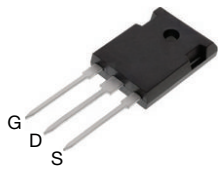
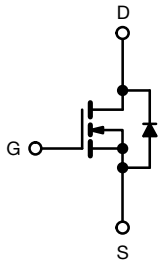
# EF Series Power MOSFET with Fast Body Diode

| 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 | |

TO-247AD




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) $R_{on}$ x $Q_g$
- 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

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 | | | $V_{GS}$ | ± 30 | |
| Continuous Drain Current ($T_J$ = 150 °C) | $V_{GS}$ at 10 V | $T_C$ = 25 °C | $I_D$ | 47 | A |
| | | $T_C$ = 100 °C | | 29 | |
| Pulsed Drain Current [a] | | | $I_{DM}$ | 138 | |
| Linear Derating Factor | | | | 3 | W/°C |
| Single Pulse Avalanche Energy [b] | | | $E_{AS}$ | 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 | $T_J$ = 125 °C | | dV/dt | 70 | V/ns |
| Reverse Diode dV/dt [d] | | | | 50 | |
| Soldering Recommendations (Peak Temperature) [c] | for 10 s | | | 300 | °C |

**Notes**

a. Repetitive rating; pulse width limited by maximum junction temperature
b. $V_{DD}$ = 50 V, starting $T_J$ = 25 °C, L = 73.5 mH, $R_g$ = 25 Ω, $I_{AS}$ = 6.4 A
c. 1.6 mm from case
d. $I_{SD} \leq I_D$, 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 | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | - | 0.33 | |

| SPECIFICATIONS ($T_J$ = 25 °C, unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Static** | | | | | | |
| Drain-Source Breakdown Voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = 250 µA | 600 | - | - | V |
| $V_{DS}$ Temperature Coefficient | $\Delta V_{DS}/T_J$ | Reference to 25 °C, $I_D$ = 1 mA | - | | - | V/°C |
| Gate-Source Threshold Voltage (N) | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 2.0 | - | 4.0 | V |
| Gate-Source Leakage | $I_{GSS}$ | $V_{GS}$ = ± 20 V | - | - | ± 100 | nA |
| | | $V_{GS}$ = ± 30 V | - | - | ± 1 | µA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | $V_{DS}$ = 480 V, $V_{GS}$ = 0 V | - | - | 1 | µA |
| | | $V_{DS}$ = 480 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | - | - | 500 | |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | $V_{GS}$ = 10 V, $I_D$ = 24 A | - | 0.056 | 0.065 | Ω |
| Forward Transconductance | $g_{fs}$ | $V_{DS}$ = 30 V, $I_D$ = 24 A | - | 17 | - | S |
| **Dynamic** | | | | | | |
| Input Capacitance | $C_{iss}$ | $V_{GS}$ = 0 V, $V_{DS}$ = 100 V, f = 1 MHz | - | 5000 | - | pF |
| Output Capacitance | $C_{oss}$ | | - | 220 | - | |
| Reverse Transfer Capacitance | $C_{rss}$ | | - | 7 | - | |
| Effective Output Capacitance, Energy Related [a] | $C_{o(er)}$ | $V_{DS}$ = 0 V to 480 V, $V_{GS}$ = 0 V | - | 172 | - | |
| Effective Output Capacitance, Time Related [b] | $C_{o(tr)}$ | | - | 634 | - | |
| Total Gate Charge | $Q_g$ | $V_{GS}$ = 10 V; $I_D$ = 24 A, $V_{DS}$ = 480 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 V, $I_D$ = 24 A, $V_{GS}$ = 10 V, $R_g$ = 4.4 Ω | - | 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 MHz, open drain | 0.2 | 0.46 | 1.0 | Ω |
| **Drain-Source Body Diode Characteristics** | | | | | | |
| 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 °C, $I_S$ = 24 A, $V_{GS}$ = 0 V | - | 0.9 | 1.2 | V |
| Body Diode Reverse Recovery Time | $t_{rr}$ | $T_J$ = 25 °C, $I_F$ = $I_{S\ =\ 24\ A}$, dI/dt = 100 A/µs, $V_R$ = 400 V | - | 199 | 398 | ns |
| Body Diode Reverse Recovery Charge | $Q_{rr}$ | | - | 1.4 | 2.8 | µC |
| 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)

