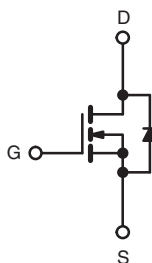
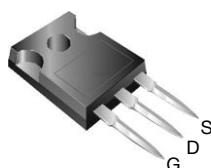


## Power MOSFET

### 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<br>SiHFP21N60L-E3 |
| SnPb           | IRFP21N60L<br>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                         | $I_D$            | $T_C = 25\text{ }^\circ\text{C}$  | A                   |
|                                                  |                  | $T_C = 100\text{ }^\circ\text{C}$ |                     |
| 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                        | $P_D$            | 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 |      |

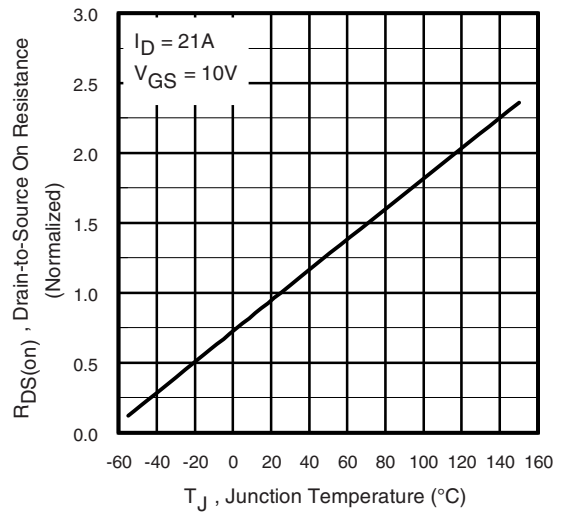
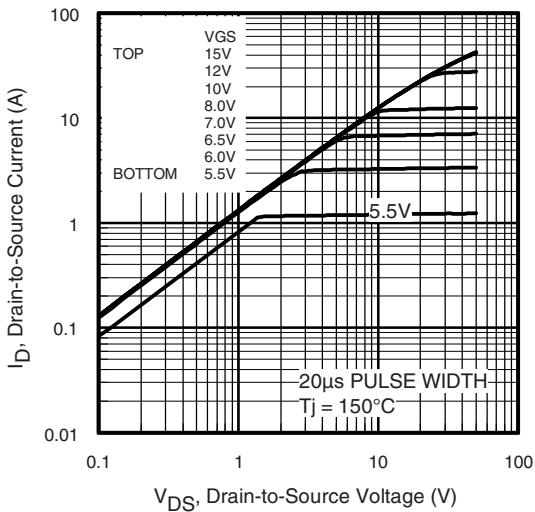
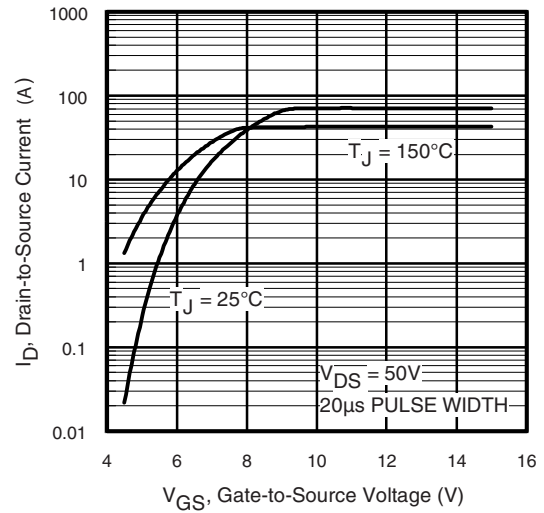
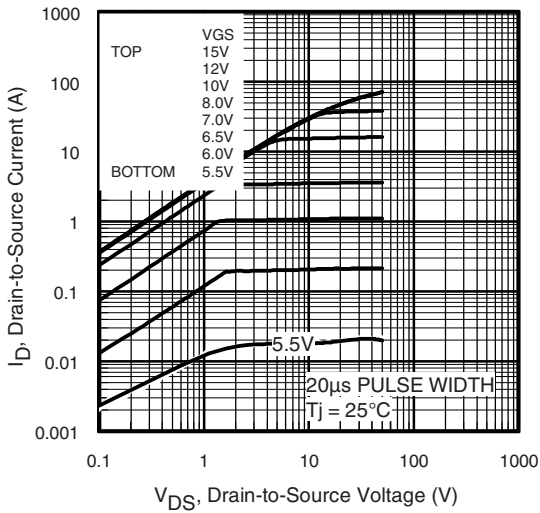
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

