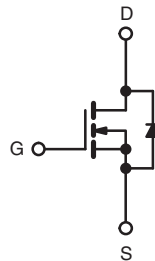
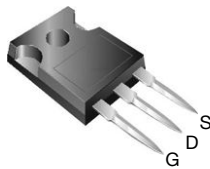


## Power MOSFET

PRODUCT SUMMARY		
$V_{DS}$ (V)	600	
$R_{DS(on)}$ ( $\Omega$ )	$V_{GS} = 10\text{ V}$	0.27
$Q_g$ (Max.) (nC)	150	
$Q_{gs}$ (nC)	46	
$Q_{gd}$ (nC)	64	
Configuration	Single	

TO-247AC



N-Channel MOSFET

### FEATURES

- Superfast Body Diode Eliminates the Need for External Diodes in ZVS Applications
- Lower Gate Charge Results in Simple Drive Requirements
- Enhanced  $dV/dt$  Capabilities Offer Improved Ruggedness
- Higher Gate Voltage Threshold Offers Improved Noise Immunity
- Compliant to RoHS Directive 2002/95/EC



**RoHS\***  
COMPLIANT

### APPLICATIONS

- Zero Voltage Switching SMPS
- Telecom and Server Power Supplies
- Uninterruptible Power Supplies
- Motor Control Applications

ORDERING INFORMATION	
Package	TO-247AC
Lead (Pb)-free	IRFP21N60LPbF SiHFP21N60L-E3
SnPb	IRFP21N60L SiHFP21N60L

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	$I_D$	$T_C = 25\text{ }^\circ\text{C}$	21	A
			$T_C = 100\text{ }^\circ\text{C}$	13	
Pulsed Drain Current <sup>a</sup>		$I_{DM}$	84		
Linear Derating Factor			2.6	W/ $^\circ\text{C}$	
Single Pulse Avalanche Energy <sup>b</sup>		$E_{AS}$	420	mJ	
Repetitive Avalanche Current <sup>a</sup>		$I_{AR}$	21	A	
Repetitive Avalanche Energy <sup>a</sup>		$E_{AR}$	33	mJ	
Maximum Power Dissipation	$T_C = 25\text{ }^\circ\text{C}$	$P_D$	330	W	
Peak Diode Recovery $dV/dt^c$		$dV/dt$	16	V/ns	
Operating Junction and Storage Temperature Range		$T_J, T_{stg}$	- 55 to + 150	$^\circ\text{C}$	
Soldering Recommendations (Peak Temperature)	for 10 s		300 <sup>d</sup>		
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  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 1.9\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 21\text{ A}$ ,  $dV/dt = 11\text{ V/ns}$  (see fig. 12a).
- $I_{SD} \leq 21\text{ A}$ ,  $dI/dt \leq 530\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$ .
- 1.6 mm from case.

\* Pb containing terminations are not RoHS compliant, exemptions may apply

THERMAL RESISTANCE RATINGS				
PARAMETER	SYMBOL	TYP.	MAX.	UNIT
Maximum Junction-to-Ambient	$R_{thJA}$	-	40	°C/W
Case-to-Sink, Flat, Greased Surface	$R_{thCS}$	0.24	-	
Maximum Junction-to-Case (Drain)	$R_{thJC}$	-	0.38	

