

## EF Series Power MOSFET with Fast Body Diode

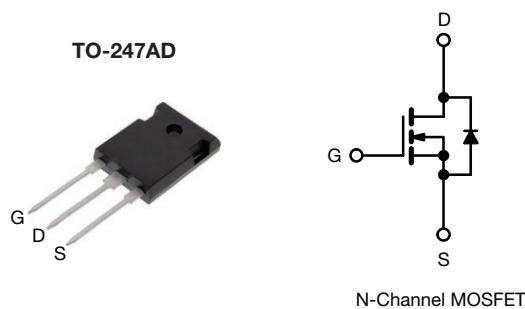
| PRODUCT SUMMARY                |                       |
|--------------------------------|-----------------------|
| $V_{DS}$ (V) at $T_J$ max.     | 650                   |
| $R_{DS(on)}$ max. at 25 °C (Ω) | $V_{GS} = 10$ V 0.065 |
| $Q_g$ max. (nC)                | 228                   |
| $Q_{gs}$ (nC)                  | 32                    |
| $Q_{gd}$ (nC)                  | 62                    |
| Configuration                  | Single                |

### 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 ( $C_{iss}$ )
- Increased robustness due to low  $Q_{rr}$
- 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 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

### ORDERING INFORMATION

|                                 |                 |
|---------------------------------|-----------------|
| Package                         | TO-247AD        |
| Lead (Pb)-free and Halogen-free | SiHW47N60EF-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                                       | $V_{GS}$       | $\pm 30$    |      |
| Continuous Drain Current ( $T_J = 150$ °C)                | $I_D$          | 47          | A    |
|   |                | 29          |      |
|   | $I_{DM}$       | 138         |      |
| Pulsed Drain Current <sup>a</sup>                         |                | 3           | W/°C |
| Linear Derating Factor                                    |                |             |      |
| Single Pulse Avalanche Energy <sup>b</sup>                | $E_{AS}$       | 1500        | mJ   |
| Maximum Power Dissipation                                 | $P_D$          | 379         | W    |
| Operating Junction and Storage Temperature Range          | $T_J, T_{stg}$ | -55 to +150 | °C   |
| Drain-Source Voltage Slope                                | $dV/dt$        | 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
- $V_{DD} = 50$  V, starting  $T_J = 25$  °C,  $L = 73.5$  mH,  $R_g = 25$  Ω,  $I_{AS} = 6.4$  A
- 1.6 mm from case
- $I_{SD} \leq I_D$ ,  $dI/dt = 500$  A/μs, starting  $T_J = 25$  °C

