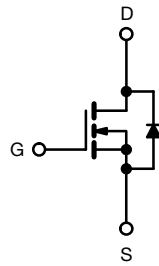
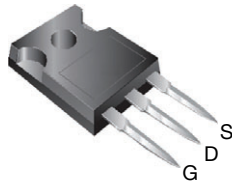


## EF Series Power MOSFET With Fast Body Diode

**TO-247AC**


N-Channel MOSFET

### FEATURES

- Fast body diode MOSFET using E series technology
- Reduced  $t_{rr}$ ,  $Q_{rr}$ , and  $I_{RRM}$
- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low switching losses due to reduced  $Q_{rr}$
- Ultra low gate charge ( $Q_g$ )
- Avalanche energy rated (UIS)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



### APPLICATIONS

- Telecommunications
  - Server and telecom power supplies
- Lighting
  - High-intensity lighting (HID)
  - Light emitting diodes (LEDs)
- Consumer and computing
  - ATX power supplies
- Industrial
  - Welding
  - Battery chargers
- Renewable energy
  - Solar (PV inverters)
- Switching mode power supplies (SMPS)
- Applications using the following topologies
  - LLC
  - Phase shifted bridge (ZVS)
  - 3-level inverter
  - AC/DC bridge

### PRODUCT SUMMARY

|   |                 |        |
|---|-----------------|--------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |        |
| $R_{DS(on)}$ typ. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.0355 |
| $Q_g$ max. (nC)                         | 410             |        |
| $Q_{gs}$ (nC)                           | 38              |        |
| $Q_{gd}$ (nC)                           | 99              |        |
| Configuration                           | Single          |        |

### ORDERING INFORMATION

|                                 |                  |
|---------------------------------|------------------|
| Package                         | TO-247AC         |
| Lead (Pb)-free and halogen-free | SiHG70N60AEF-GE3 |

### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °C, unless otherwise noted)


| PARAMETER   | SYMBOL           | LIMIT          | UNIT |
|---|------------------|----------------|------|
| Drain-source voltage                                      | $V_{DS}$         | 600            | V    |
| Gate-source voltage                                       | $V_{GS}$         | $\pm 20$       |      |
| Gate-source voltage AC ( $f > 1$ Hz)                      |                  | 30             |      |
| Continuous drain current ( $T_J = 150$ °C)                | $V_{GS}$ at 10 V | $T_C = 25$ °C  | A    |
|   |                  | $T_C = 100$ °C |      |
| Pulsed drain current <sup>a</sup>                         | $I_{DM}$         | 173            |      |
| Linear derating factor                                    |                  | 3.3            | W/°C |
| Single pulse avalanche energy <sup>b</sup>                | $E_{AS}$         | 1019           | mJ   |
| Maximum power dissipation                                 | $P_D$            | 417            | W    |
| Operating junction and storage temperature range          | $T_J, T_{stg}$   | -55 to +150    | °C   |
| Drain-source voltage slope                                | dv/dt            | $T_J = 125$ °C | V/ns |
| Reverse diode dv/dt <sup>d</sup>                          |                  | 70             |      |
| Soldering recommendations (peak temperature) <sup>c</sup> |                  | 50             |      |
|   | For 10 s         | 300            | °C   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DD} = 140$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 8.5$  A
- 1.6 mm from case
- $I_{SD} = 35$  A,  $di/dt = 300$  A/ $\mu$ s,  $V_{DS} = 400$  V



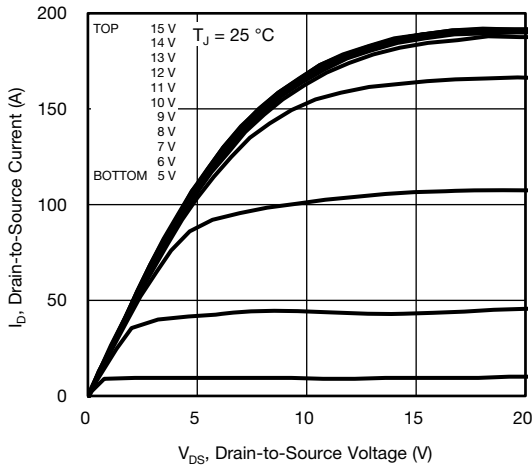
| THERMAL RESISTANCE RATINGS       |                   |      |      |      |
|----------------------------------|-------------------|------|------|------|
| PARAMETER                        | SYMBOL            | TYP. | MAX. | UNIT |
| Maximum junction-to-ambient      | R <sub>thJA</sub> | -    | 40   | °C/W |
| Maximum junction-to-case (drain) | R <sub>thJC</sub> | -    | 0.3  |      |

