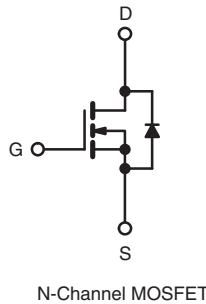
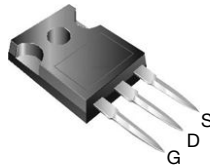


## Power MOSFET

| PRODUCT SUMMARY           |                               |
|---------------------------|-------------------------------|
| $V_{DS}$ (V)              | 600                           |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$   0.24 |
| $Q_g$ (Max.) (nC)         | 150                           |
| $Q_{gs}$ (nC)             | 45                            |
| $Q_{gd}$ (nC)             | 76                            |
| Configuration             | Single                        |

TO-247AC



### 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
- Enhanced Body Diode  $dV/dt$  Capability
- Compliant to RoHS Directive 2002/95/EC



**RoHS\***  
COMPLIANT

### BENEFITS

- Hard Switching Primary or PFS Switch
- Switch Mode Power Supply (SMPS)
- Uninterruptible Power Supply
- High Speed Power Switching
- Motor Drive

| ORDERING INFORMATION |                |
|----------------------|----------------|
| Package              | TO-247AC       |
| Lead (Pb)-free       | IRFP22N60KPbF  |
|                      | SiHFP22N60K-E3 |
| SnPb                 | IRFP22N60K     |
|                      | SiHFP22N60K    |

| 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                 | $T_C = 25\text{ }^\circ\text{C}$  | A                   |                  |
|   |                                  | $T_C = 100\text{ }^\circ\text{C}$ |                     |                  |
| Pulsed Drain Current <sup>a</sup>   | $I_{DM}$                         | 88                                |                     |                  |
| Linear Derating Factor  |                                  | 2.9                               | W/ $^\circ\text{C}$ |                  |
| Single Pulse Avalanche Energy <sup>b</sup>  | $E_{AS}$                         | 380                               | mJ                  |                  |
| Repetitive Avalanche Current <sup>a</sup>   | $I_{AR}$                         | 22                                | A                   |                  |
| Repetitive Avalanche Energy <sup>a</sup>  | $E_{AR}$                         | 37                                | mJ                  |                  |
| Maximum Power Dissipation   | $T_C = 25\text{ }^\circ\text{C}$ | $P_D$                             | 370                 | W                |
| Peak Diode Recovery $dV/dt^c$   |                                  | $dV/dt$                           | 15                  | 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>    |                  |


#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- Starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 1.5\text{ mH}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 22\text{ A}$  (see fig. 12).
- $I_{SD} \leq 22\text{ A}$ ,  $dI/dt \leq 360\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$ .
- 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)    | $R_{thJC}$ | -    | 0.34 |      |

