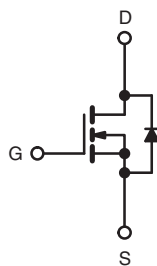
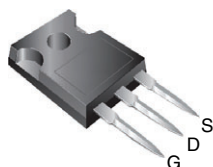


# Power MOSFET

**TO-247**


N-Channel MOSFET

## FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- Isolated central mounting hole
- Fast switching
- Ease of paralleling
- Simple drive requirements
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS\***  
Available

## Note

\* This datasheet provides information about parts that are RoHS-compliant and / or parts that are non RoHS-compliant. For example, parts with lead (Pb) terminations are not RoHS-compliant. Please see the information / tables in this datasheet for details

## DESCRIPTION

Third generation Power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-247 package is preferred for commercial-industrial applications where higher power levels preclude the use of TO-220 devices. The TO-247 is similar but superior to the earlier TO-218 package because its isolated mounting hole. It also provides greater creepage distances between pins to meet the requirements of most safety specifications.

## PRODUCT SUMMARY

|                           |                        |      |
|---------------------------|------------------------|------|
| $V_{DS}$ (V)              | 500                    |      |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ | 0.27 |
| $Q_g$ (max.) (nC)         | 210                    |      |
| $Q_{gs}$ (nC)             | 29                     |      |
| $Q_{gd}$ (nC)             | 110                    |      |
| Configuration             | Single                 |      |

## ORDERING INFORMATION

|                |            |
|----------------|------------|
| Package        | TO-247     |
| Lead (Pb)-free | IRFP460PbF |

## ABSOLUTE MAXIMUM RATINGS $T_C = 25\text{ }^\circ\text{C}$ , unless otherwise noted

| PARAMETER  |                         |                         | SYMBOL                            | LIMIT            | UNIT     |
|--|-------------------------|-------------------------|-----------------------------------|------------------|----------|
| Drain-source voltage                             |                         |                         | V <sub>DS</sub>                   | 500              | V        |
| Gate-source voltage                              |                         |                         | V <sub>GS</sub>                   | ± 20             |          |
| Continuous drain current                         | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 20               | A        |
|  |                         | T <sub>C</sub> = 100 °C |                                   | 13               |          |
| Pulsed drain current <sup>a</sup>                |                         |                         | I <sub>DM</sub>                   | 80               |          |
| Linear derating factor                           |                         |                         |                                   | 2.2              | W/°C     |
| Single pulse avalanche energy <sup>b</sup>       |                         |                         | E <sub>AS</sub>                   | 960              | mJ       |
| Repetitive avalanche current <sup>a</sup>        |                         |                         | I <sub>AR</sub>                   | 20               | A        |
| Repetitive avalanche energy <sup>a</sup>         |                         |                         | E <sub>AR</sub>                   | 28               | mJ       |
| Maximum power dissipation                        | T <sub>C</sub> = 25 °C  |                         | P <sub>D</sub>                    | 280              | W        |
| Peak diode recovery dV/dt <sup>c</sup>           |                         |                         | dV/dt                             | 3.5              | V/ns     |
| Operating junction and storage temperature range |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | -55 to +150      | °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)
- $V_{DD} = 50\text{ V}$ , starting  $T_J = 25\text{ }^\circ\text{C}$ ,  $L = 4.3\text{ mH}$ ,  $R_G = 25\text{ }\Omega$ ,  $I_{AS} = 20\text{ A}$  (see fig. 12)
- $I_{SD} \leq 20\text{ A}$ ,  $dI/dt \leq 160\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150\text{ }^\circ\text{C}$
- 1.6 mm from case

**THERMAL RESISTANCE RATINGS**

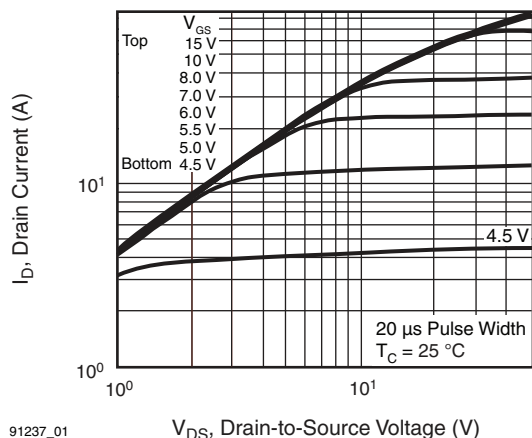
| PARAMETER                           | SYMBOL     | TYP. | MAX. | UNIT |
|-------------------------------------|------------|------|------|------|
| Maximum junction-to-ambient         | $R_{thJA}$ | -    | 40   | °C/W |
| Case-to-sink, flat, greased surface | $R_{thCS}$ | 0.24 | -    |      |
| Maximum junction-to-case (drain)    | $R_{thJC}$ | -    | 0.45 |      |