| PARAMETER                                     | SYMBOL                           | TEST CONDITIONS                                                                                                                                         |                                                                                  | MIN. | TYP. | MAX.  | UNIT  |
|-----------------------------------------------|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------|------|-------|-------|
| Static                                        |                                  |                                                                                                                                                         |                                                                                  |      |      |       |       |
| Drain-Source Breakdown Voltage                | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                                                                                          |                                                                                  | 600  | -    | -     | V     |
| V <sub>DS</sub> Temperature Coefficient       | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = 1 mA                                                                                                               |                                                                                  | -    | 420  | -     | mV/°C |
| Gate-Source Threshold Voltage                 | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                                             |                                                                                  | 3.0  | -    | 5.0   | V     |
| Gate-Source Leakage                           | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 30 V                                                                                                                                |                                                                                  | -    | -    | ± 100 | nA    |
| Zero Gate Voltage Drain Current               | I <sub>DSS</sub>                 | V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V                                                                                                          |                                                                                  | -    | -    | 50    | μA    |
|                                               |                                  | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C                                                                                 |                                                                                  | -    | -    | 2.0   | mA    |
| Drain-Source On-State Resistance              | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                                                  | I <sub>D</sub> = 13 A <sup>b</sup>                                               | -    | 0.27 | 0.32  | Ω     |
| Forward Transconductance                      | g <sub>fs</sub>                  | V <sub>DS</sub> = 50 V, I <sub>D</sub> = 13 A                                                                                                           |                                                                                  | 11   | -    | -     | S     |
| Dynamic                                       |                                  |                                                                                                                                                         |                                                                                  |      |      |       |       |
| Input Capacitance                             | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 25 V,<br>f = 1.0 MHz, see fig. 5                                                                            |                                                                                  | -    | 4000 | -     | pF    |
| Output Capacitance                            | C <sub>oss</sub>                 |                                                                                                                                                         |                                                                                  | -    | 340  | -     |       |
| Reverse Transfer Capacitance                  | C <sub>rss</sub>                 |                                                                                                                                                         |                                                                                  | -    | 29   | -     |       |
| Effective Output Capacitance                  | C <sub>oss</sub> eff.            | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 0 V to 480 V <sup>c</sup>                                                                                   |                                                                                  | -    | 170  | -     |       |
| Effective Output Capacitance (Energy Related) | C <sub>oss</sub> eff. (ER)       |                                                                                                                                                         |                                                                                  | -    | 130  | -     |       |
| Total Gate Charge                             | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                                                  | I <sub>D</sub> = 21 A, V <sub>DS</sub> = 480 V<br>see fig. 7 and 15 <sup>b</sup> | -    | -    | 150   | nC    |
| Gate-Source Charge                            | Q <sub>gs</sub>                  |                                                                                                                                                         |                                                                                  | -    | -    | 46    |       |
| Gate-Drain Charge                             | Q <sub>gd</sub>                  |                                                                                                                                                         |                                                                                  | -    | -    | 64    |       |
| Gate Resistance                               | R <sub>g</sub>                   | f = 1 MHz, open drain                                                                                                                                   |                                                                                  | -    | 0.63 | -     | Ω     |
| Turn-On Delay Time                            | t <sub>d(on)</sub>               | V <sub>DD</sub> = 300 V, I <sub>D</sub> = 21 A,<br>R <sub>g</sub> = 1.3 Ω, V <sub>GS</sub> = 10 V,<br>see fig. 11a and 11b <sup>b</sup>                 |                                                                                  | -    | 20   | -     | ns    |
| Rise Time                                     | t <sub>r</sub>                   |                                                                                                                                                         |                                                                                  | -    | 58   | -     |       |
| Turn-Off Delay Time                           | t <sub>d(off)</sub>              |                                                                                                                                                         |                                                                                  | -    | 33   | -     |       |
| Fall Time                                     | t <sub>f</sub>                   |                                                                                                                                                         |                                                                                  | -    | 10   | -     |       |
| Drain-Source Body Diode Characteristics       |                                  |                                                                                                                                                         |                                                                                  |      |      |       |       |
| Continuous Source-Drain Diode Current         | I <sub>S</sub>                   | MOSFET symbol showing the integral reverse p - n junction diode<br> |                                                                                  | -    | -    | 21    | A     |
| Pulsed Diode Forward Current <sup>a</sup>     | I <sub>SM</sub>                  |                                                                                                                                                         |                                                                                  | -    | -    | 84    |       |
| Body Diode Voltage                            | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 21 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                                                       |                                                                                  | -    | -    | 1.5   | V     |
| Body Diode Reverse Recovery Time              | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 21 A                                                                                                           |                                                                                  | -    | 160  | 240   | ns    |
|                                               |                                  | T <sub>J</sub> = 125 °C, dI/dt = 100 A/μs <sup>b</sup>                                                                                                  |                                                                                  | -    | 400  | 610   |       |
| Body Diode Reverse Recovery Charge            | Q <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 21 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                                                       |                                                                                  | -    | 480  | 730   | nC    |
|                                               |                                  | T <sub>J</sub> = 125 °C, dI/dt = 100 A/μs <sup>b</sup>                                                                                                  |                                                                                  | -    | 1540 | 2310  |       |
| Reverse Recovery Time                         | I <sub>RRM</sub>                 | T <sub>J</sub> = 25 °C                                                                                                                                  |                                                                                  | -    | 5.3  | 7.9   | A     |
| Forward Turn-On Time                          | t <sub>on</sub>                  | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )                                                       |                                                                                  |      |      |       |       |