## 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 $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}^d$  | -  | 0.30  | -         | V/°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        | $\mu\text{A}$ |
|  |                       | $V_{DS} = 480\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^\circ\text{C}$  | -  | -     | 250       |               |
| Drain-Source On-State Resistance               | $R_{DS(on)}$          | $V_{GS} = 10\text{ V}$ , $I_D = 13\text{ A}^b$   | -  | 0.240 | 0.280     | $\Omega$      |
| Forward Transconductance                       | $g_{fs}$              | $V_{DS} = 50\text{ V}$ , $I_D = 13\text{ A}^b$   | 11   | -     | -         | S             |
| <b>Dynamic</b>                                 |                       |  |  |       |           |               |
| Input Capacitance                              | $C_{iss}$             | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 25\text{ V}$ ,<br>$f = 1.0\text{ MHz}$ , see fig. 5   | -  | 3570  | -         | pF            |
| Output Capacitance                             | $C_{oss}$             |  | -  | 350   | -         |               |
| Reverse Transfer Capacitance                   | $C_{rss}$             |  | -  | 36    | -         |               |
| Output Capacitance                             | $C_{oss}$             | $V_{GS} = 0\text{ V}$  | $V_{DS} = 1.0\text{ V}$ , $f = 1.0\text{ MHz}$ | -     | 4710      | -             |
|  |                       |  | $V_{DS} = 480\text{ V}$ , $f = 1.0\text{ MHz}$ | -     | 92        | -             |
| Effective Output Capacitance                   | $C_{oss\text{ eff.}}$ | $V_{DS} = 0\text{ V to }480\text{ V}$  | -  | 180   | -         |               |
| Total Gate Charge                              | $Q_g$                 | $V_{GS} = 10\text{ V}$ ,<br>$I_D = 22\text{ A}$ , $V_{DS} = 480\text{ V}$<br>see fig. 6 and 13 <sup>b</sup>  | -  | -     | 150       | nC            |
| Gate-Source Charge                             | $Q_{gs}$              |  | -  | -     | 45        |               |
| Gate-Drain Charge                              | $Q_{gd}$              |  | -  | -     | 76        |               |
| Turn-On Delay Time                             | $t_{d(on)}$           | $V_{DD} = 300\text{ V}$ , $I_D = 22\text{ A}$ ,<br>$R_g = 6.2$ , $V_{GS} = 10\text{ V}$ ,<br>see fig. 10 <sup>b</sup>                                | -  | 26    | -         | ns            |
| Rise Time                                      | $t_r$                 |  | -  | 99    | -         |               |
| Turn-Off Delay Time                            | $t_{d(off)}$          |  | -  | 48    | -         |               |
| Fall Time                                      | $t_f$                 |  | -  | 37    | -         |               |
| <b>Drain-Source Body Diode Characteristics</b> |                       |  |  |       |           |               |
| Continuous Source-Drain Diode Current          | $I_S$                 | MOSFET symbol showing the integral reverse p - n junction diode  | -  | -     | 22        | A             |
| Pulsed Diode Forward Current <sup>a</sup>      | $I_{SM}$              |  | -  | -     | 88        |               |
| Body Diode Voltage                             | $V_{SD}$              | $T_J = 25\text{ }^\circ\text{C}$ , $I_S = 22\text{ A}$ , $V_{GS} = 0\text{ V}^b$   | -  | -     | 1.5       | V             |
| Body Diode Reverse Recovery Time               | $t_{rr}$              | $T_J = 25\text{ }^\circ\text{C}$   | -  | 590   | 890       | ns            |
|  |                       | $T_J = 125\text{ }^\circ\text{C}$  | -  | 670   | 1010      |               |
| Body Diode Reverse Recovery Charge             | $Q_{rr}$              | $T_J = 25\text{ }^\circ\text{C}$   | -  | 7.2   | 11        | $\mu\text{C}$ |
|  |                       | $T_J = 125\text{ }^\circ\text{C}$  | -  | 8.5   | 13        |               |
| Reverse Recovery Current                       | $I_{RRM}$             | $T_J = 25\text{ }^\circ\text{C}$   | -  | 26    | 39        |               |
| 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 %  $V_{DS}$ .