| SPECIFICATIONS (T <sub>J</sub> = 25 °C, unless otherwise noted) |                                  |   |  |      |        |       |      |
|---|----------------------------------|---|--|------|--------|-------|------|
| PARAMETER   | SYMBOL                           | TEST CONDITIONS   |  | MIN. | TYP.   | MAX.  | UNIT |
| <b>Static</b>   |                                  |   |  |      |        |       |      |
| 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   |  | -    | 0.62   | -     | V/°C |
| Gate-source threshold voltage (N)                               | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA   |  | 2    | -      | 4     | 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> = 480 V, V <sub>GS</sub> = 0 V  |  | -    | -      | 1     | μA   |
|   |                                  | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C   |  | -    | -      | 2     | mA   |
| Drain-source on-state resistance                                | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V  | I <sub>D</sub> = 35 A                          | -    | 0.0355 | 0.041 | Ω    |
| Forward transconductance <sup>a</sup>                           | g <sub>fs</sub>                  | V <sub>DS</sub> = 30 V, I <sub>D</sub> = 35 A   |  | -    | 23     | -     | S    |
| <b>Dynamic</b>  |                                  |   |  |      |        |       |      |
| Input capacitance   | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 100 V,<br>f = 1 MHz   |  | -    | 5348   | -     | pF   |
| Output capacitance  | C <sub>oss</sub>                 |   |  | -    | 238    | -     |      |
| Reverse transfer capacitance                                    | C <sub>rss</sub>                 |   |  | -    | 7      | -     |      |
| Effective output capacitance, energy related <sup>a</sup>       | C <sub>o(er)</sub>               |   |  | -    | 159    | -     |      |
| Effective output capacitance, time related <sup>b</sup>         | C <sub>o(tr)</sub>               | V <sub>DS</sub> = 0 V to 480 V, V <sub>GS</sub> = 0 V   |  | -    | 810    | -     |      |
| Total gate charge   | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V  | I <sub>D</sub> = 35 A, V <sub>DS</sub> = 480 V | -    | 205    | 410   | nC   |
| Gate-source charge  | Q <sub>gs</sub>                  |   |  | -    | 38     | -     |      |
| Gate-drain charge   | Q <sub>gd</sub>                  |   |  | -    | 99     | -     |      |
| Turn-on delay time  | t <sub>d(on)</sub>               | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 35 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 9.1 Ω   |  | -    | 45     | 90    | ns   |
| Rise time   | t <sub>r</sub>                   |   |  | -    | 104    | 208   |      |
| Turn-off delay time   | t <sub>d(off)</sub>              |   |  | -    | 219    | 438   |      |
| Fall time   | t <sub>f</sub>                   |   |  | -    | 113    | 226   |      |
| Gate input resistance   | R <sub>g</sub>                   | f = 1 MHz, open drain   |  | 0.5  | 1.0    | 2.0   | Ω    |
| <b>Drain-Source Body Diode Characteristics</b>                  |                                  |   |  |      |        |       |      |
| Continuous source-drain diode current                           | I <sub>S</sub>                   | MOSFET symbol showing the integral reverse p - n junction diode  |  | -    | -      | 60    | A    |
| Pulsed diode forward current                                    | I <sub>SM</sub>                  |   |  | -    | -      | 173   |      |
| Diode forward voltage   | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 35 A, V <sub>GS</sub> = 0 V  |  | -    | 0.9    | 1.2   | V    |
| Reverse recovery time   | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = I <sub>S</sub> = 35 A,<br>di/dt = 100 A/μs, V <sub>R</sub> = 400 V   |  | -    | 184    | 368   | ns   |
| Reverse recovery charge   | Q <sub>rr</sub>                  |   |  | -    | 1.6    | 3.2   | μC   |
| Reverse recovery current  | I <sub>RRM</sub>                 |   |  | -    | 16     | -     | A    |