**THERMAL RESISTANCE RATINGS**

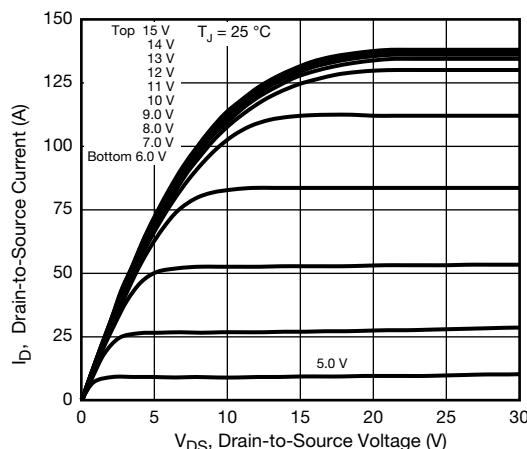
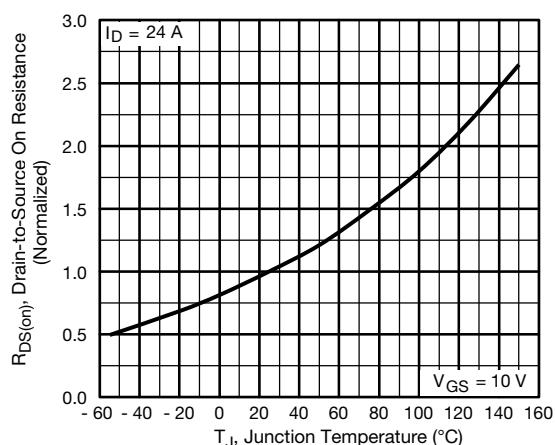
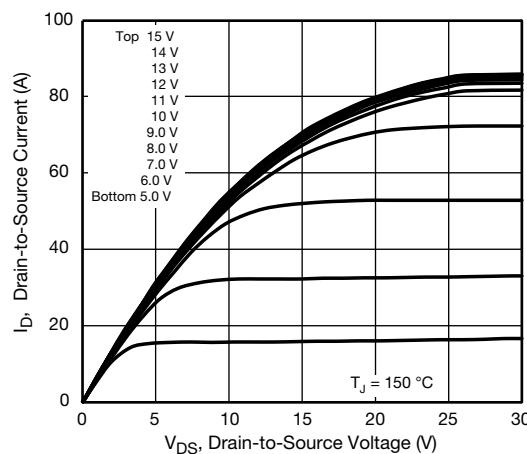
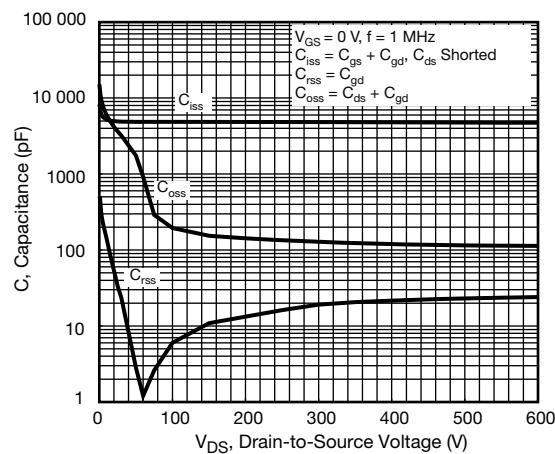
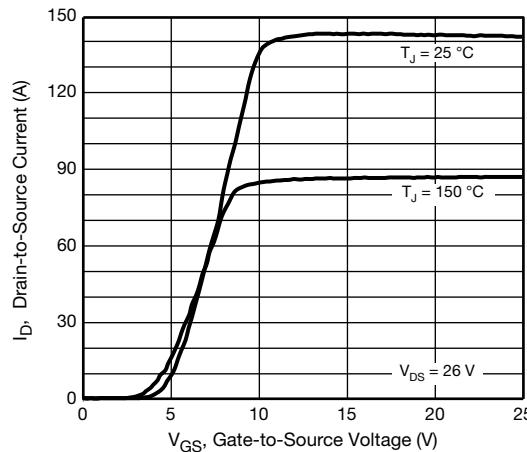
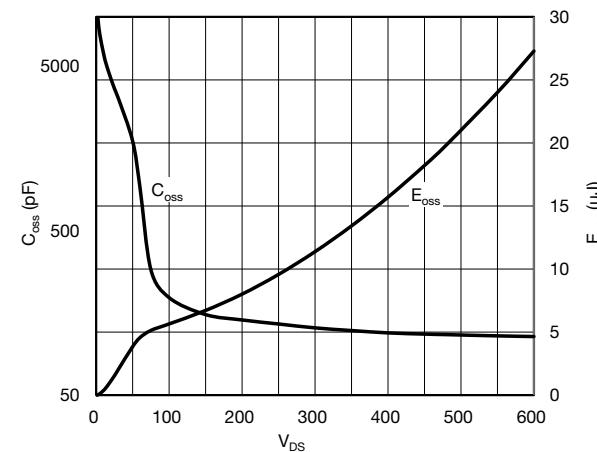
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT                        |
|----------------------------------|------------|------|------|-----------------------------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 40   | $^{\circ}\text{C}/\text{W}$ |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 0.33 |                             |

