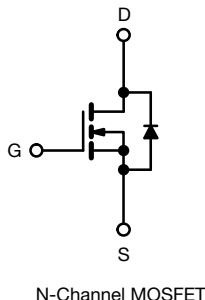
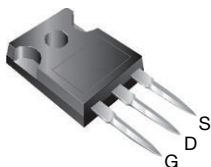


## EF Series Power MOSFET with Fast Body Diode

| PRODUCT SUMMARY                         |                 |       |
|-----------------------------------------|-----------------|-------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |       |
| $R_{DS(on)}$ max. at 25 °C ( $\Omega$ ) | $V_{GS} = 10$ V | 0.123 |
| $Q_g$ (Max.) (nC)                       | 120             |       |
| $Q_{gs}$ (nC)                           | 17              |       |
| $Q_{gd}$ (nC)                           | 33              |       |
| Configuration                           | Single          |       |

**TO-247AC**


### 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 input capacitance ( $C_{iss}$ )
- 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)



**RoHS**  
COMPLIANT  
HALOGEN  
FREE

### APPLICATIONS

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

| ORDERING INFORMATION            |                 |
|---------------------------------|-----------------|
| Package                         | TO-247AC        |
| Lead (Pb)-free and Halogen-free | SiHG28N60EF-GE3 |

| ABSOLUTE MAXIMUM RATINGS (T <sub>C</sub> = 25 °C, unless otherwise noted) |                         |                         |                                   |             |      |      |
|---------------------------------------------------------------------------|-------------------------|-------------------------|-----------------------------------|-------------|------|------|
| PARAMETER                                                                 |                         |                         | SYMBOL                            | LIMIT       | UNIT |      |
| Drain-Source Voltage                                                      |                         |                         | V <sub>DS</sub>                   | 600         | V    |      |
| Gate-Source Voltage                                                       |                         |                         | V <sub>GS</sub>                   | ± 30        |      |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C)                        | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 28          | A    |      |
|                                                                           |                         | T <sub>C</sub> = 100 °C |                                   | 18          |      |      |
| Pulsed Drain Current <sup>a</sup>                                         |                         |                         | I <sub>DM</sub>                   | 75          |      |      |
| Linear Derating Factor                                                    |                         |                         |                                   | 2           | W/°C |      |
| Single Pulse Avalanche Energy <sup>b</sup>                                |                         |                         | E <sub>AS</sub>                   | 691         | mJ   |      |
| Maximum Power Dissipation                                                 |                         |                         | P <sub>D</sub>                    | 250         | W    |      |
| Operating Junction and Storage Temperature Range                          |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | -55 to +150 | °C   |      |
| Drain-Source Voltage Slope                                                |                         | T <sub>J</sub> = 125 °C |                                   | dV/dt       | 70   | V/ns |
| Reverse Diode dV/dt <sup>d</sup>                                          |                         |                         | 50                                |             |      |      |
| Soldering Recommendations (Peak Temperature) <sup>c</sup>                 |                         | for 10 s                |                                   |             | 300  | °C   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DS} = 50$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 7$  A
- 1.6 mm from case
- $I_{SD} \leq I_D$ ,  $dI/dt = 900$  A/ $\mu$ s, starting  $T_J = 25$  °C