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

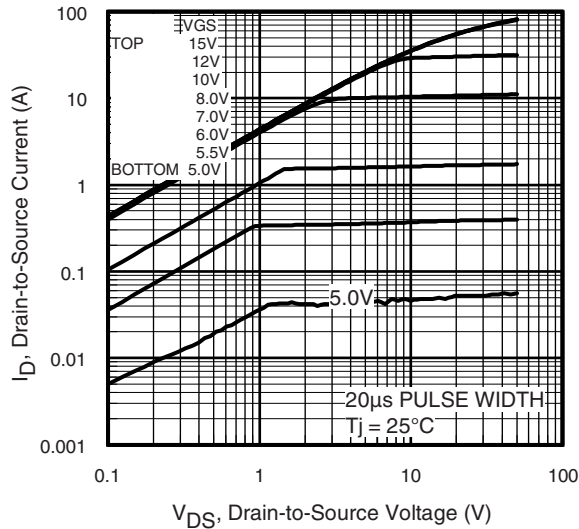


Fig. 1 - Typical Output Characteristics

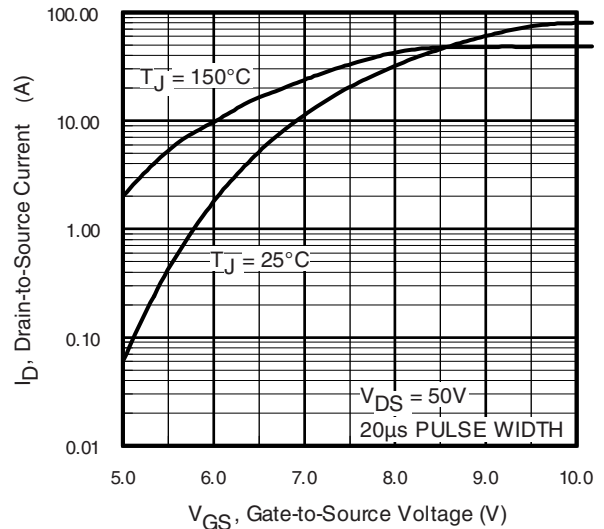


Fig. 3 - Typical Transfer Characteristics

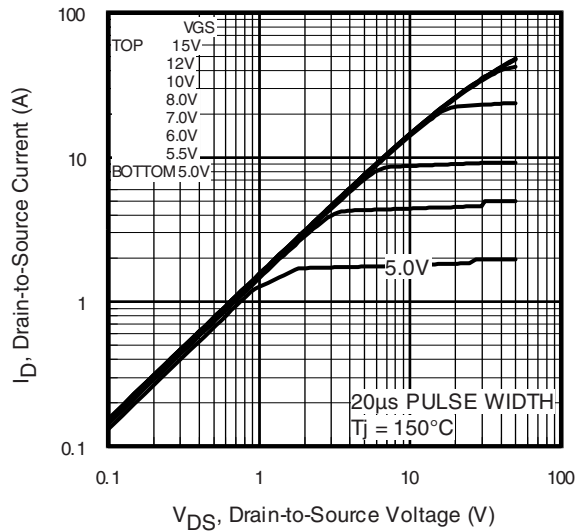


Fig. 2 - Typical Output Characteristics

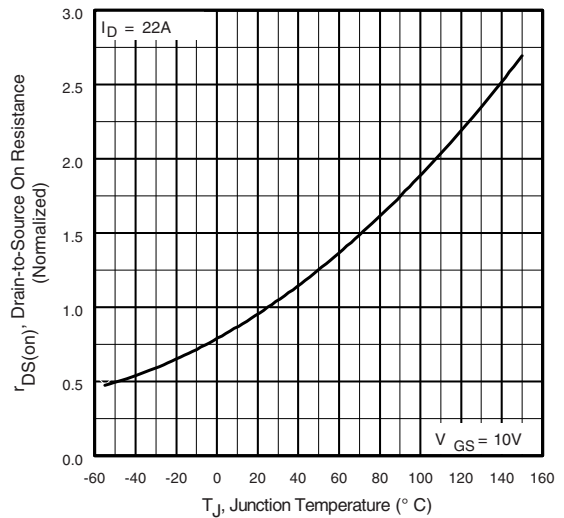


Fig. 4 - Normalized On-Resistance vs. Temperature