## 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 $25\text{ }^\circ\text{C}, I_D = 1\text{ mA}$	-	420	-	mV/°C
Gate-Source Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$	3.0	-	5.0	V
Gate-Source Leakage	$I_{GSS}$	$V_{GS} = \pm 30\text{ V}$	-	-	$\pm 100$	nA
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$	-	-	50	$\mu\text{A}$
		$V_{DS} = 480\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	-	2.0	mA
Drain-Source On-State Resistance	$R_{DS(on)}$	$V_{GS} = 10\text{ V}, I_D = 13\text{ A}^b$	-	0.27	0.32	$\Omega$
Forward Transconductance	$g_{fs}$	$V_{DS} = 50\text{ V}, I_D = 13\text{ A}$	11	-	-	S
<b>Dynamic</b>						
Input Capacitance	$C_{iss}$	$V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1.0\text{ MHz}, \text{ see fig. 5}$	-	4000	-	pF
Output Capacitance	$C_{oss}$		-	340	-	
Reverse Transfer Capacitance	$C_{rss}$		-	29	-	
Effective Output Capacitance	$C_{oss\text{ eff.}}$	$V_{GS} = 0\text{ V}, V_{DS} = 0\text{ V to } 480\text{ V}^c$	-	170	-	pF
Effective Output Capacitance (Energy Related)	$C_{oss\text{ eff. (ER)}}$		-	130	-	
Total Gate Charge	$Q_g$	$V_{GS} = 10\text{ V}, I_D = 21\text{ A}, V_{DS} = 480\text{ V}$ see fig. 7 and 15 <sup>b</sup>	-	-	150	nC
Gate-Source Charge	$Q_{gs}$		-	-	46	
Gate-Drain Charge	$Q_{gd}$		-	-	64	
Gate Resistance	$R_g$	$f = 1\text{ MHz}, \text{ open drain}$	-	0.63	-	$\Omega$
Turn-On Delay Time	$t_{d(on)}$	$V_{DD} = 300\text{ V}, I_D = 21\text{ A}, R_g = 1.3\text{ }\Omega, V_{GS} = 10\text{ V}, \text{ see fig. 11a and 11b}^b$	-	20	-	ns
Rise Time	$t_r$		-	58	-	
Turn-Off Delay Time	$t_{d(off)}$		-	33	-	
Fall Time	$t_f$		-	10	-	
<b>Drain-Source Body Diode Characteristics</b>						
Continuous Source-Drain Diode Current	$I_S$	MOSFET symbol showing the integral reverse p - n junction diode 	-	-	21	A
Pulsed Diode Forward Current <sup>a</sup>	$I_{SM}$		-	-	84	
Body Diode Voltage	$V_{SD}$	$T_J = 25\text{ }^\circ\text{C}, I_S = 21\text{ A}, V_{GS} = 0\text{ V}^b$	-	-	1.5	V
Body Diode Reverse Recovery Time	$t_{rr}$	$T_J = 25\text{ }^\circ\text{C}, I_F = 21\text{ A}$	-	160	240	ns
		$T_J = 125\text{ }^\circ\text{C}, dI/dt = 100\text{ A}/\mu\text{s}^b$	-	400	610	
Body Diode Reverse Recovery Charge	$Q_{rr}$	$T_J = 25\text{ }^\circ\text{C}, I_F = 21\text{ A}, V_{GS} = 0\text{ V}^b$	-	480	730	nC
		$T_J = 125\text{ }^\circ\text{C}, dI/dt = 100\text{ A}/\mu\text{s}^b$	-	1540	2310	
Reverse Recovery Time	$I_{RRM}$	$T_J = 25\text{ }^\circ\text{C}$	-	5.3	7.9	A
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  $\leq 2\%$ .
- $C_{oss\text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DS}$ .  
 $C_{oss\text{ eff. (ER)}}$  is a fixed capacitance that stores the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DS}$ .