**THERMAL RESISTANCE RATINGS**

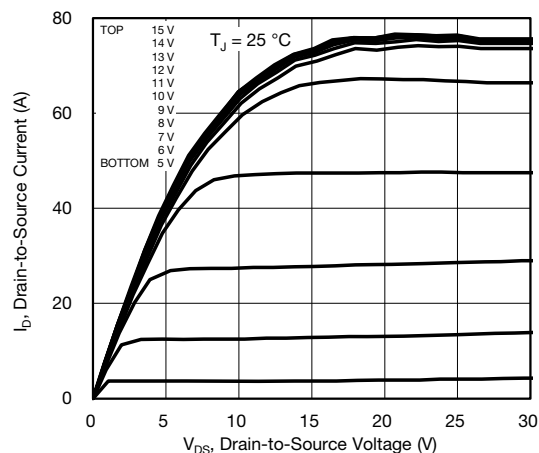
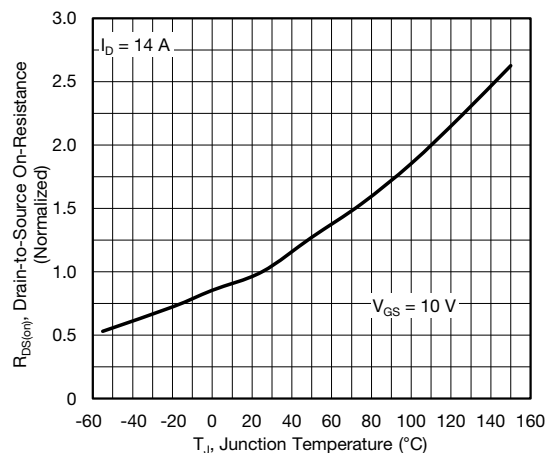
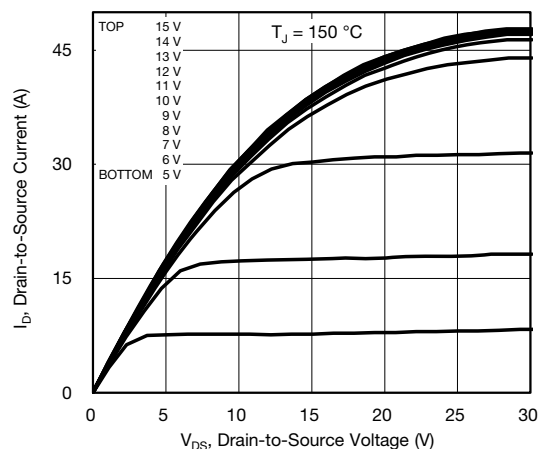
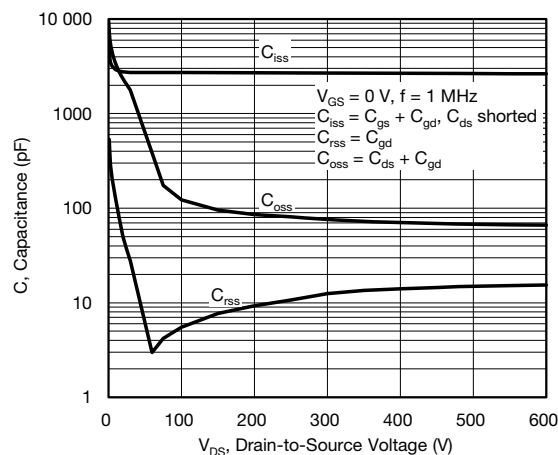
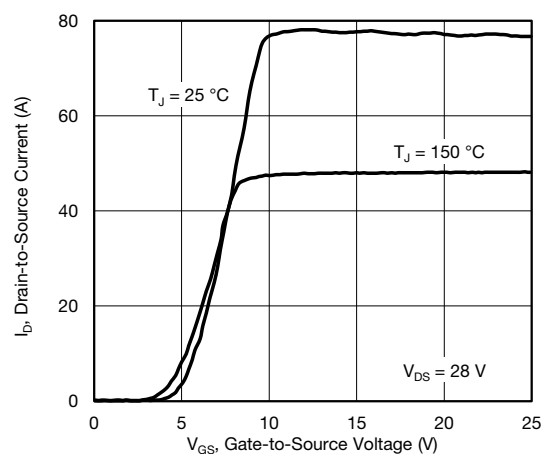
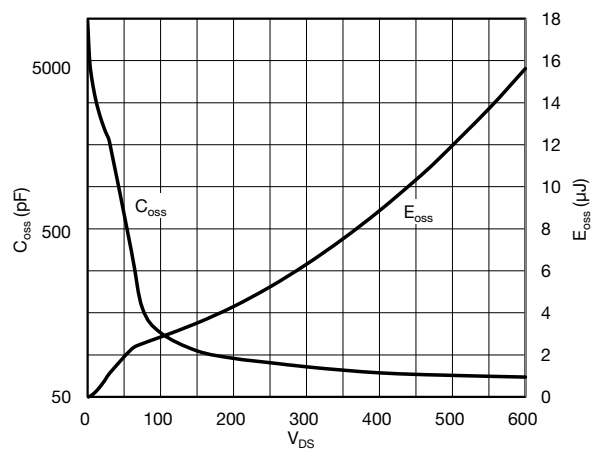
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 0.5  |      |