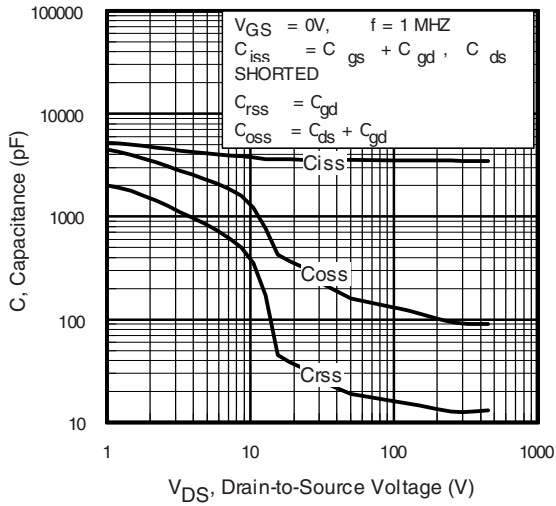


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

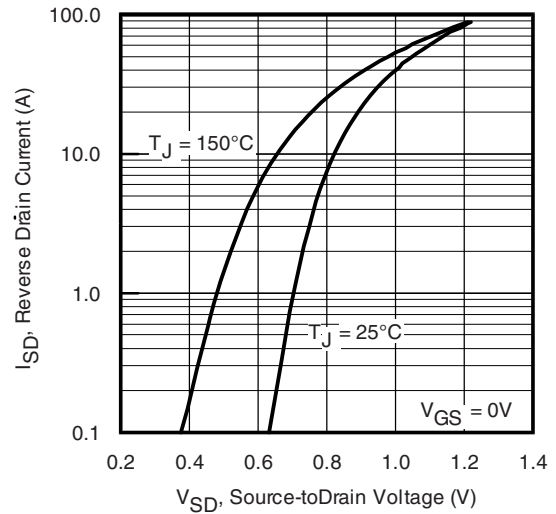


Fig. 7 - Typical Source-Drain Diode Forward Voltage

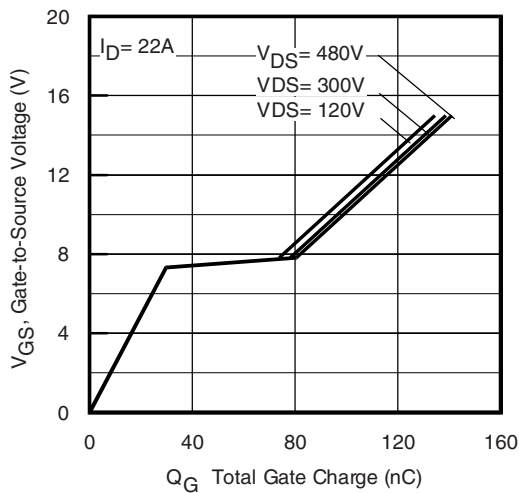


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

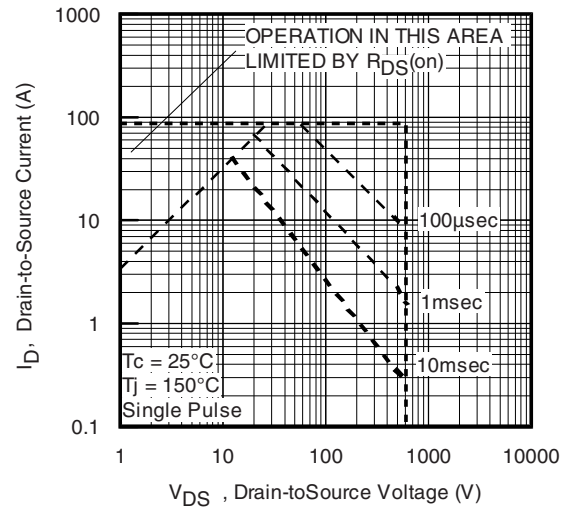
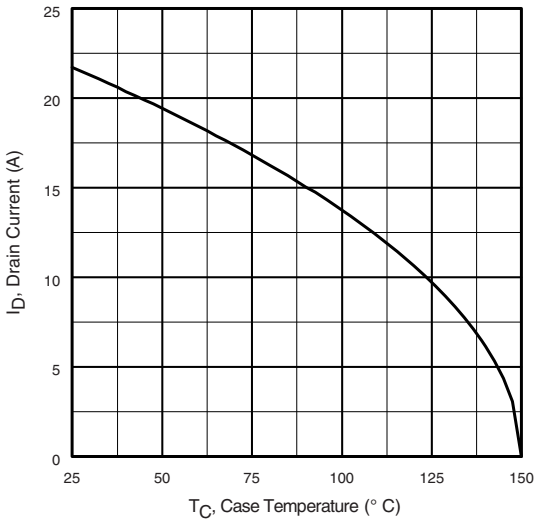