**SPECIFICATIONS**  $T_J = 25\text{ °C}$ , unless otherwise noted

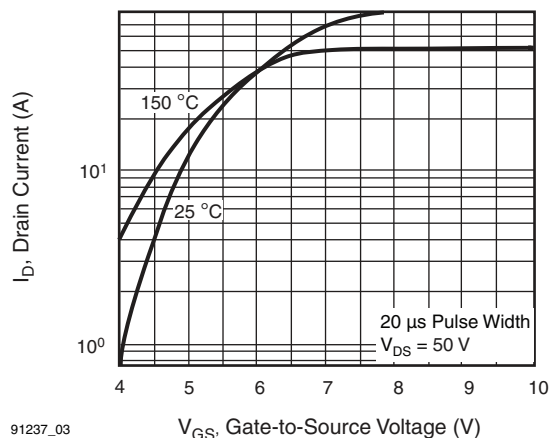
| PARAMETER                                 | SYMBOL                           | TEST CONDITIONS   |  | MIN. | TYP. | MAX.  | UNIT |
|---|----------------------------------|---|--|------|------|-------|------|
| Static                                    |                                  |   |  |      |      |       |      |
| Drain-source breakdown voltage            | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA  |  | 500  | -    | -     | 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   |  | -    | 0.63 | -     | V/°C |
| Gate-source threshold voltage             | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA   |  | 2.0  | -    | 4.0   | V    |
| Gate-source leakage                       | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 20 V  |  | -    | -    | ± 100 | nA   |
| Zero gate voltage drain current           | I <sub>DSS</sub>                 | V <sub>DS</sub> = 500 V, V <sub>GS</sub> = 0 V  |  | -    | -    | 25    | μA   |
|   |                                  | V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C   |  | -    | -    | 250   |      |
| Drain-source on-state resistance          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V  | I <sub>D</sub> = 12 A <sup>b</sup>   | -    | -    | 0.27  | Ω    |
| Forward transconductance                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 50 V, I <sub>D</sub> = 12 A <sup>b</sup>  |  | 13   | -    | -     | 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  |  | -    | 4200 | -     | pF   |
| Output capacitance                        | C <sub>oss</sub>                 |   |  | -    | 870  | -     |      |
| Reverse transfer capacitance              | C <sub>rss</sub>                 |   |  | -    | 350  | -     |      |
| Total gate charge                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V  | I <sub>D</sub> = 20 A, V <sub>DS</sub> = 400 V<br>see fig. 6 and 13 <sup>b</sup> | -    | -    | 210   | nC   |
| Gate-source charge                        | Q <sub>gs</sub>                  |   |  | -    | -    | 29    |      |
| Gate-drain charge                         | Q <sub>gd</sub>                  |   |  | -    | -    | 110   |      |
| Turn-on delay time                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 250 V, I <sub>D</sub> = 20 A ,<br>R <sub>G</sub> = 4.3 Ω, R <sub>D</sub> = 13 Ω, see fig. 10 <sup>b</sup> |  | -    | 18   | -     | ns   |
| Rise time                                 | t <sub>r</sub>                   |   |  | -    | 59   | -     |      |
| Turn-off delay time                       | t <sub>d(off)</sub>              |   |  | -    | 110  | -     |      |
| Fall time                                 | t <sub>f</sub>                   |   |  | -    | 58   | -     |      |
| Internal drain inductance                 | L <sub>D</sub>                   | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact  |  | -    | 5.0  | -     | nH   |
| Internal source inductance                | L <sub>S</sub>                   |   |  | -    | 13   | -     |      |
| Drain-Source Body Diode Characteristics   |                                  |   |  |      |      |       |      |
| Continuous source-drain diode current     | I <sub>S</sub>                   | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode  |  | -    | -    | 20    | A    |
| Pulsed diode forward current <sup>a</sup> | I <sub>SM</sub>                  |   |  | -    | -    | 80    |      |
| Body diode voltage                        | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 20 A, V <sub>GS</sub> = 0 V <sup>b</sup>   |  | -    | -    | 1.8   | V    |
| Body diode reverse recovery time          | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 20A, dI/dt = 100 A/μs <sup>b</sup>   |  | -    | 570  | 860   | ns   |
| Body diode reverse recovery charge        | Q <sub>rr</sub>                  |   |  | -    | 5.7  | 8.6   | μC   |
| 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**