**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)



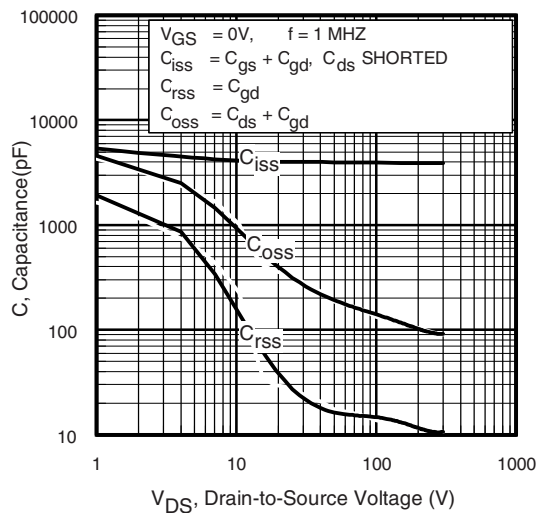


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

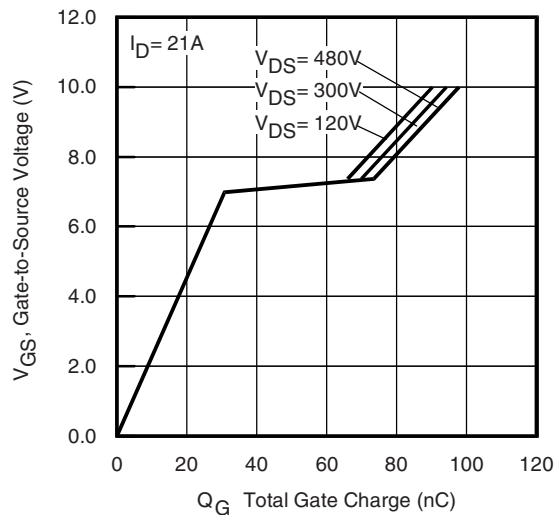


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage

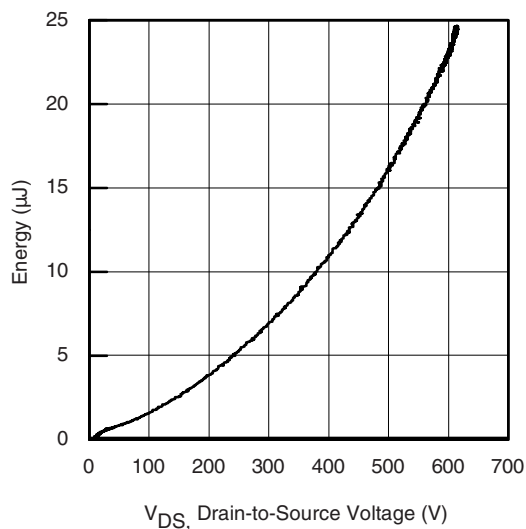