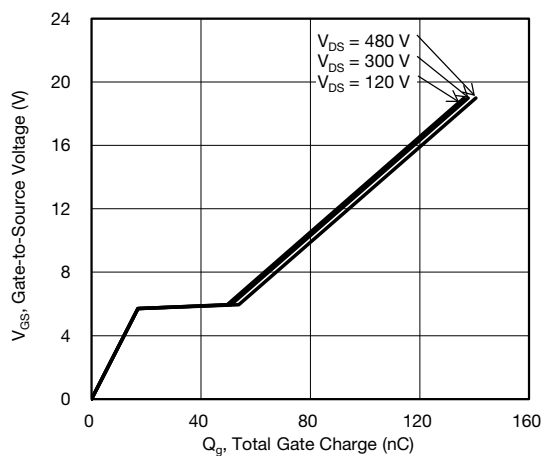
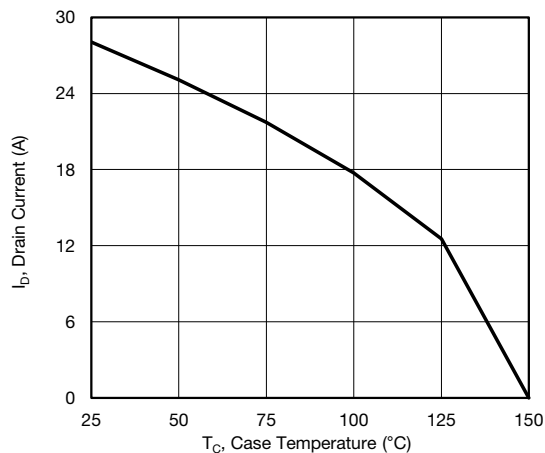
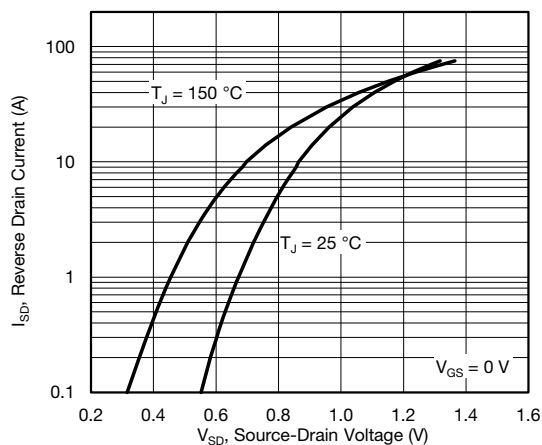
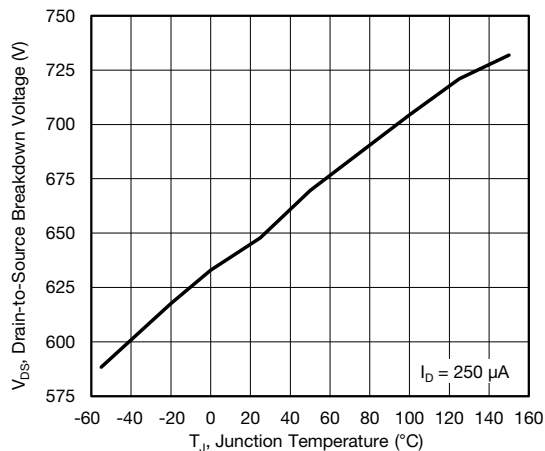
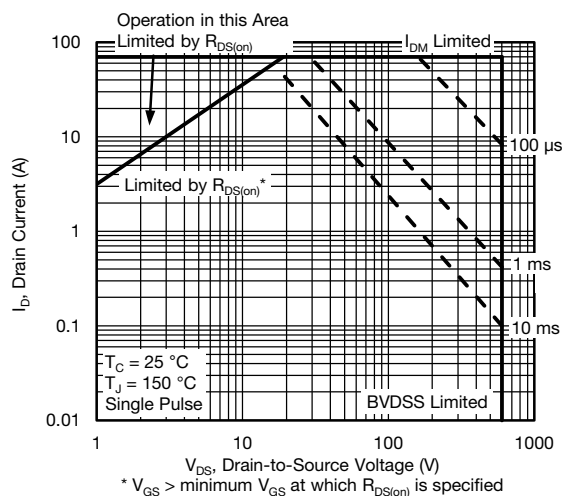
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