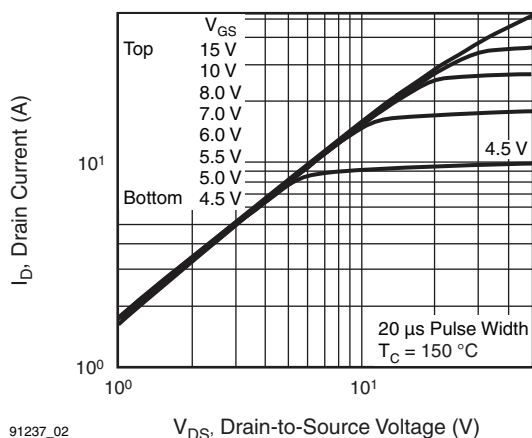
- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)  
b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$

**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted


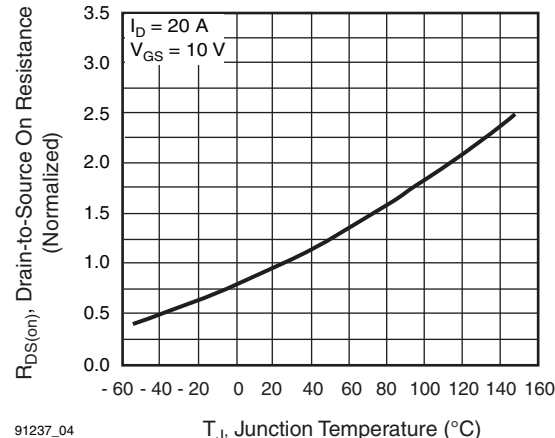
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**Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$** 


91237\_03

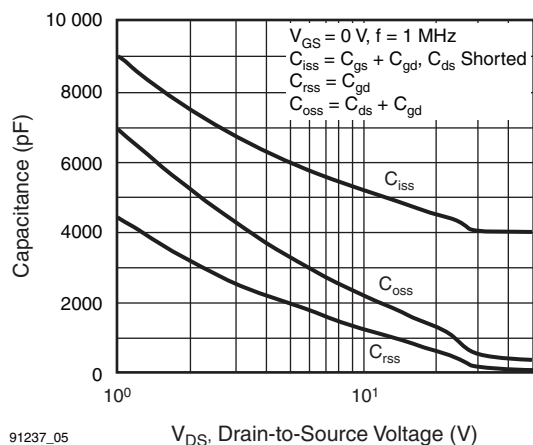
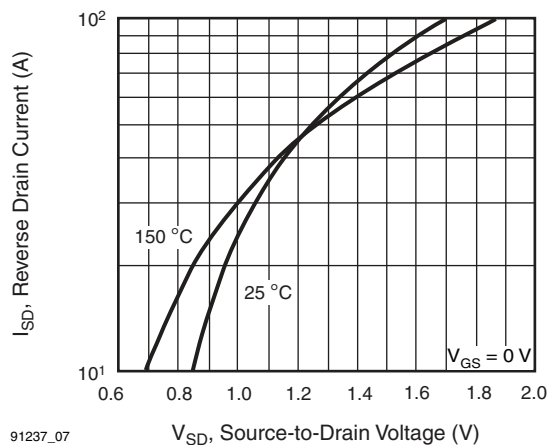
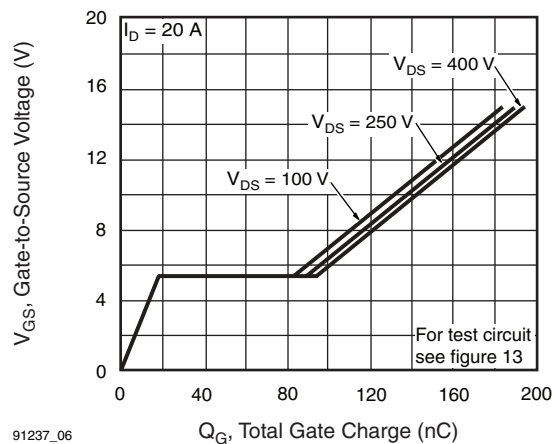
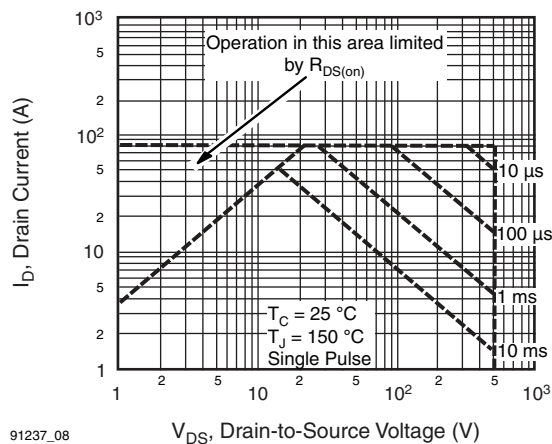
**Fig. 3 - Typical Transfer Characteristics**