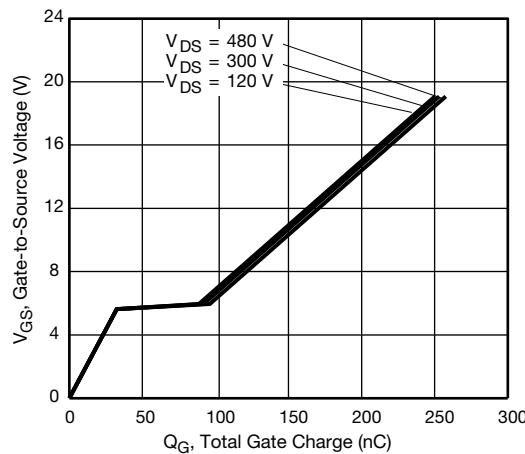
**SPECIFICATIONS** ( $T_J = 25^{\circ}\text{C}$ , unless otherwise noted)

| PARAMETER   | SYMBOL              | TEST CONDITIONS  |   | MIN. | TYP.  | MAX.      | UNIT                        |
|---|---------------------|--|---|------|-------|-----------|-----------------------------|
| <b>Static</b>   |                     |  |   |      |       |           |                             |
| Drain-Source Breakdown Voltage                            | $V_{DS}$            | $V_{GS} = 0 \text{ V}$ , $I_D = 250 \mu\text{A}$   |   | 600  | -     | -         | V                           |
| $V_{DS}$ Temperature Coefficient                          | $\Delta V_{DS}/T_J$ | Reference to $25^{\circ}\text{C}$ , $I_D = 1 \text{ mA}$   |   | -    | -     | -         | $\text{V}/^{\circ}\text{C}$ |
| Gate-Source Threshold Voltage (N)                         | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250 \mu\text{A}$  |   | 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         | $\mu\text{A}$               |
|   |                     | $V_{DS} = 480 \text{ V}$ , $V_{GS} = 0 \text{ V}$ , $T_J = 125^{\circ}\text{C}$  |   | -    | -     | 500       |                             |
| Drain-Source On-State Resistance                          | $R_{DS(on)}$        | $V_{GS} = 10 \text{ V}$  | $I_D = 24 \text{ A}$                            | -    | 0.056 | 0.065     | $\Omega$                    |
| Forward Transconductance                                  | $g_{fs}$            | $V_{DS} = 30 \text{ V}$ , $I_D = 24 \text{ A}$   |   | -    | 17    | -         | S                           |
| <b>Dynamic</b>  |                     |  |   |      |       |           |                             |
| Input Capacitance   | $C_{iss}$           | $V_{GS} = 0 \text{ V}$ ,<br>$V_{DS} = 100 \text{ V}$ ,<br>$f = 1 \text{ MHz}$  |   | -    | 5000  | -         | pF                          |
| Output Capacitance  | $C_{oss}$           |  |   | -    | 220   | -         |                             |
| Reverse Transfer Capacitance                              | $C_{rss}$           |  |   | -    | 7     | -         |                             |
| Effective Output Capacitance, Energy Related <sup>a</sup> | $C_{o(er)}$         | $V_{DS} = 0 \text{ V}$ to $480 \text{ V}$ , $V_{GS} = 0 \text{ V}$   |   | -    | 172   | -         |                             |
| Effective Output Capacitance, Time Related <sup>b</sup>   | $C_{o(tr)}$         |  |   | -    | 634   | -         |                             |
| Total Gate Charge   | $Q_g$               | $V_{GS} = 10 \text{ V}$  | $I_D = 24 \text{ A}$ , $V_{DS} = 480 \text{ V}$ | -    | 152   | 228       | nC                          |
| Gate-Source Charge  | $Q_{gs}$            |  |   | -    | 32    | -         |                             |
| Gate-Drain Charge   | $Q_{gd}$            |  |   | -    | 62    | -         |                             |
| Turn-On Delay Time  | $t_{d(on)}$         | $V_{DD} = 480 \text{ V}$ , $I_D = 24 \text{ A}$ ,<br>$V_{GS} = 10 \text{ V}$ , $R_g = 4.4 \Omega$                        |   | -    | 30    | 60        | ns                          |
| Rise Time   | $t_r$               |  |   | -    | 56    | 84        |                             |
| Turn-Off Delay Time                                       | $t_{d(off)}$        |  |   | -    | 91    | 137       |                             |
| Fall Time   | $t_f$               |  |   | -    | 56    | 84        |                             |
| Gate Input Resistance                                     | $R_g$               | $f = 1 \text{ MHz}$ , open drain   |   | 0.2  | 0.46  | 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  |   | -    | -     | 47        | A                           |
| Pulsed Diode Forward Current                              | $I_{SM}$            |  |   | -    | -     | 138       |                             |
| Diode Forward Voltage                                     | $V_{SD}$            | $T_J = 25^{\circ}\text{C}$ , $I_S = 24 \text{ A}$ , $V_{GS} = 0 \text{ V}$   |   | -    | 0.9   | 1.2       | V                           |
| Body Diode Reverse Recovery Time                          | $t_{rr}$            | $T_J = 25^{\circ}\text{C}$ , $I_F = I_S = 24 \text{ A}$ ,<br>$dI/dt = 100 \text{ A}/\mu\text{s}$ , $V_R = 400 \text{ V}$ |   | -    | 199   | 398       | ns                          |
| Body Diode Reverse Recovery Charge                        | $Q_{rr}$            |  |   | -    | 1.4   | 2.8       | $\mu\text{C}$               |
| Reverse Recovery Current                                  | $I_{RRM}$           |  |   | -    | 13.2  | -         | A                           |