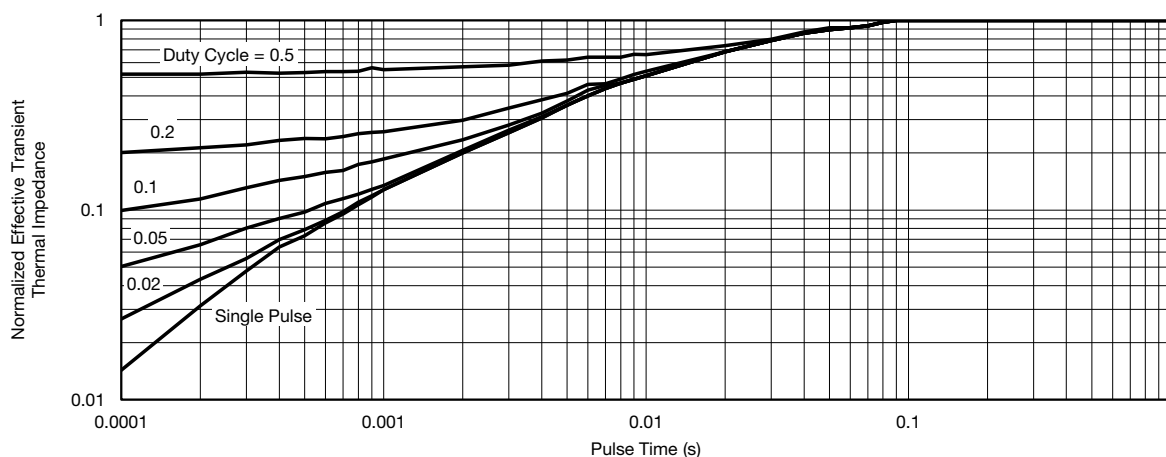
| PARAMETER                                                 | SYMBOL              | TEST CONDITIONS                                                                                                                                          | MIN. | TYP.  | MAX.      | UNIT                  |
|-----------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|-----------|-----------------------|
| <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 $25\text{ }^{\circ}\text{C}$ , $I_D = 1\text{ mA}$                                                                                          | -    | 0.76  | -         | V/ $^{\circ}\text{C}$ |
| Gate-Source Threshold Voltage (N)                         | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                                       | 2.0  | -     | 4.0       | V                     |
| Gate-Source Leakage                                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                               | -    | -     | $\pm 100$ | nA                    |
|                                                           |                     | $V_{GS} = \pm 30\text{ V}$                                                                                                                               | -    | -     | $\pm 1$   | $\mu\text{A}$         |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$           | $V_{DS} = 480\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                                          | -    | -     | 1         | $\mu\text{A}$         |
|                                                           |                     | $V_{DS} = 480\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$                                                                    | -    | -     | 2         | mA                    |
| Drain-Source On-State Resistance                          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$ , $I_D = 14\text{ A}$                                                                                                             | -    | 0.107 | 0.123     | $\Omega$              |
| Forward Transconductance                                  | $g_{fs}$            | $V_{DS} = 30\text{ V}$ , $I_D = 14\text{ A}$                                                                                                             | -    | 9.7   | -         | S                     |
| <b>Dynamic</b>                                            |                     |                                                                                                                                                          |      |       |           |                       |
| Input Capacitance                                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 100\text{ V}$ ,<br>$f = 1\text{ MHz}$                                                                               | -    | 2714  | -         | pF                    |
| Output Capacitance                                        | $C_{oss}$           |                                                                                                                                                          | -    | 123   | -         |                       |
| Reverse Transfer Capacitance                              | $C_{rss}$           |                                                                                                                                                          | -    | 6     | -         |                       |
| Effective output capacitance, energy related <sup>a</sup> | $C_{o(er)}$         | $V_{GS} = 0\text{ V}$ , $V_{DS} = 0\text{ V to } 480\text{ V}$                                                                                           | -    | 98    | -         |                       |
| Effective output capacitance, time related <sup>b</sup>   | $C_{o(tr)}$         |                                                                                                                                                          | -    | 356   | -         |                       |
| Total Gate Charge                                         | $Q_g$               | $V_{GS} = 10\text{ V}$ , $I_D = 14\text{ A}$ , $V_{DS} = 480\text{ V}$                                                                                   | -    | 80    | 120       | nC                    |
| Gate-Source Charge                                        | $Q_{gs}$            |                                                                                                                                                          | -    | 17    | -         |                       |
| Gate-Drain Charge                                         | $Q_{gd}$            |                                                                                                                                                          | -    | 33    | -         |                       |
| Turn-On Delay Time                                        | $t_{d(on)}$         | $V_{DD} = 480\text{ V}$ , $I_D = 14\text{ A}$<br>$R_g = 9.1\text{ }\Omega$ , $V_{GS} = 10\text{ V}$                                                      | -    | 24    | 48        | ns                    |
| Rise Time                                                 | $t_r$               |                                                                                                                                                          | -    | 40    | 80        |                       |
| Turn-Off Delay Time                                       | $t_{d(off)}$        |                                                                                                                                                          | -    | 82    | 123       |                       |
| Fall Time                                                 | $t_f$               |                                                                                                                                                          | -    | 39    | 78        |                       |
| Gate Input Resistance                                     | $R_g$               | $f = 1\text{ MHz}$ , open drain                                                                                                                          | 0.2  | 0.5   | 1.0       | $\Omega$              |
| <b>Drain-Source Body Diode Characteristics</b>            |                     |                                                                                                                                                          |      |       |           |                       |
| Continuous Source-Drain Diode Current                     | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode<br> | -    | -     | 28        | A                     |
| Pulsed Diode Forward Current                              | $I_{SM}$            |                                                                                                                                                          | -    | -     | 70        |                       |
| Diode Forward Voltage                                     | $V_{SD}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_S = 11\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                         | -    | 0.9   | 1.2       | V                     |
| Reverse Recovery Time                                     | $t_{rr}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_F = I_S = 14\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 400\text{ V}$                            | -    | 142   | 284       | ns                    |
| Reverse Recovery Charge                                   | $Q_{rr}$            |                                                                                                                                                          | -    | 0.97  | 1.94      | $\mu\text{C}$         |
| Reverse Recovery Current                                  | $I_{RRM}$           |                                                                                                                                                          | -    | 13.2  | -         | A                     |

