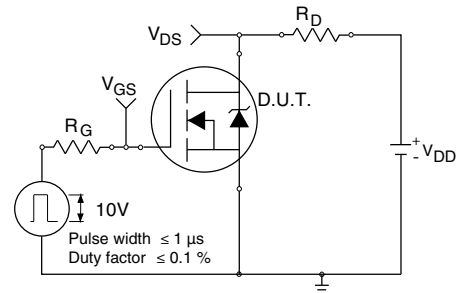


Fig. 10a - Switching Time Test Circuit

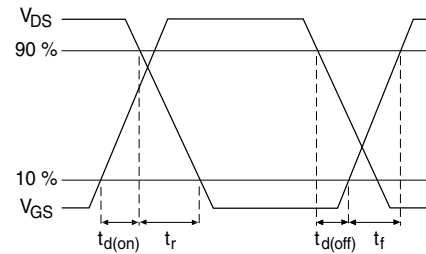


Fig. 10b - Switching Time Waveforms

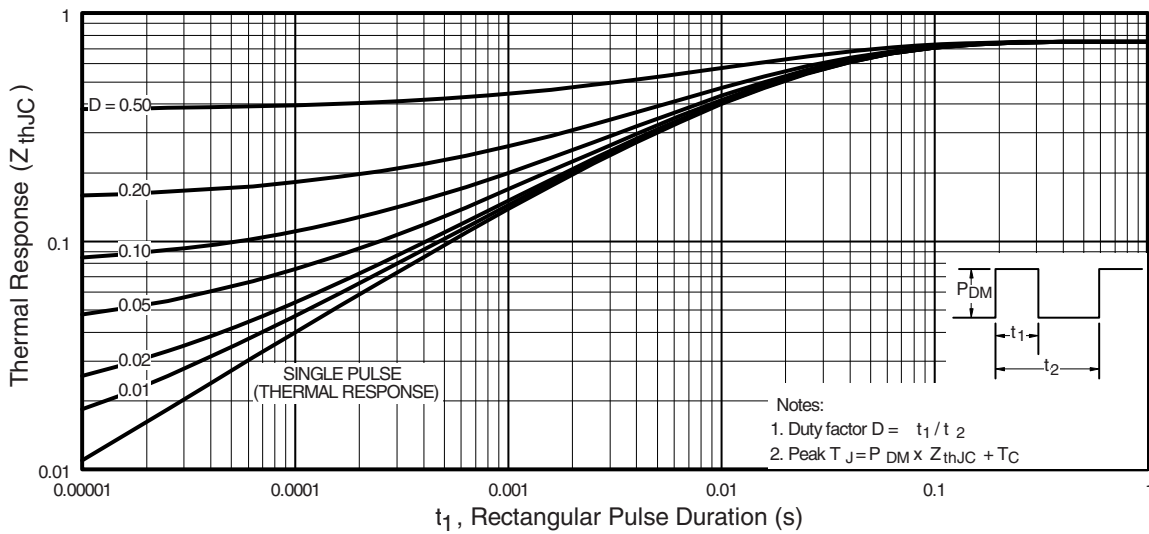
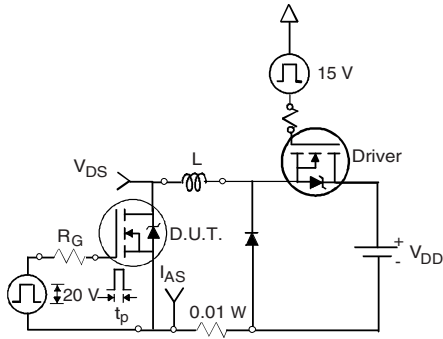
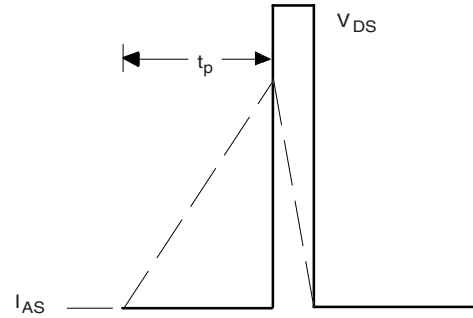
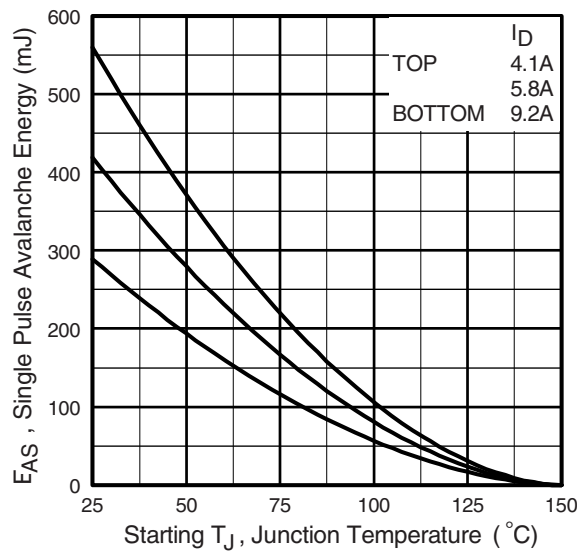
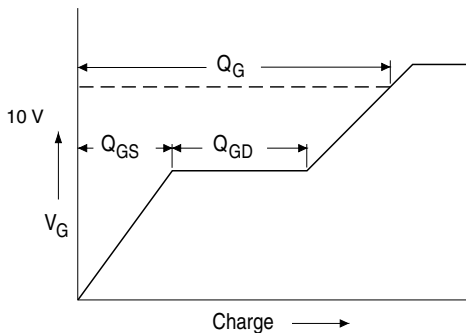
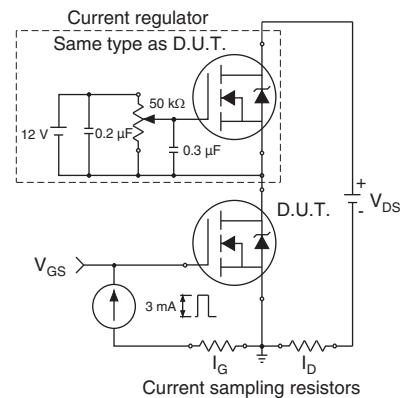
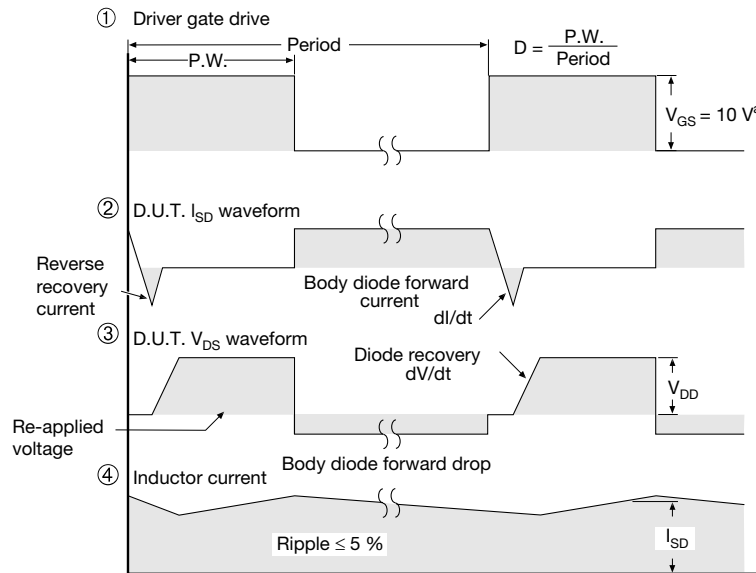
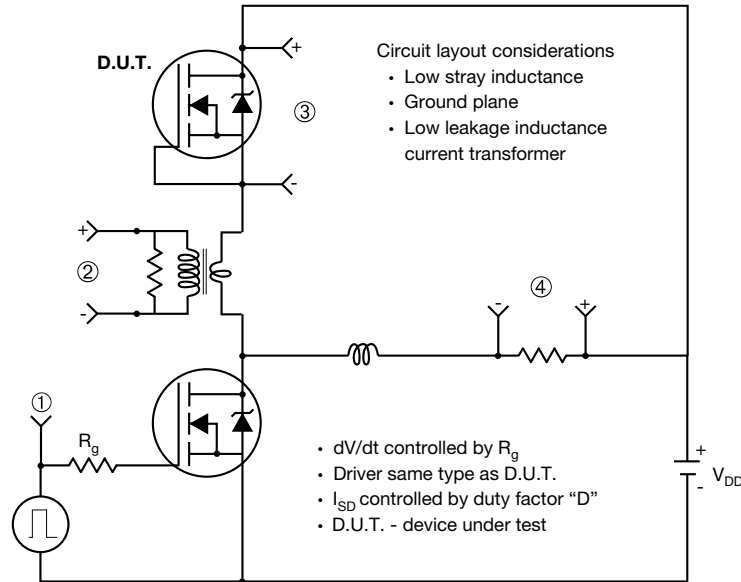


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case


**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**

**Peak Diode Recovery dV/dt Test Circuit**



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

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

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# TO-220-1



DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	4.24	4.65	0.167	0.183
b	0.69	1.02	0.027	0.040
b(1)	1.14	1.78	0.045	0.070
c	0.36	0.61	0.014	0.024
D	14.33	15.85	0.564	0.624
E	9.96	10.52	0.392	0.414
e	2.41	2.67	0.095	0.105
e(1)	4.88	5.28	0.192	0.208
F	1.14	1.40	0.045	0.055
H(1)	6.10	6.71	0.240	0.264
J(1)	2.41	2.92	0.095	0.115
L	13.36	14.40	0.526	0.567
L(1)	3.33	4.04	0.131	0.159
Ø P	3.53	3.94	0.139	0.155
Q	2.54	3.00	0.100	0.118

ECN: E21-0621-Rev. D, 04-Nov-2021  
 DWG: 6031

**Note**

- M\* = 0.052 inches to 0.064 inches (dimension including protrusion), heatsink hole for HVM





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