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

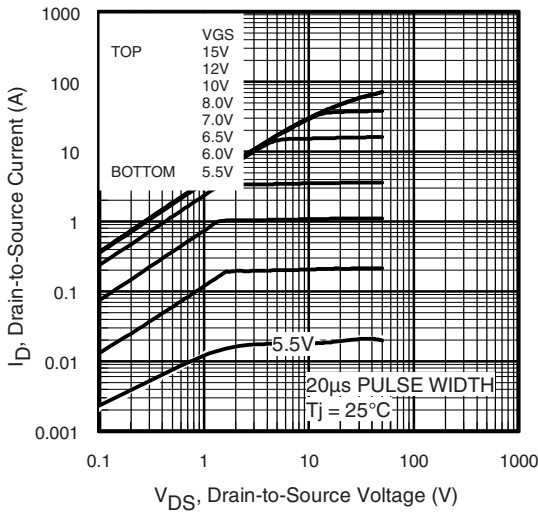


Fig. 1 - Typical Output Characteristics

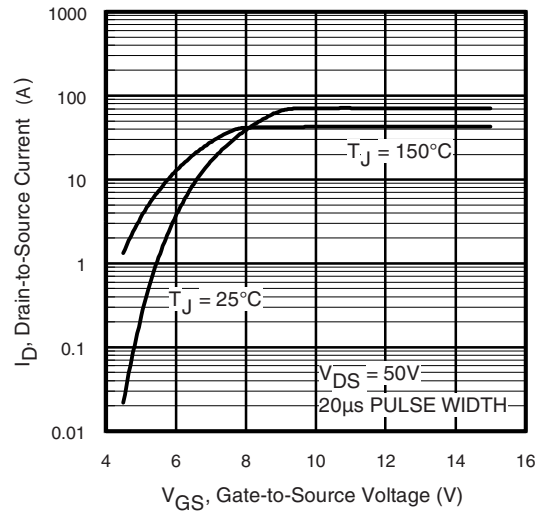


Fig. 3 - Typical Transfer Characteristics

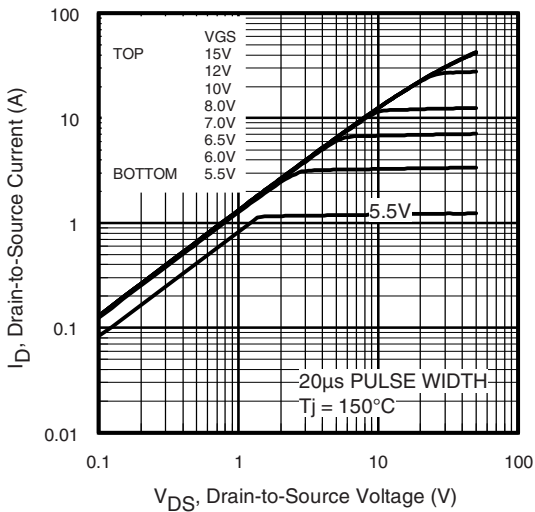


Fig. 2 - Typical Output Characteristics

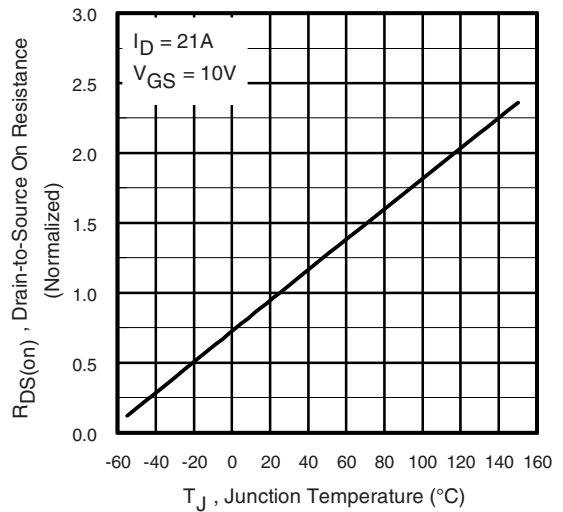


Fig. 4 - Normalized On-Resistance vs. Temperature