**Notes**

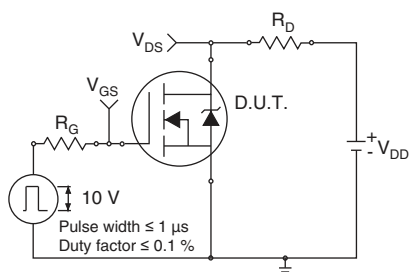
- a.  $C_{oss(er)}$  is a fixed capacitance that gives the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DS}$   
b.  $C_{oss(tr)}$  is a fixed capacitance that gives the charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DS}$

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

**Fig. 1 - Typical Output Characteristics**

**Fig. 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 -  $C_{oss}$  and  $E_{oss}$  vs.  $V_{DS}$**

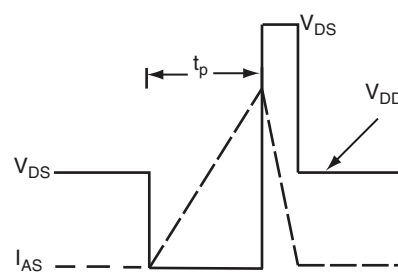

**Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage**

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

**Fig. 8 - Typical Source-Drain Diode Forward Voltage**

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

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



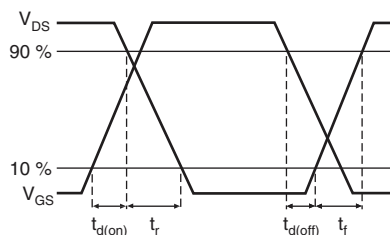
**Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case**