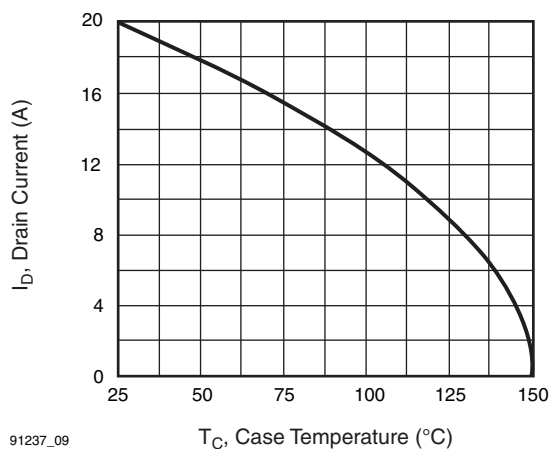
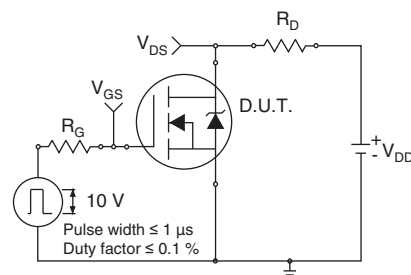
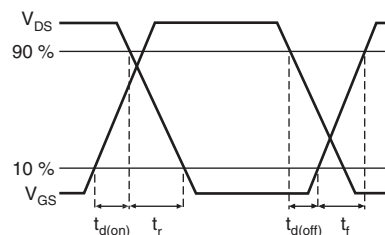
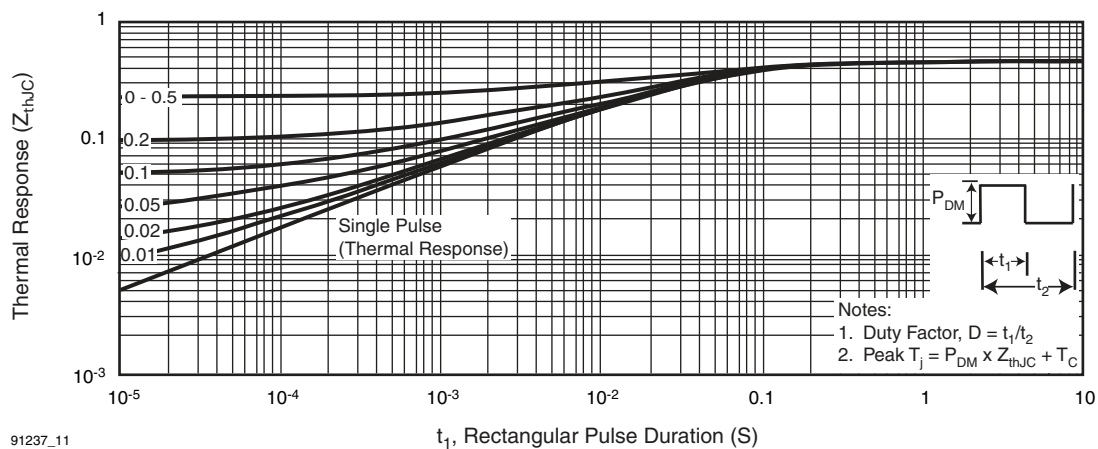
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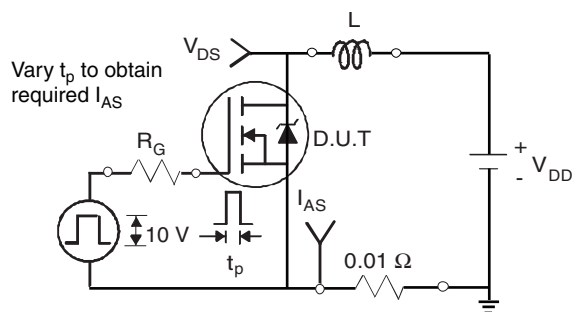
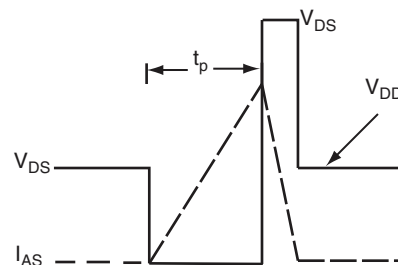
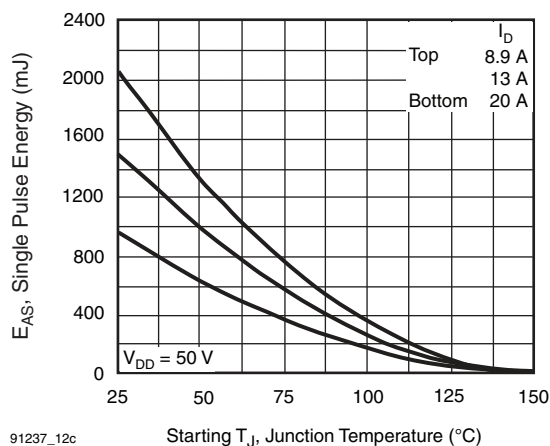
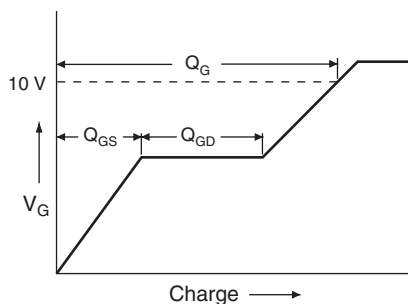
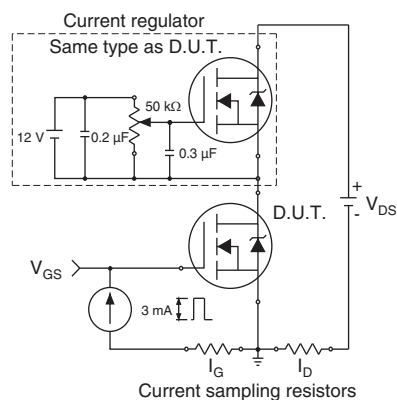
**Fig. 2 - Typical Output Characteristics,  $T_C = 150^\circ\text{C}$** 