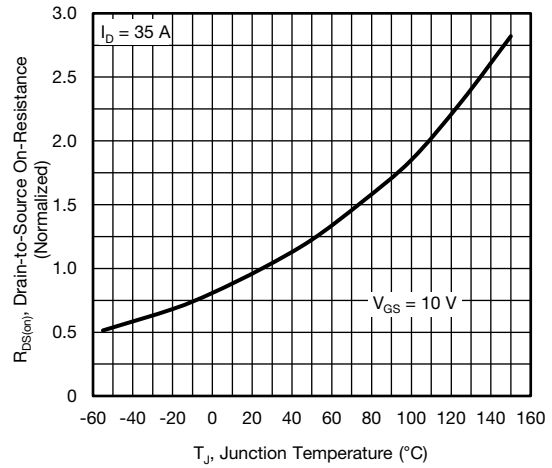
**Notes**

- a. C<sub>oss(er)</sub> is a fixed capacitance that gives the same energy as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 % to 80 % V<sub>DSS</sub>
- b. C<sub>oss(tr)</sub> is a fixed capacitance that gives the same charging time as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 % to 80 % V<sub>DSS</sub>

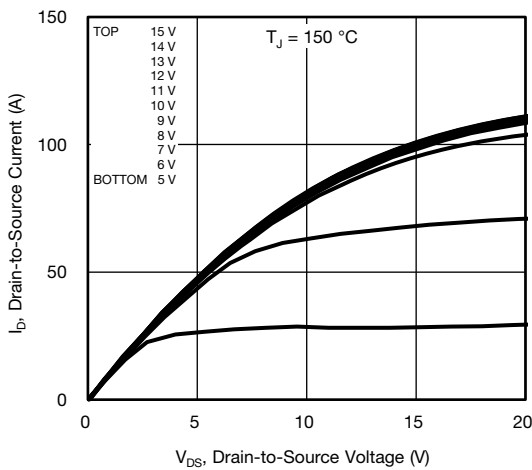
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



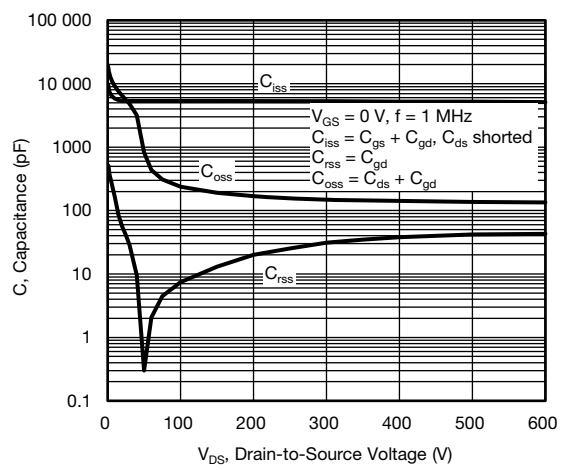
**Fig. 1 - Typical Output Characteristics**



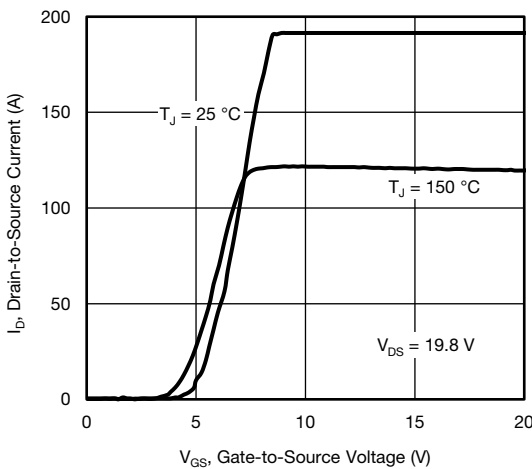
**Fig. 4 - Normalized On-Resistance vs. Temperature**