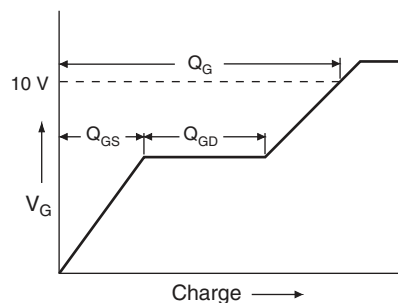
**Fig. 13 - Switching Time Test Circuit**



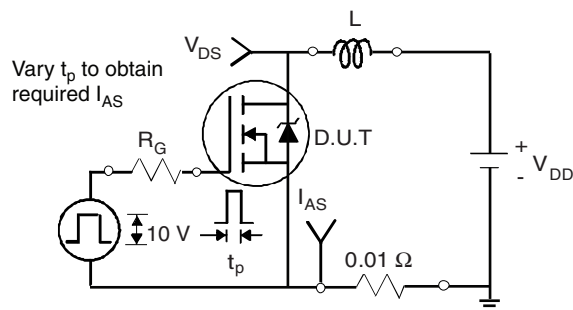
**Fig. 16 - Unclamped Inductive Waveforms**



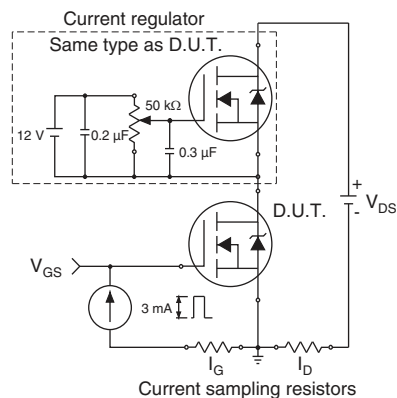
**Fig. 14 - Switching Time Waveforms**



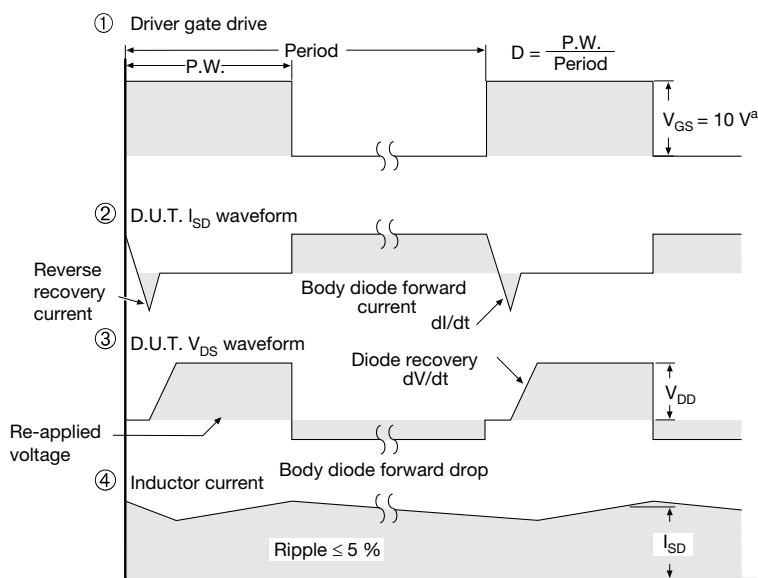
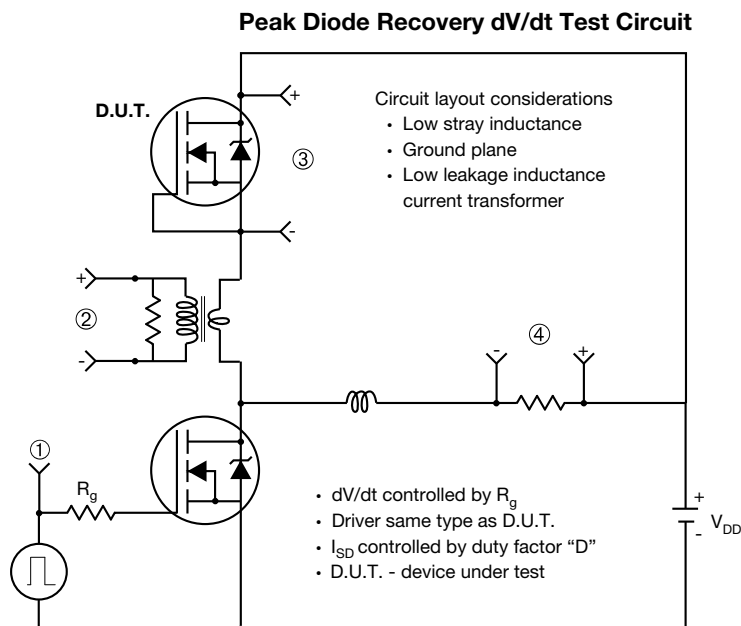
**Fig. 17 - Basic Gate Charge Waveform**