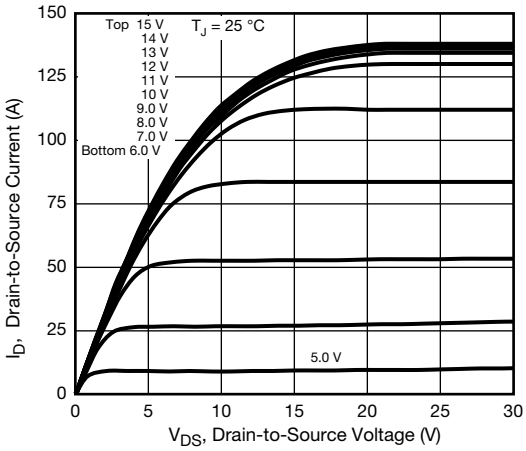



**Fig. 1 - Typical Output Characteristics**

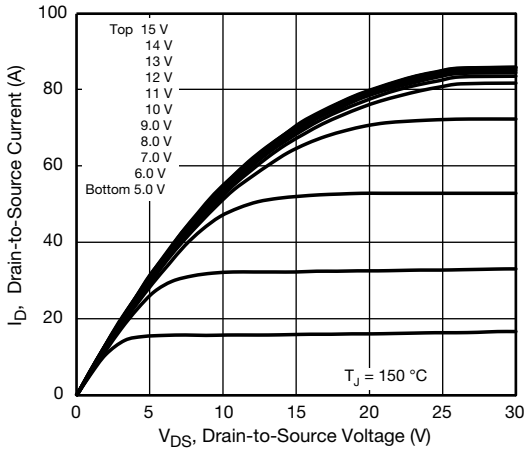



**Fig. 2 - Typical Output Characteristics**

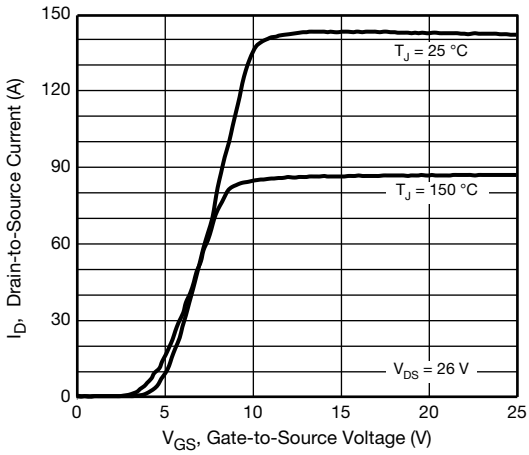



**Fig. 3 - Typical Transfer Characteristics**

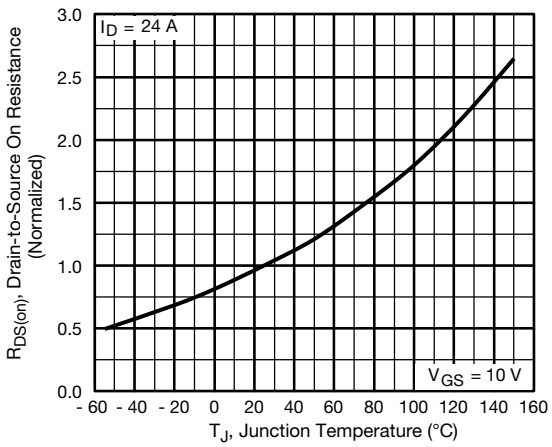



**Fig. 4 - Normalized On-Resistance vs. Temperature**

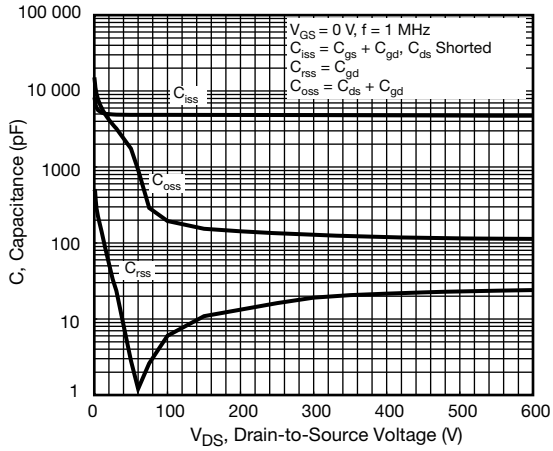



**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

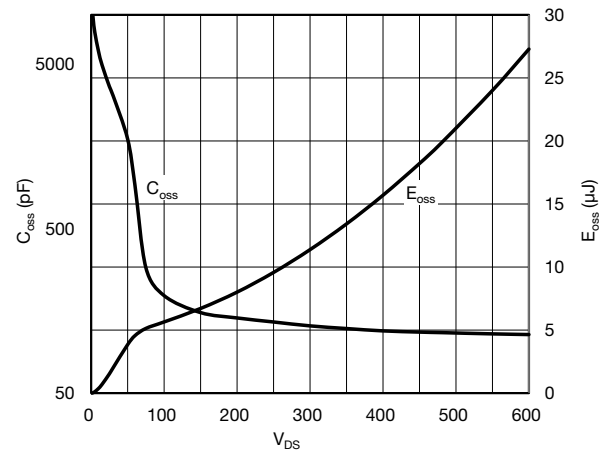