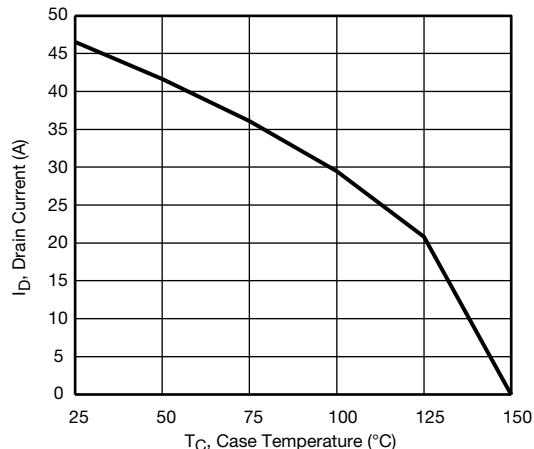
**Notes**

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

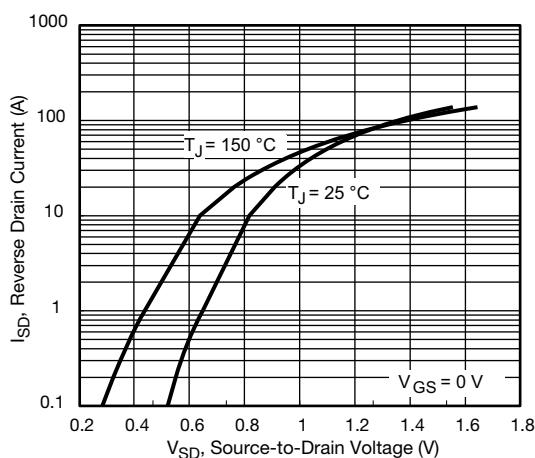
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**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.  $V_{DS}$**



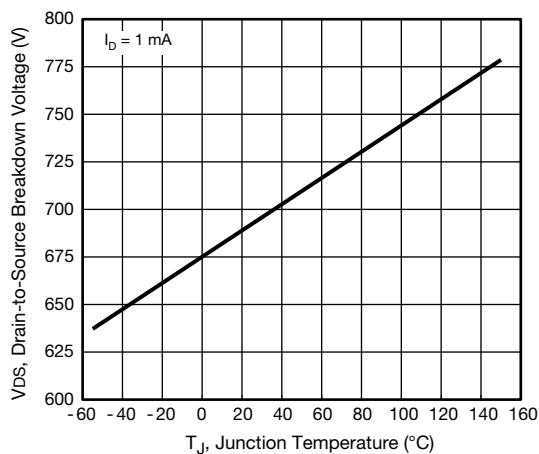
**Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage**