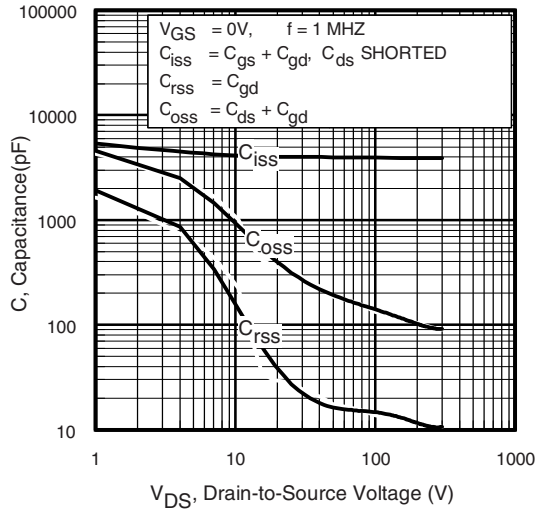


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

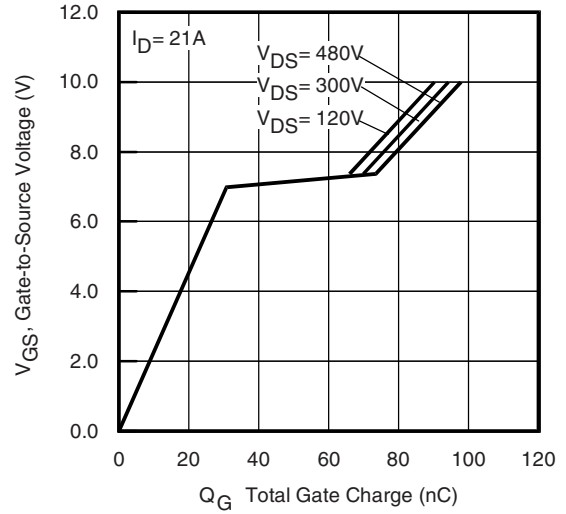


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage

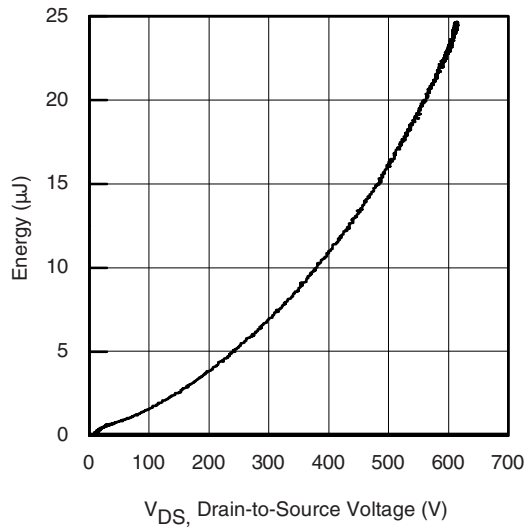


Fig. 6 - Typical Output Capacitance Stored Energy vs.  $V_{DS}$

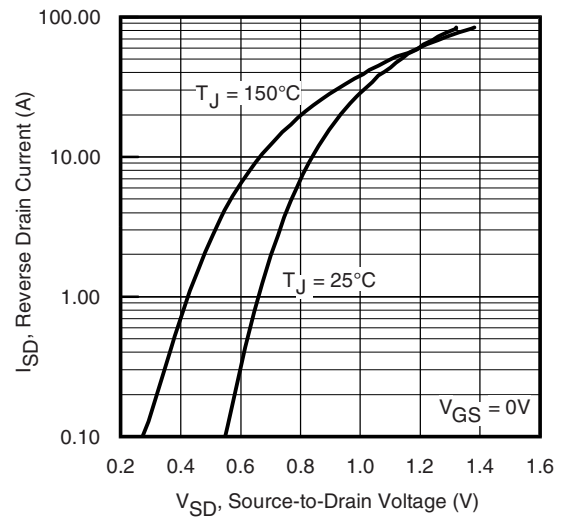
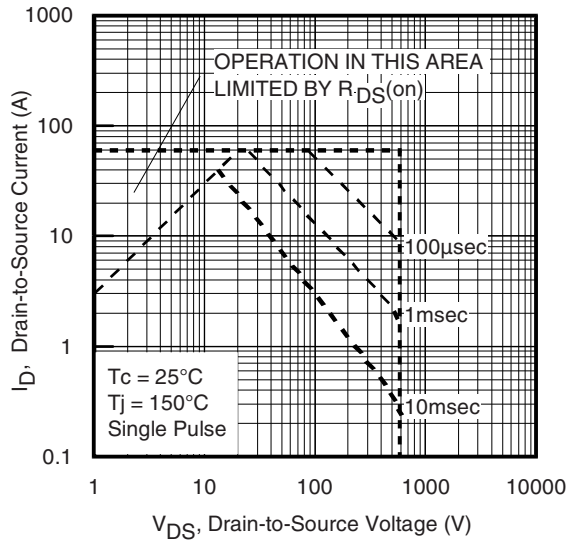
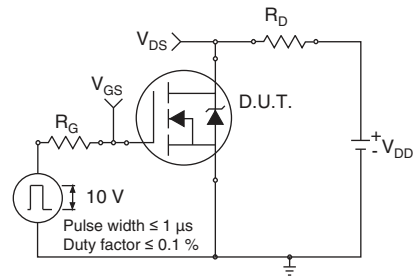