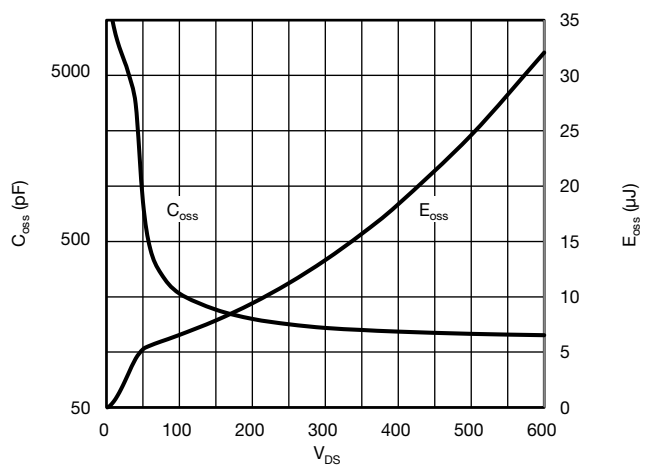
**Fig. 2 - Typical Output Characteristics**



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



**Fig. 3 - Typical Transfer Characteristics**



**Fig. 6 - C<sub>oss</sub> and E<sub>oss</sub> vs. V<sub>DS</sub>**

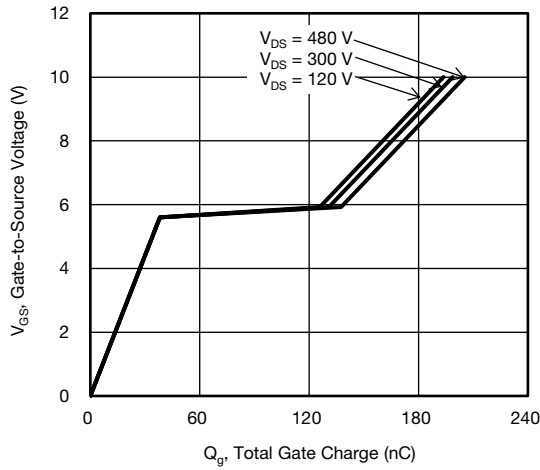


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage

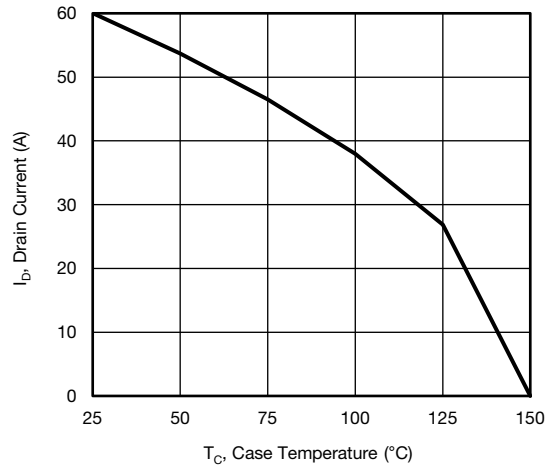


Fig. 10 - Maximum Drain Current vs. Case Temperature

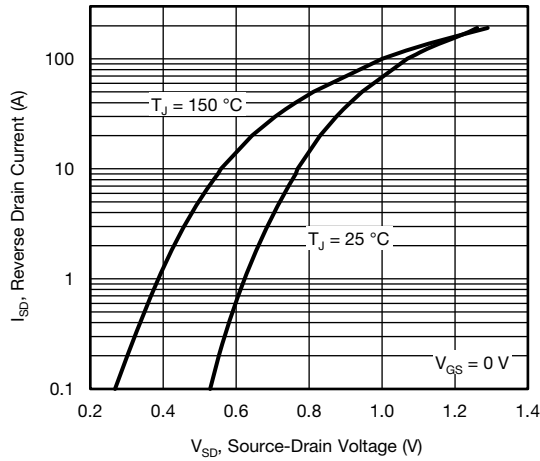


Fig. 8 - Typical Source-Drain Diode Forward Voltage

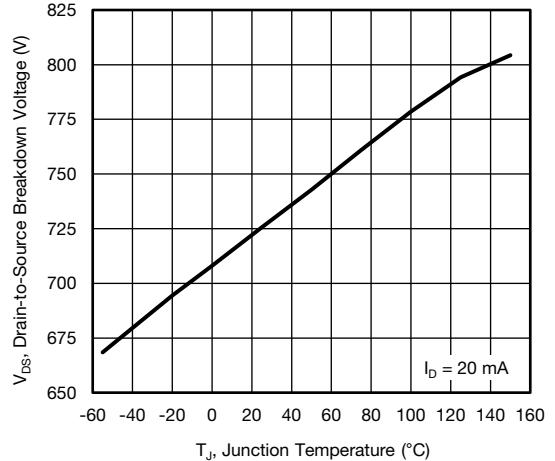