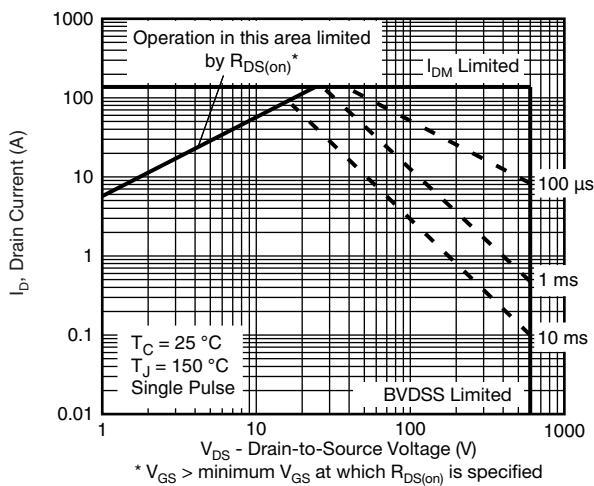
**Fig. 10 - Maximum Drain Current vs. Case Temperature**



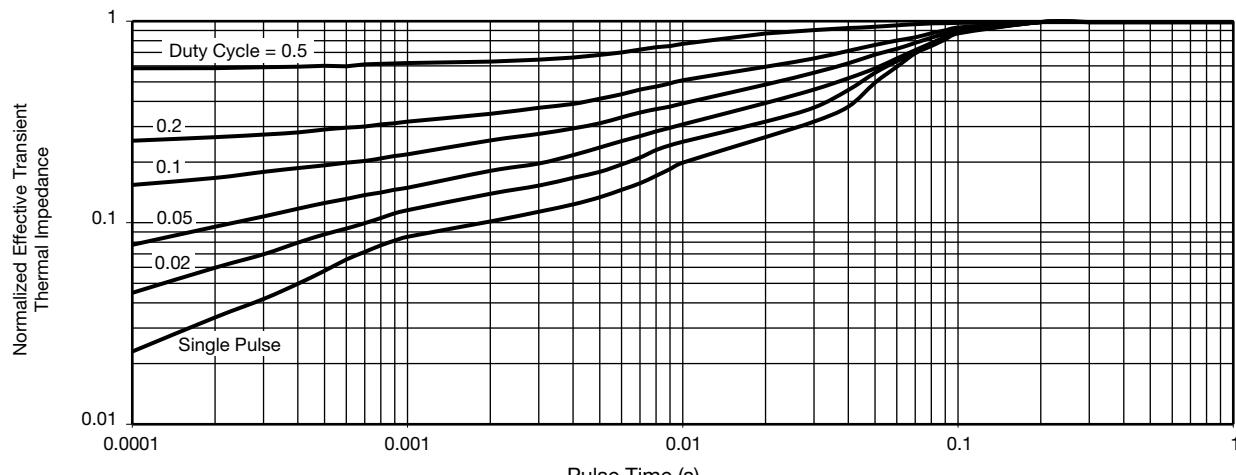
**Fig. 8 - Typical Source-Drain Diode Forward Voltage**



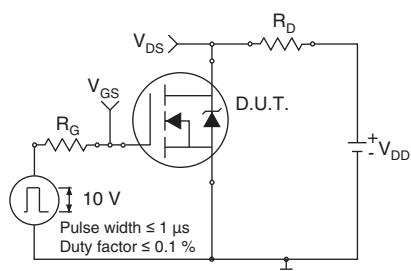
**Fig. 11 - Temperature vs. Drain-to-Source Voltage**



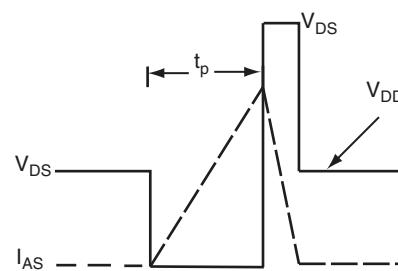
**Fig. 9 - Maximum Safe Operating Area**



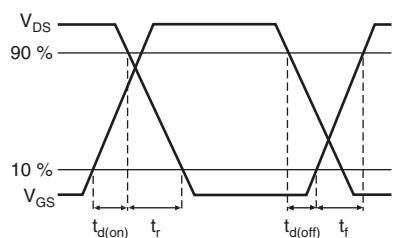
**Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case**