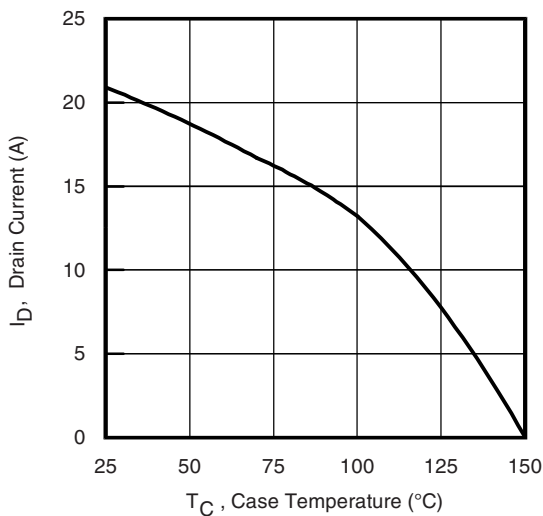
Fig. 8 - Typical Source-Drain Diode Forward Voltage



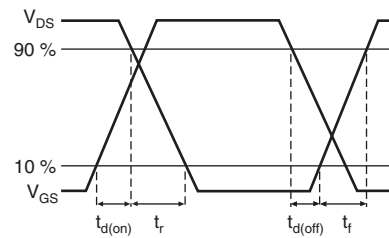
**Fig. 9 - Maximum Safe Operating Area**



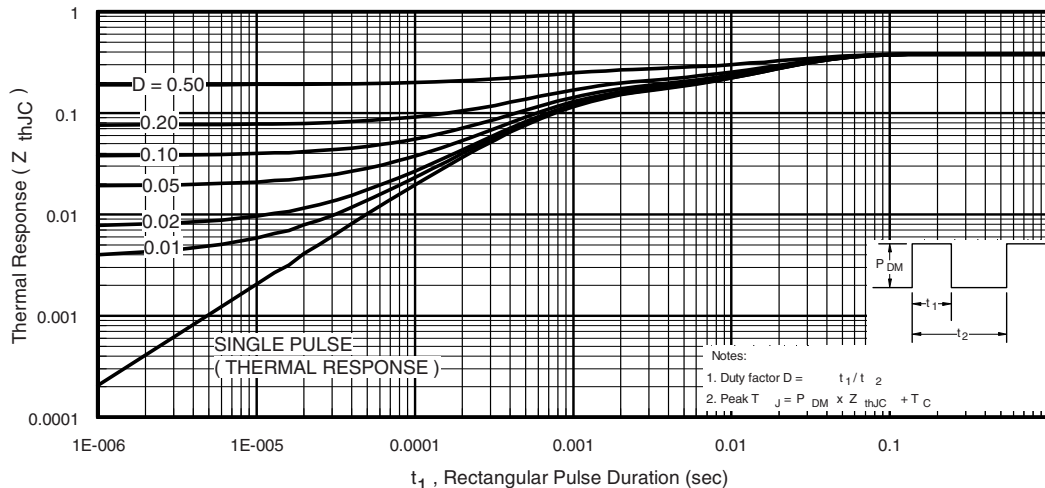
**Fig. 11a - Switching Time Test Circuit**



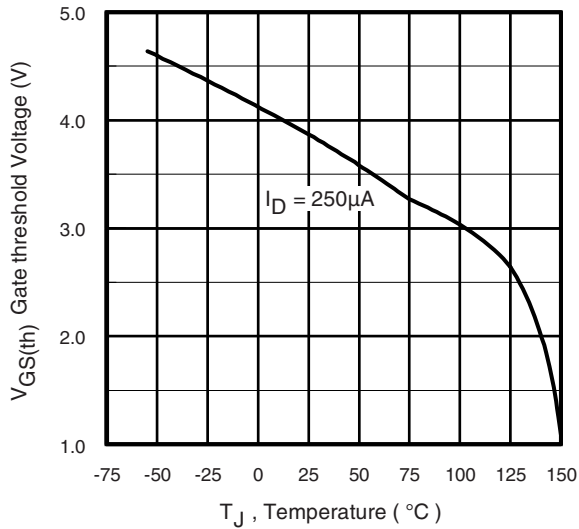
**Fig. 10 - Maximum Drain Current vs. Case Temperature**