Fig. 6 - Typical Output Capacitance Stored Energy vs.  $V_{DS}$

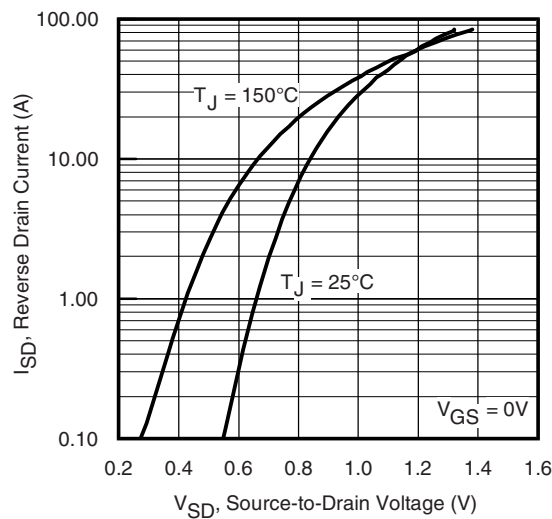
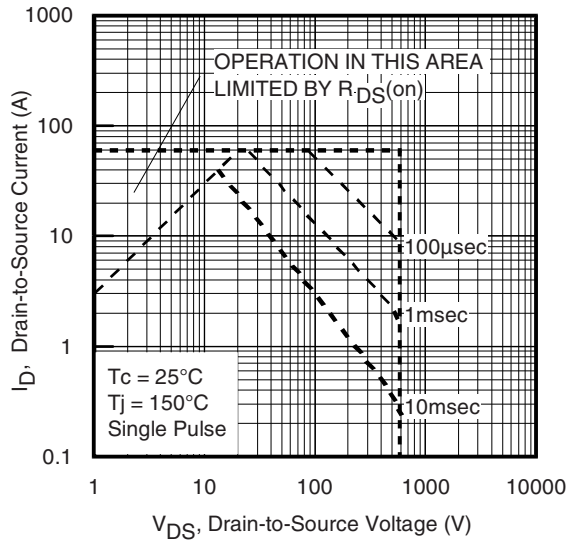
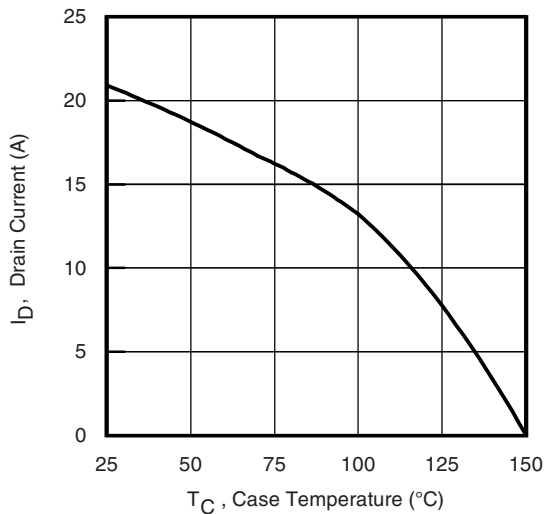


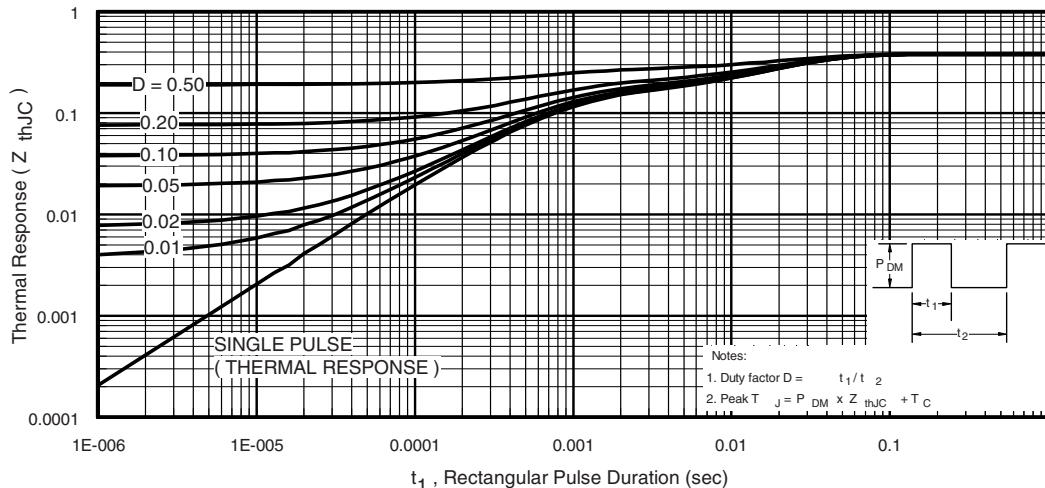
Fig. 8 - Typical Source-Drain Diode Forward Voltage