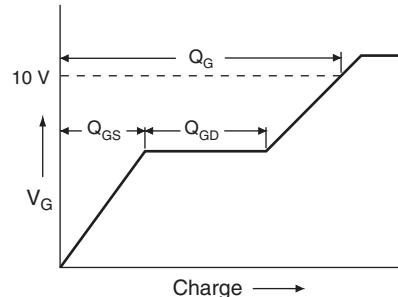
**Fig. 13 - Switching Time Test Circuit**



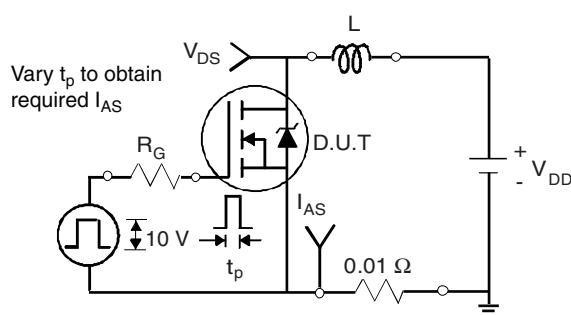
**Fig. 16 - Unclamped Inductive Waveforms**



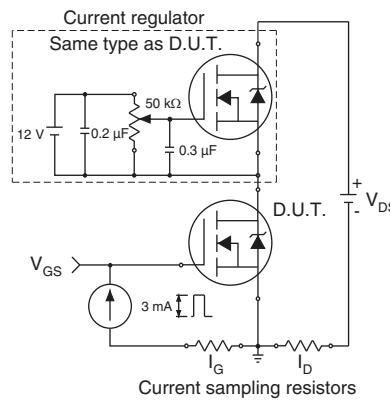
**Fig. 14 - Switching Time Waveforms**



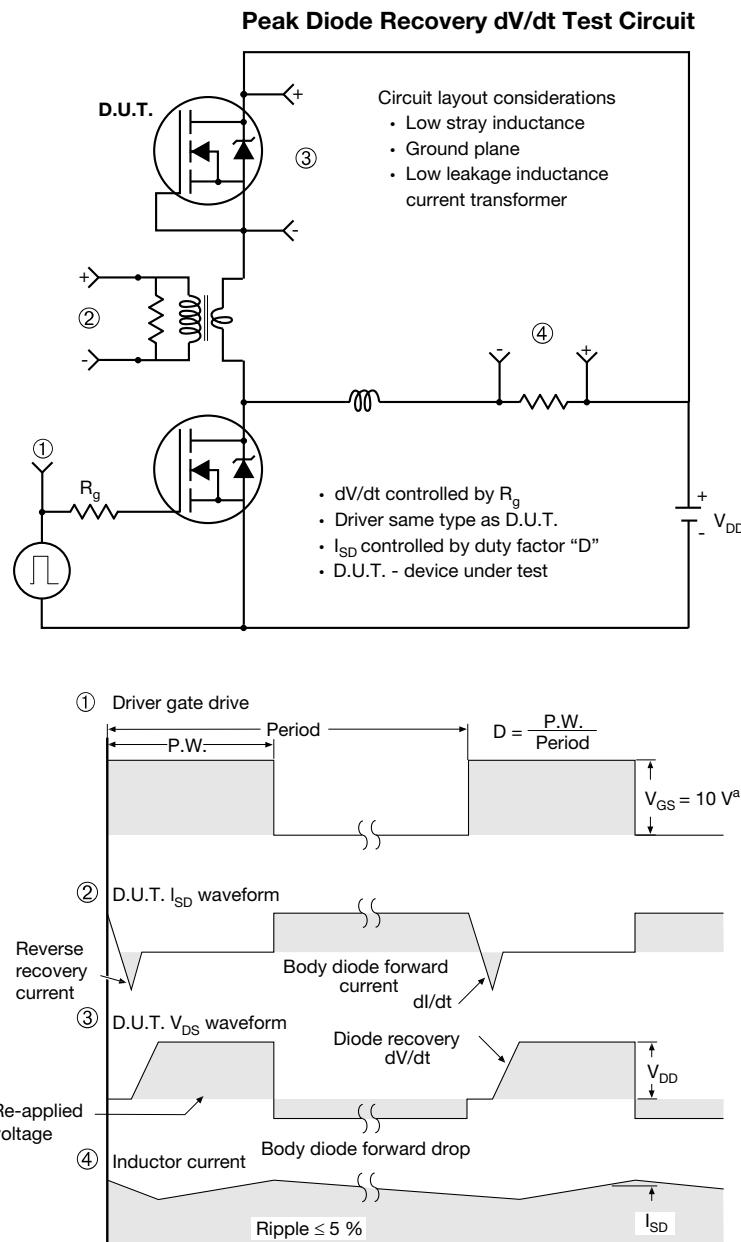
**Fig. 17 - Basic Gate Charge Waveform**