Fig. 11 - Temperature vs. Drain-to-Source Voltage

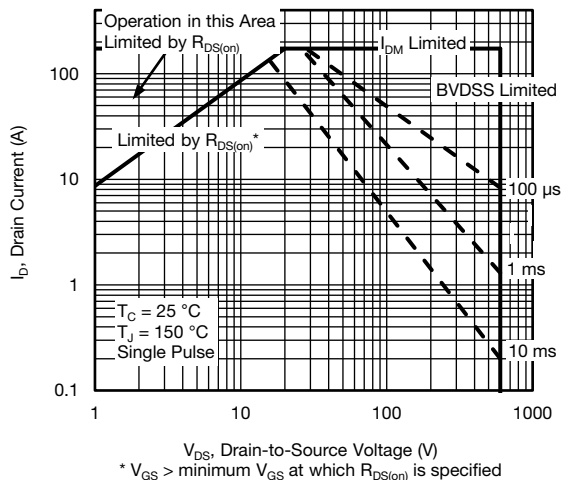


Fig. 9 - Maximum Safe Operating Area

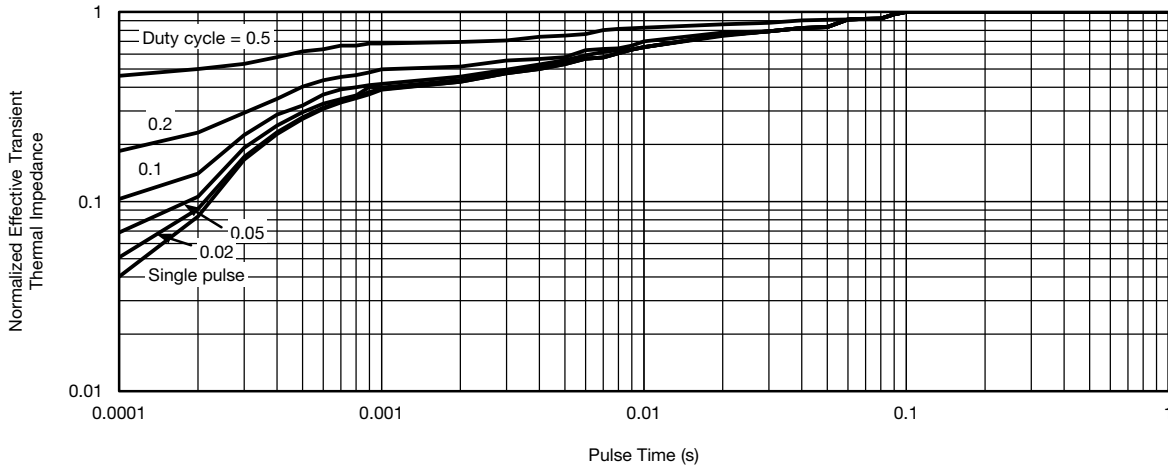


Fig. 12 - Normalized Transient Thermal Impedance, Junction-to-Case

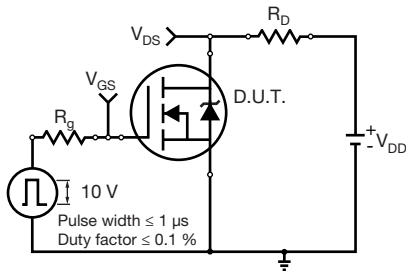


Fig. 13 - Switching Time Test Circuit

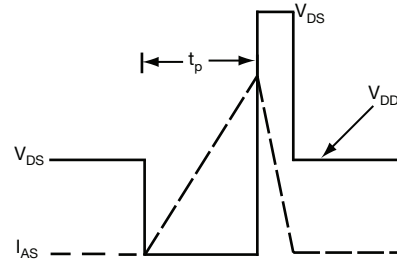


Fig. 16 - Unclamped Inductive Waveforms

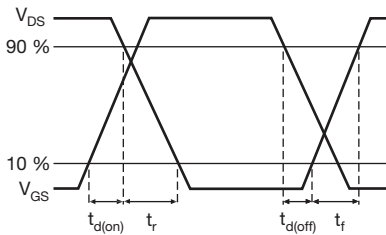


Fig. 14 - Switching Time Waveforms

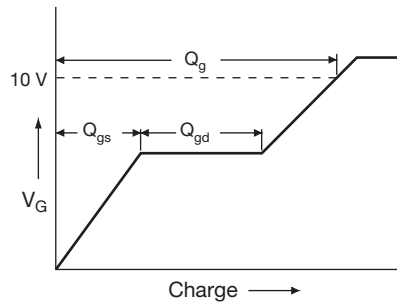


Fig. 17 - Basic Gate Charge Waveform

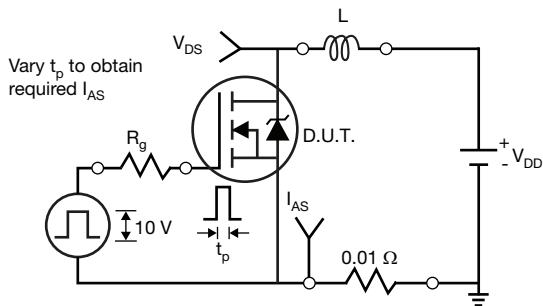


Fig. 15 - Unclamped Inductive Test Circuit