Fig. 8 - Maximum Safe Operating Area



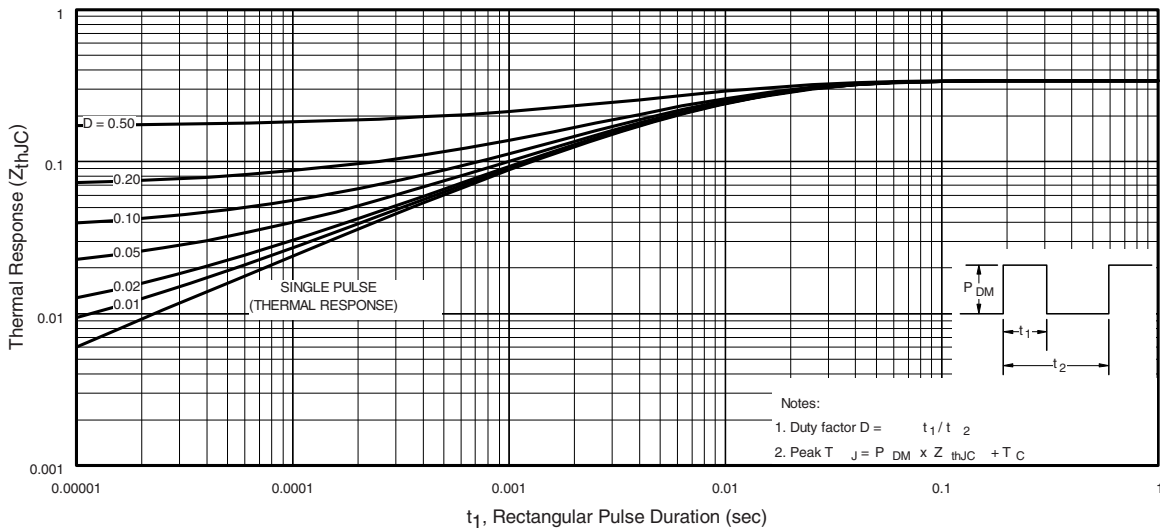
**Fig. 9 - Maximum Drain Current vs. Case Temperature**