**Fig. 15 - Unclamped Inductive Test Circuit**



**Fig. 18 - Gate Charge Test Circuit**


**Note**

a.  $V_{GS} = 5 V$  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

| 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     |

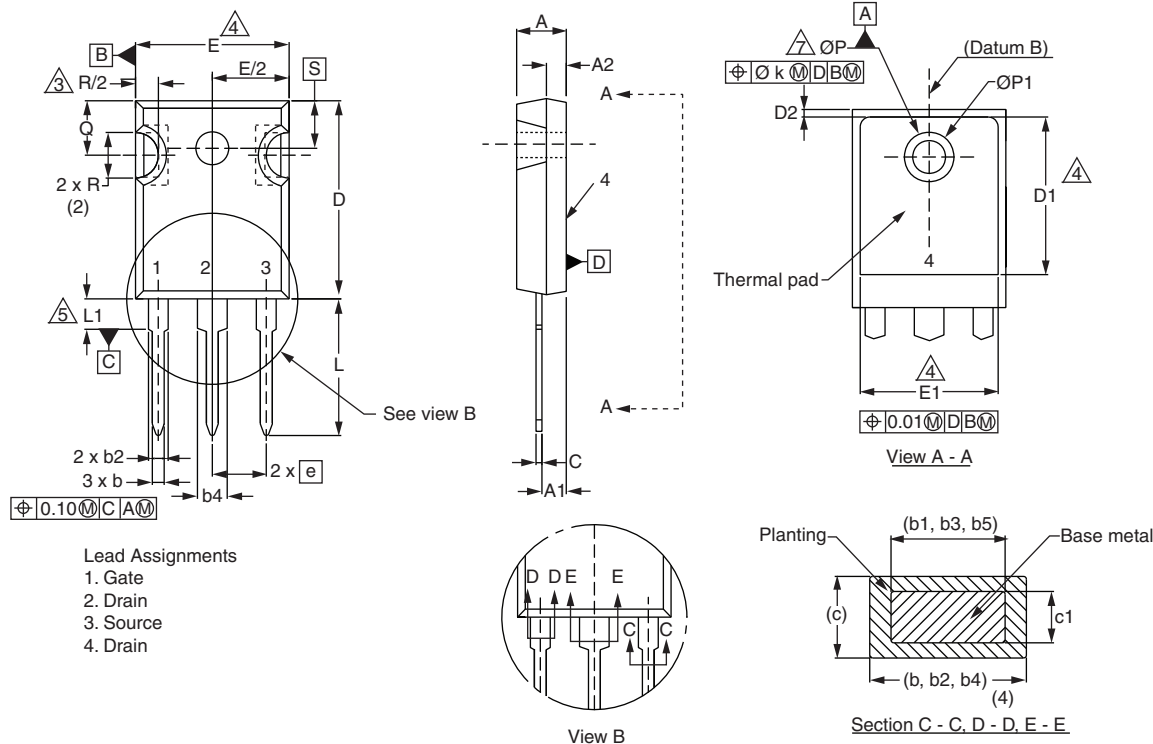
| MILLIMETERS |           |       |       |       |
|-------------|-----------|-------|-------|-------|
| DIM.        | MIN.      | NOM.  | MAX.  | NOTES |
| D1          | 16.46     | 16.76 | 17.06 | 5     |
| D2          | 0.56      | 0.66  | 0.76  |       |
| E           | 15.50     | 15.70 | 15.87 | 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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