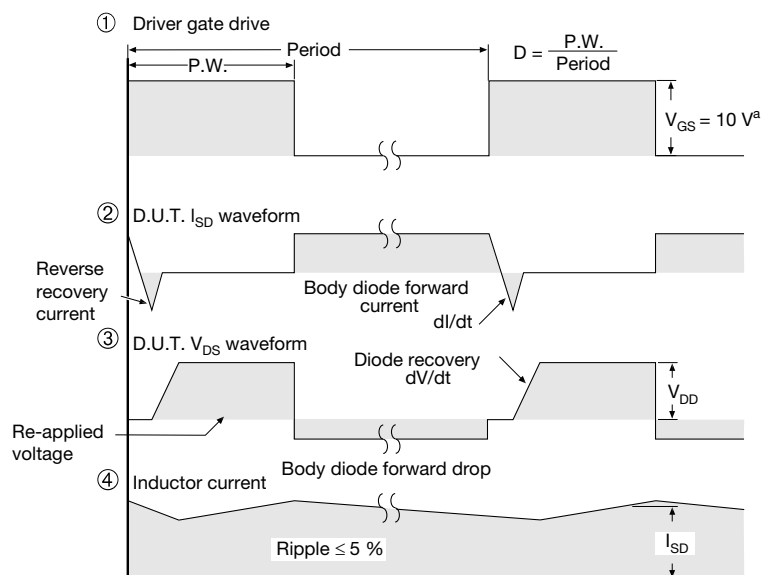
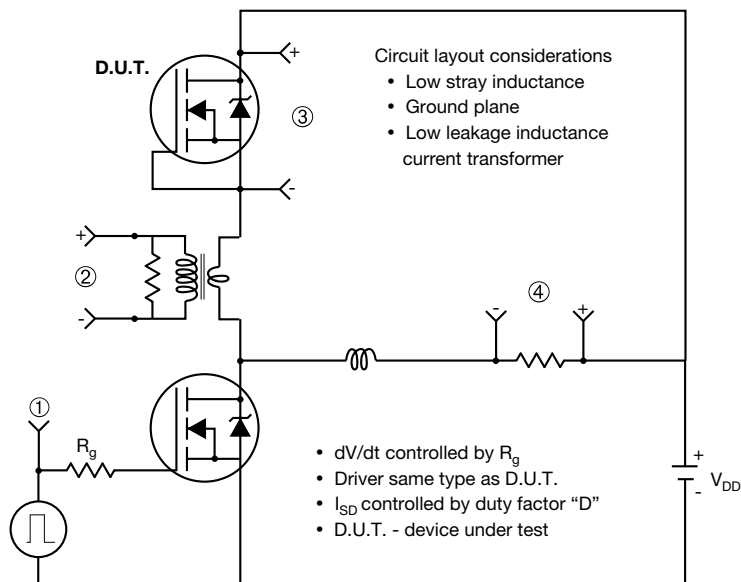
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**Fig. 4 - Normalized On-Resistance vs. Temperature**