**Fig. 10a - Switching Time Test Circuit**



**Fig. 10b - Switching Time Waveforms**



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

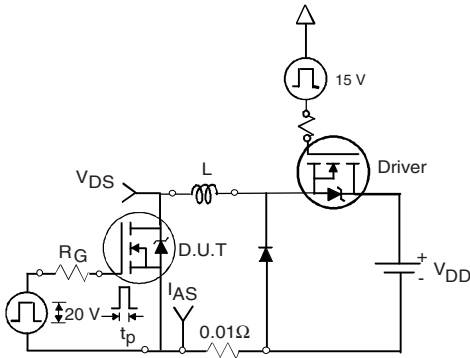


Fig. 12a - Unclamped Inductive Test Circuit



Fig. 12b - Unclamped Inductive Waveforms

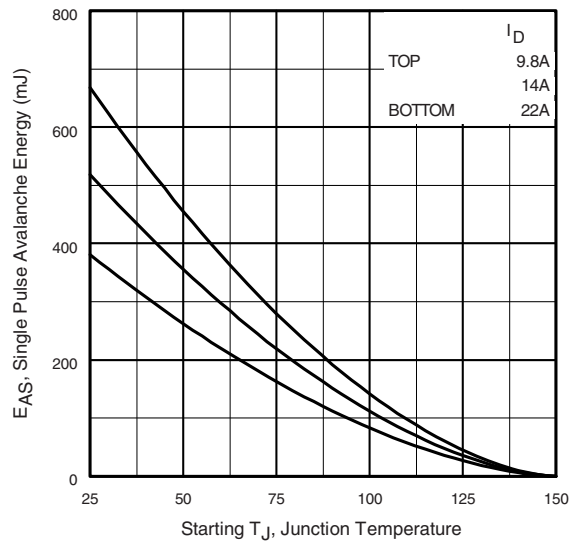


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

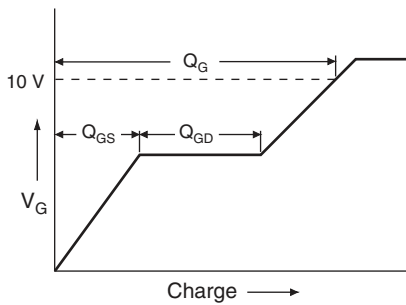


Fig. 13a - Basic Gate Charge Waveform

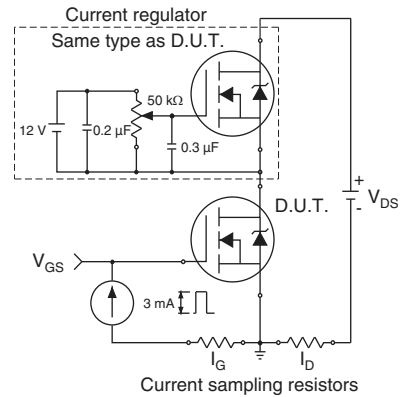


Fig. 13b - Gate Charge Test Circuit

### 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-247AC (High Voltage)

VERSION 1: FACILITY CODE = 9



Section C--C, D--D, E--E

| DIM. | MILLIMETERS |       | NOTES |
|------|-------------|-------|-------|
|      | MIN.        | MAX.  |       |
| A    | 4.83        | 5.21  |       |
| A1   | 2.29        | 2.55  |       |
| A2   | 1.50        | 2.49  |       |
| b    | 1.12        | 1.33  |       |
| b1   | 1.12        | 1.28  |       |
| b2   | 1.91        | 2.39  | 6     |
| b3   | 1.91        | 2.34  |       |
| b4   | 2.87        | 3.22  | 6, 8  |
| b5   | 2.87        | 3.18  |       |
| c    | 0.55        | 0.69  | 6     |
| c1   | 0.55        | 0.65  |       |
| D    | 20.40       | 20.70 | 4     |

| DIM. | MILLIMETERS |       | NOTES |
|------|-------------|-------|-------|
|      | MIN.        | MAX.  |       |
| D1   | 16.25       | 16.85 | 5     |
| D2   | 0.56        | 0.76  |       |
| E    | 15.50       | 15.87 | 4     |
| E1   | 13.46       | 14.16 | 5     |
| E2   | 4.52        | 5.49  | 3     |
| e    | 5.44 BSC    |       |       |
| L    | 14.90       | 15.40 |       |
| L1   | 3.96        | 4.16  | 6     |
| Ø P  | 3.56        | 3.65  | 7     |
| Ø P1 | 7.19 ref.   |       |       |
| Q    | 5.31        | 5.69  |       |
| S    | 5.54        | 5.74  |       |

**Notes**

- (1) Package reference: JEDEC TO247, variation AC
- (2) All dimensions are in mm
- (3) Slot required, notch may be rounded
- (4) Dimension D and E do not include mold flash. Mold flash shall not exceed 0.127 mm per side. These dimensions are measured at the outermost extremes of the plastic body
- (5) Thermal pad contour optional with dimensions D1 and E1
- (6) Lead finish uncontrolled in L1
- (7) 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
- (8) Dimension b2 and b4 does not include dambar protrusion. Allowable dambar protrusion shall be 0.1 mm total in excess of b2 and b4 dimension at maximum material condition





**VERSION 2: FACILITY CODE = Y**



| DIM. | MILLIMETERS |       | NOTES |
|------|-------------|-------|-------|
|      | MIN.        | MAX.  |       |
| A    | 4.58        | 5.31  |       |
| A1   | 2.21        | 2.59  |       |
| A2   | 1.17        | 2.49  |       |
| b    | 0.99        | 1.40  |       |
| b1   | 0.99        | 1.35  |       |
| b2   | 1.53        | 2.39  |       |
| b3   | 1.65        | 2.37  |       |
| b4   | 2.42        | 3.43  |       |
| b5   | 2.59        | 3.38  |       |
| c    | 0.38        | 0.86  |       |
| c1   | 0.38        | 0.76  |       |
| D    | 19.71       | 20.82 |       |
| D1   | 13.08       | -     |       |

| DIM. | MILLIMETERS |       | NOTES |
|------|-------------|-------|-------|
|      | MIN.        | MAX.  |       |
| D2   | 0.51        | 1.30  |       |
| E    | 15.29       | 15.87 |       |
| E1   | 13.72       | -     |       |
| e    | 5.46 BSC    |       |       |
| Ø k  | 0.254       |       |       |
| L    | 14.20       | 16.25 |       |
| L1   | 3.71        | 4.29  |       |
| Ø P  | 3.51        | 3.66  |       |
| Ø P1 | -           | 7.39  |       |
| Q    | 5.31        | 5.69  |       |
| R    | 4.52        | 5.49  |       |
| S    | 5.51 BSC    |       |       |

ECN: E19-0614-Rev. E, 25-Nov-2019  
 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) 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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