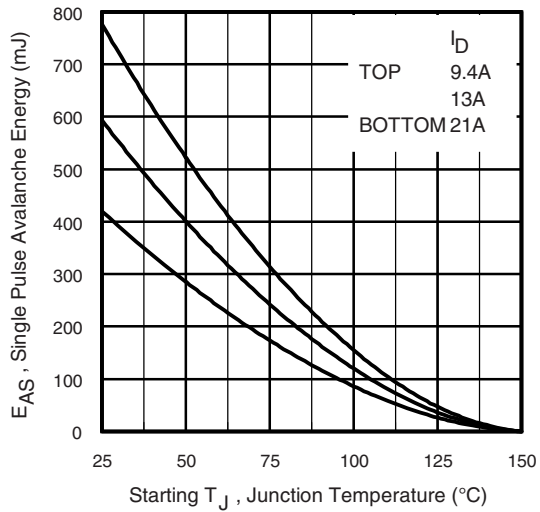
**Fig. 11b - Switching Time Waveforms**



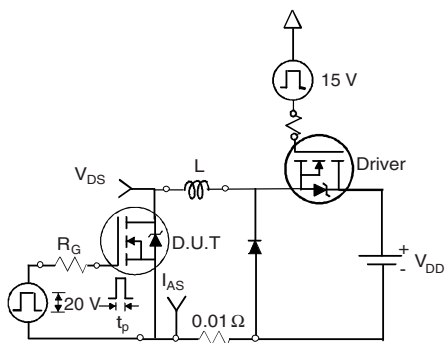
**Fig. 12 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**



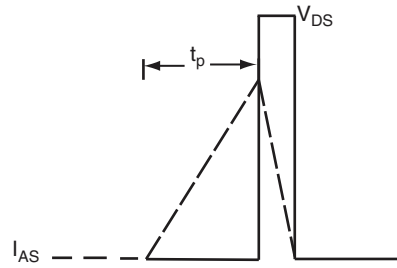
**Fig. 13 - Threshold Voltage vs. Temperature**



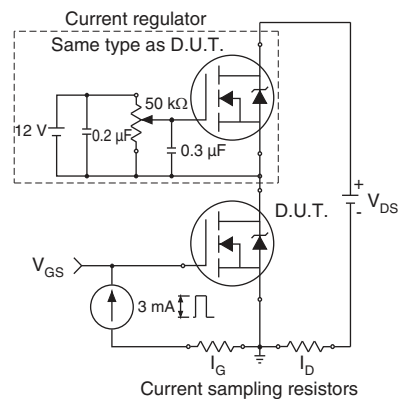
**Fig. 14a - Maximum Avalanche Energy vs. Drain Current**



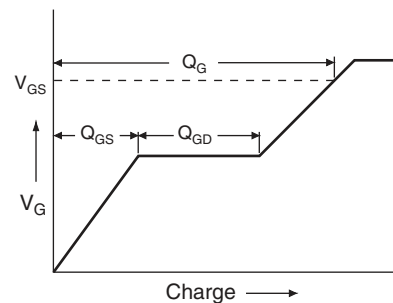
**Fig. 14b - Unclamped Inductive Test Circuit**