**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. 10 - Switching Time Test Circuit**

**Fig. 11 - Switching Time Waveforms**

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


**Fig. 13 - Unclamped Inductive Test Circuit**

**Fig. 14 - Unclamped Inductive Waveforms**

**Fig. 15 - Maximum Avalanche Energy vs. Drain Current**

**Fig. 16 - Basic Gate Charge Waveform**

**Fig. 17 - Gate Charge Test Circuit**

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

**Note**

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

**Fig. 18 - For N-Channel**

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## TO-247AC (High Voltage)

### VERSION 1: FACILITY CODE = 9



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

| MILLIMETERS |       |       |       |       |
|-------------|-------|-------|-------|-------|
| DIM.        | MIN.  | NOM.  | MAX.  | NOTES |
| A           | 4.83  | 5.02  | 5.21  |       |
| A1          | 2.29  | 2.41  | 2.55  |       |
| A2          | 1.17  | 1.27  | 1.37  |       |
| b           | 1.12  | 1.20  | 1.33  |       |
| b1          | 1.12  | 1.20  | 1.28  |       |
| b2          | 1.91  | 2.00  | 2.39  | 6     |
| b3          | 1.91  | 2.00  | 2.34  |       |
| b4          | 2.87  | 3.00  | 3.22  | 6, 8  |
| b5          | 2.87  | 3.00  | 3.18  |       |
| c           | 0.40  | 0.50  | 0.60  | 6     |
| c1          | 0.40  | 0.50  | 0.56  |       |
| D           | 20.40 | 20.55 | 20.70 | 4     |

| MILLIMETERS |           |       |       |       |
|-------------|-----------|-------|-------|-------|
| DIM.        | MIN.      | NOM.  | MAX.  | NOTES |
| D1          | 16.46     | 16.76 | 17.06 | 5     |
| D2          | 0.56      | 0.66  | 0.76  |       |
| E           | 15.50     | 15.70 | 15.87 | 4     |
| E1          | 13.46     | 14.02 | 14.16 | 5     |
| E2          | 4.52      | 4.91  | 5.49  | 3     |
| e           | 5.46 BSC  |       |       |       |
| L           | 14.90     | 15.15 | 15.40 |       |
| L1          | 3.96      | 4.06  | 4.16  | 6     |
| Ø P         | 3.56      | 3.61  | 3.65  | 7     |
| Ø P1        | 7.19 ref. |       |       |       |
| Q           | 5.31      | 5.50  | 5.69  |       |
| S           | 5.51 BSC  |       |       |       |