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

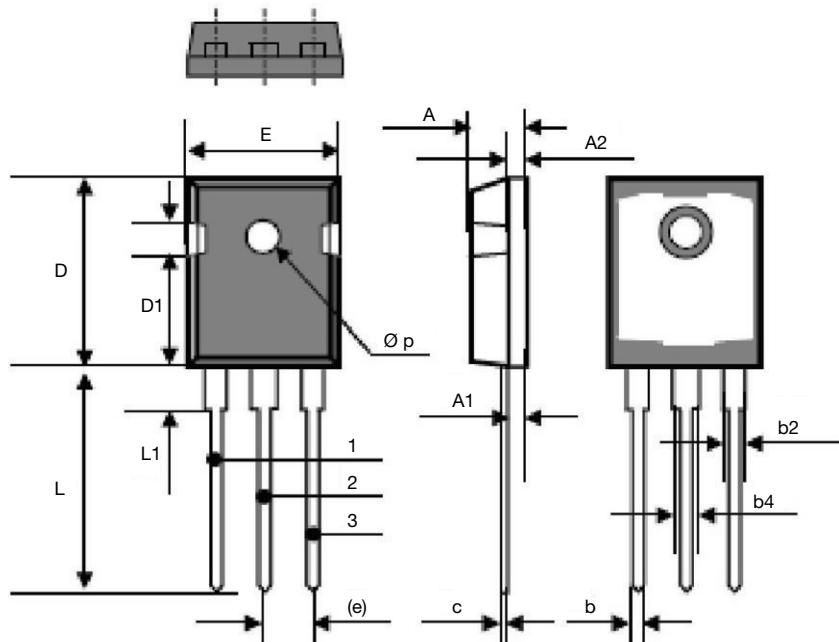


**Fig. 18 - Gate Charge Test Circuit**


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

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## TO-247AD (High Voltage)



| DIM. | MILLIMETERS |       | INCHES    |       |
|------|-------------|-------|-----------|-------|
|      | MIN.        | MAX.  | MIN.      | MAX.  |
| A    | 4.70        | 5.31  | 0.185     | 0.209 |
| A1   | 2.21        | 2.59  | 0.087     | 0.102 |
| A2   | 1.50        | 2.49  | 0.059     | 0.098 |
| b    | 0.99        | 1.40  | 0.039     | 0.055 |
| b2   | 1.65        | 2.41  | 0.065     | 0.095 |
| b4   | 2.59        | 3.43  | 0.102     | 0.135 |
| c    | 0.61 BSC    |       | 0.024 BSC |       |
| D    | 20.80       | 21.46 | 0.819     | 0.845 |
| D1   | 3.68        | 5.49  | 0.145     | 0.216 |
| (e)  | 5.46 BSC    |       | 0.215 BSC |       |
| E    | 15.49       | 16.26 | 0.610     | 0.640 |
| L    | 19.81       | 20.32 | 0.780     | 0.800 |
| L1   | 4.06        | 4.50  | 0.160     | 0.177 |
| Øp   | 3.51        | 3.66  | 0.138     | 0.144 |

ECN: S17-0178-Rev. B, 06-Feb-17  
DWG: 6010

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