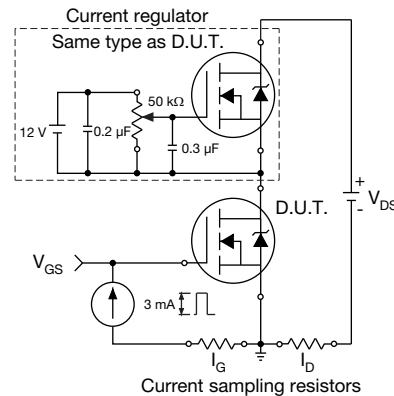


Fig. 18 - Gate Charge Test Circuit



**Note**

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

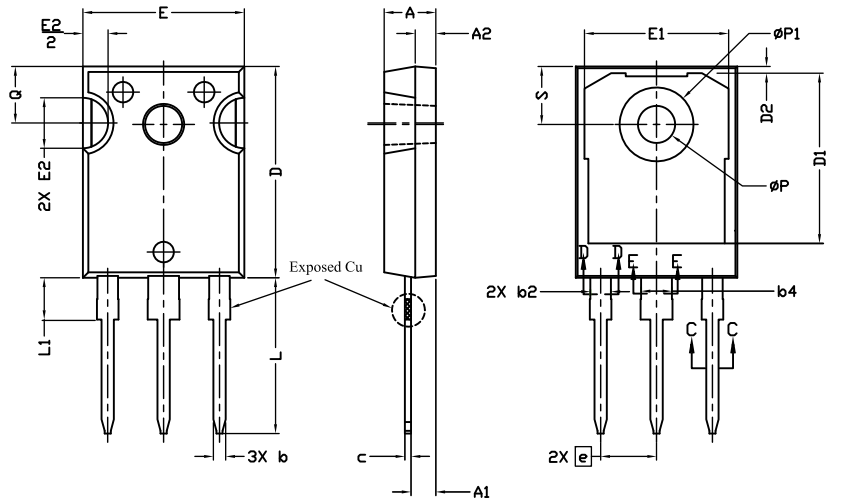
**Fig. 19 - For N-Channel**

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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    |       |       |

**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





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: E20-0545-Rev. F, 19-Oct-2020  
 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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