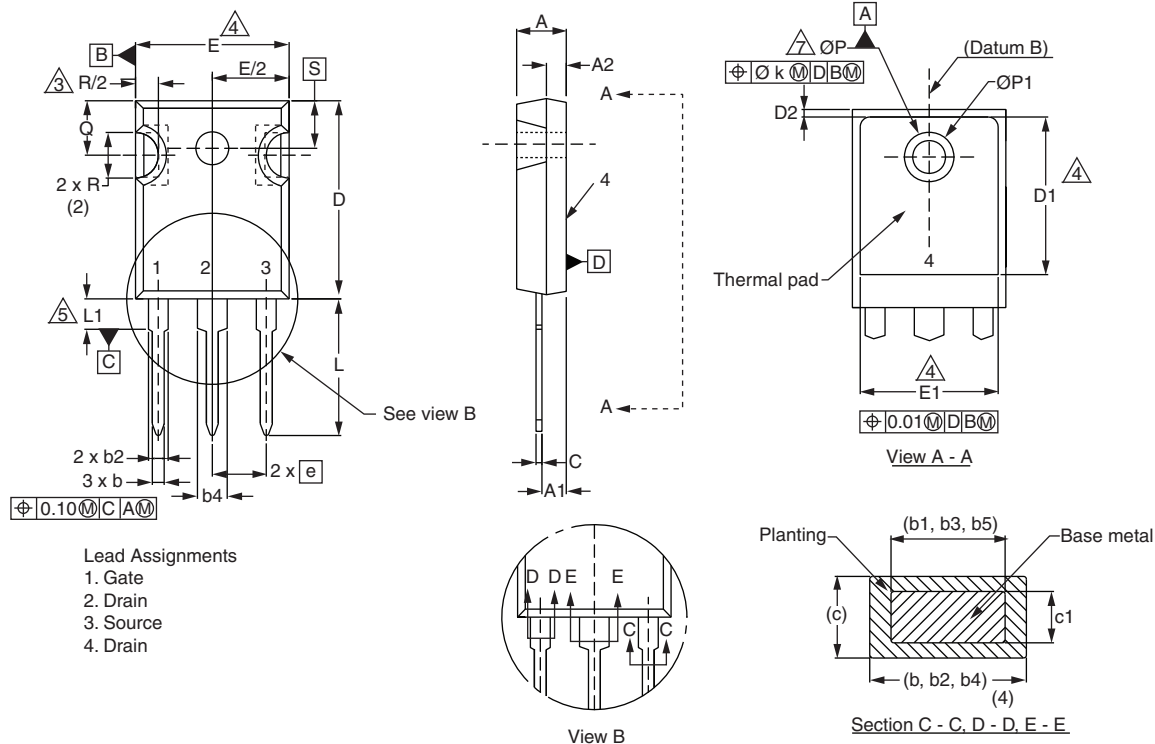
#### Notes

- (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    |       |       |

### Notes

- Dimensioning and tolerancing per ASME Y14.5M-1994
- Contour of slot optional
- 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
- Thermal pad contour optional with dimensions D1 and E1
- Lead finish uncontrolled in L1
- 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")
- Outline conforms to JEDEC outline TO-247 with exception of dimension c



## VERSION 3: FACILITY CODE = N



| MILLIMETERS |       |       |
|-------------|-------|-------|
| DIM.        | MIN.  | MAX.  |
| A           | 4.65  | 5.31  |
| A1          | 2.21  | 2.59  |
| A2          | 1.17  | 1.37  |
| b           | 0.99  | 1.40  |
| b1          | 0.99  | 1.35  |
| b2          | 1.65  | 2.39  |
| b3          | 1.65  | 2.34  |
| b4          | 2.59  | 3.43  |
| b5          | 2.59  | 3.38  |
| c           | 0.38  | 0.89  |
| c1          | 0.38  | 0.84  |
| D           | 19.71 | 20.70 |
| D1          | 13.08 | -     |

| MILLIMETERS |          |       |
|-------------|----------|-------|
| DIM.        | MIN.     | MAX.  |
| D2          | 0.51     | 1.35  |
| E           | 15.29    | 15.87 |
| E1          | 13.46    | -     |
| e           | 5.46 BSC |       |
| k           | 0.254    |       |
| L           | 14.20    | 16.10 |
| L1          | 3.71     | 4.29  |
| N           | 7.62 BSC |       |
| P           | 3.56     | 3.66  |
| P1          | -        | 7.39  |
| Q           | 5.31     | 5.69  |
| R           | 4.52     | 5.49  |
| S           | 5.51 BSC |       |

ECN: E22-0452-Rev. G, 31-Oct-2022  
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")



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