**Fig. 14c - Unclamped Inductive Waveforms**



**Fig. 15a - Gate Charge Test Circuit**



**Fig. 15b - Basic Gate Charge Waveform**

### Peak Diode Recovery dV/dt Test Circuit



**Note**

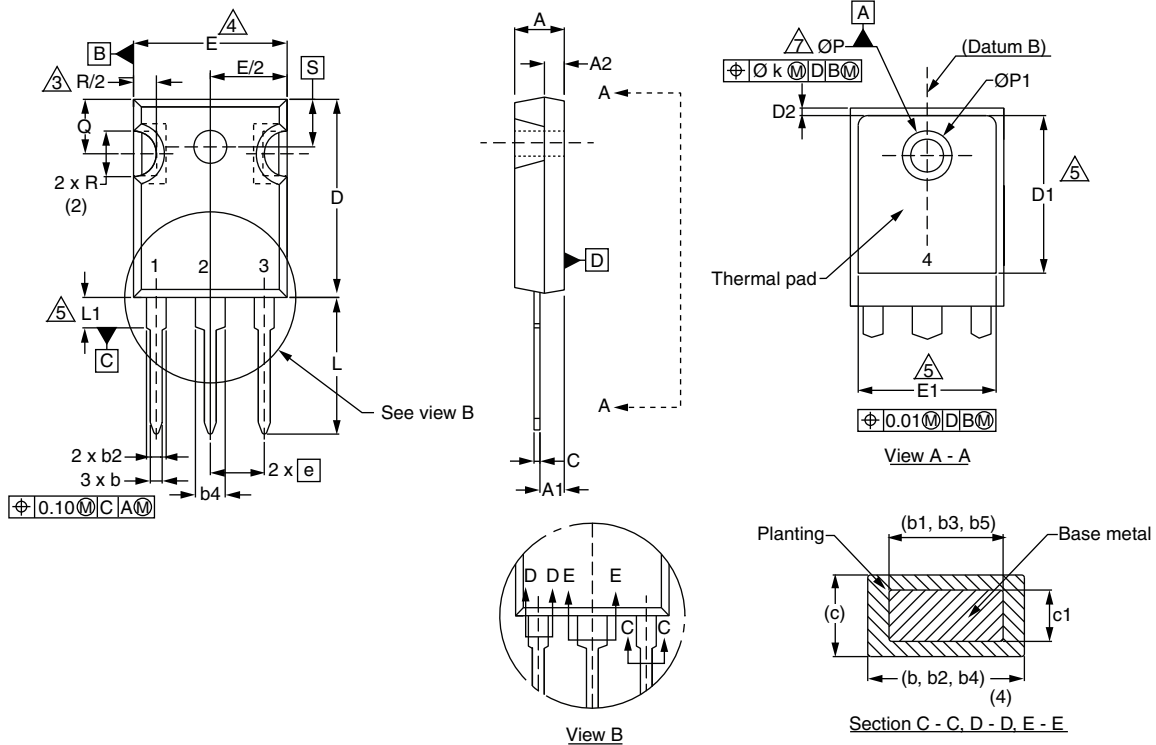
a.  $V_{GS} = 5\text{ V}$  for logic level devices

**Fig. 16 - For N-Channel**

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# TO-247AC (High Voltage)



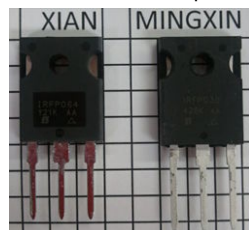
DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	4.58	5.31	0.180	0.209
A1	2.21	2.59	0.087	0.102
A2	1.17	2.49	0.046	0.098
b	0.99	1.40	0.039	0.055
b1	0.99	1.35	0.039	0.053
b2	1.53	2.39	0.060	0.094
b3	1.65	2.37	0.065	0.093
b4	2.42	3.43	0.095	0.135
b5	2.59	3.38	0.102	0.133
c	0.38	0.86	0.015	0.034
c1	0.38	0.76	0.015	0.030
D	19.71	20.82	0.776	0.820
D1	13.08	-	0.515	-

DIM.	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
D2	0.51	1.30	0.020	0.051
E	15.29	15.87	0.602	0.625
E1	13.72	-	0.540	-
e	5.46 BSC		0.215 BSC	
$\phi k$	0.254		0.010	
L	14.20	16.25	0.559	0.640
L1	3.71	4.29	0.146	0.169
N	7.62 BSC		0.300 BSC	
$\phi P$	3.51	3.66	0.138	0.144
$\phi P1$	-	7.39	-	0.291
Q	5.31	5.69	0.209	0.224
R	4.52	5.49	0.178	0.216
S	5.51 BSC		0.217 BSC	

ECN: X12-0167-Rev. B, 24-Sep-12  
DWG: 5971

**Notes**

1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Contour of slot optional.
3. Dimension D and E do not include mold flash. Mold flash shall not exceed 0.127 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body.
4. Thermal pad contour optional with dimensions D1 and E1.
5. Lead finish uncontrolled in L1.
6.  $\phi P$  to have a maximum draft angle of 1.5 to the top of the part with a maximum hole diameter of 3.91 mm (0.154").
7. Outline conforms to JEDEC outline TO-247 with exception of dimension c.
8. Xian and Mingxin actually photo.







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