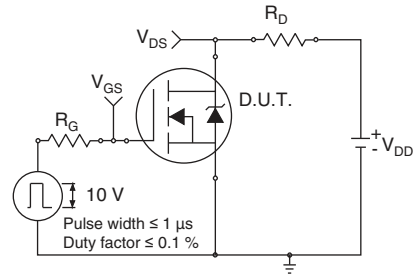
**Fig. 9 - Maximum Safe Operating Area**



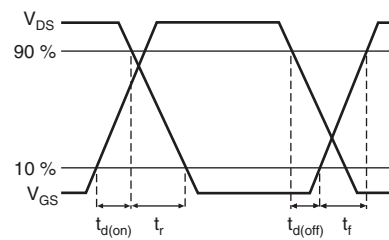
**Fig. 10 - Maximum Drain Current vs. Case Temperature**



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



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



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

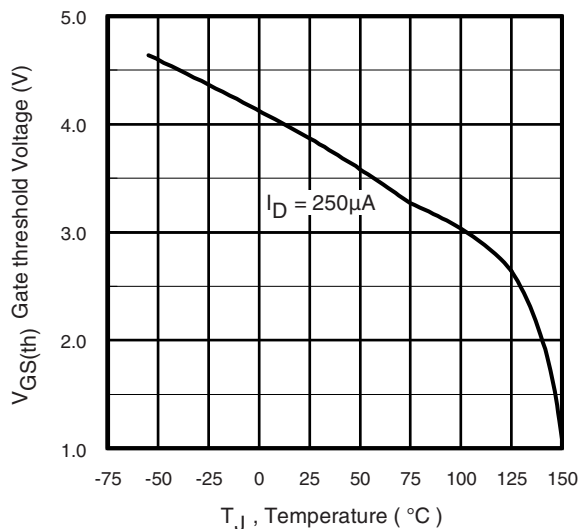


Fig. 13 - Threshold Voltage vs. Temperature

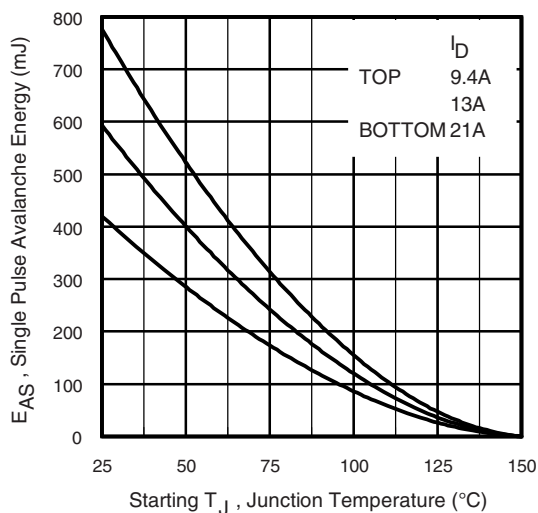


Fig. 14a - Maximum Avalanche Energy vs. Drain Current

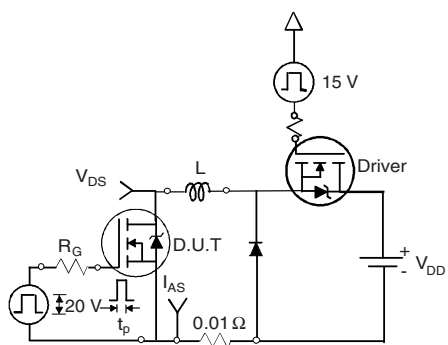


Fig. 14b - Unclamped Inductive Test Circuit

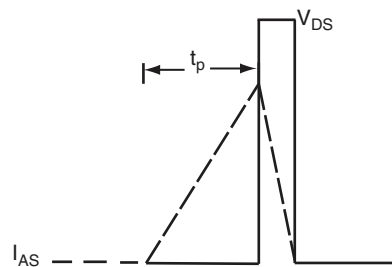


Fig. 14c - Unclamped Inductive Waveforms

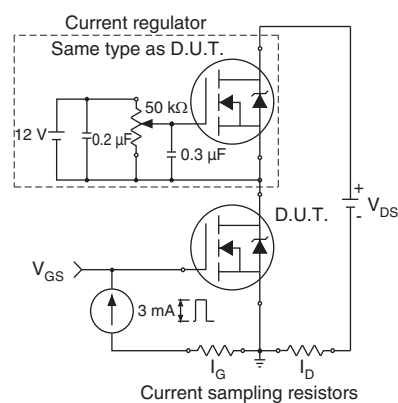


Fig. 15a - Gate Charge Test Circuit

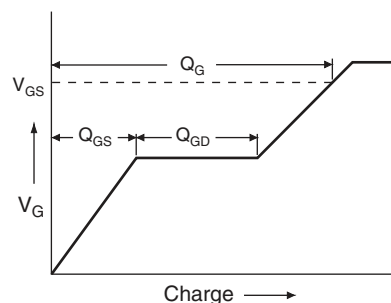
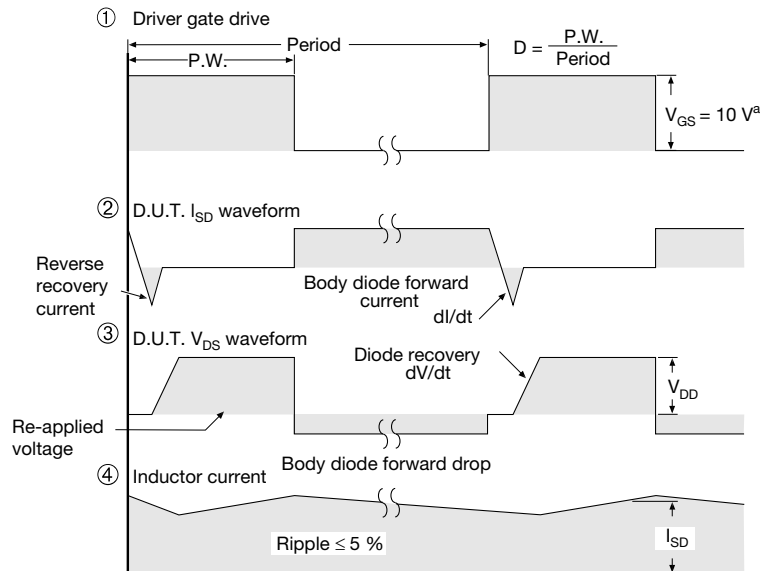
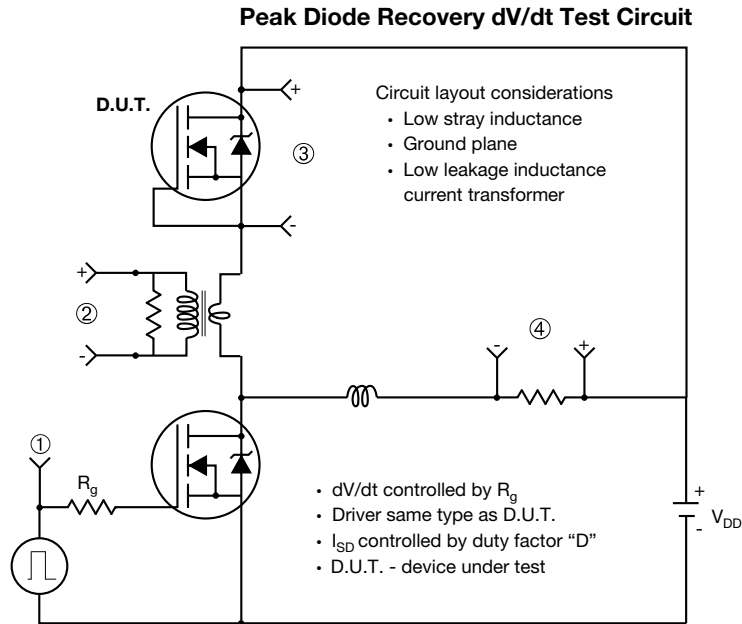


Fig. 15b - Basic Gate Charge Waveform



**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  | -     |

ECN: X13-0103-Rev. D, 01-Jul-13  
DWG: 5971

| 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 |       |
| Ø 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 |       |
| Ø P  | 3.51        | 3.66  | 0.138     | 0.144 |
| Ø 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 |       |

## 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. Ø 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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