**Fig. 6 - $C_{oss}$ and $E_{oss}$ vs. $V_{DS}$**

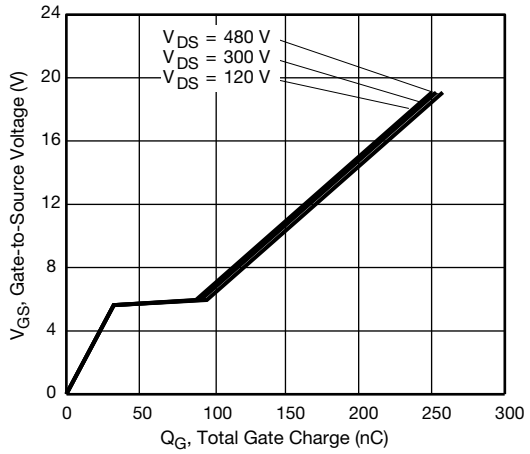



**Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage**

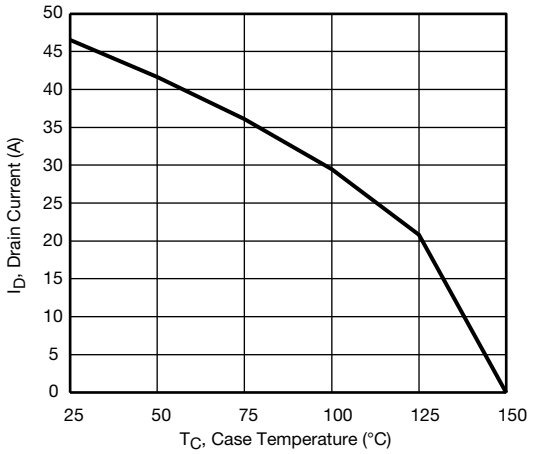



**Fig. 10 - Maximum Drain Current vs. Case Temperature**

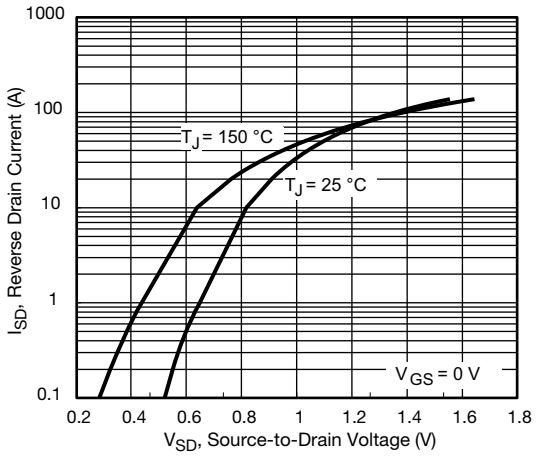



**Fig. 8 - Typical Source-Drain Diode Forward Voltage**

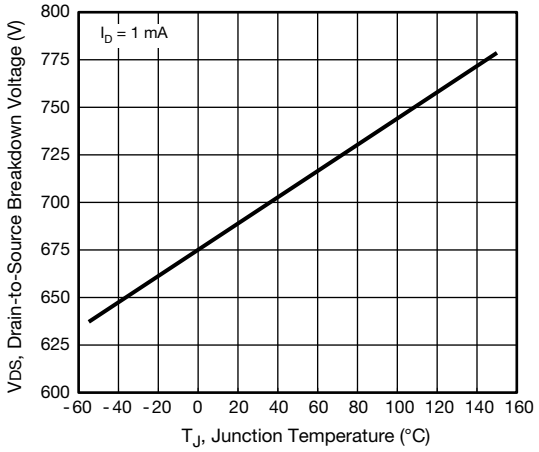



**Fig. 11 - Temperature vs. Drain-to-Source Voltage**

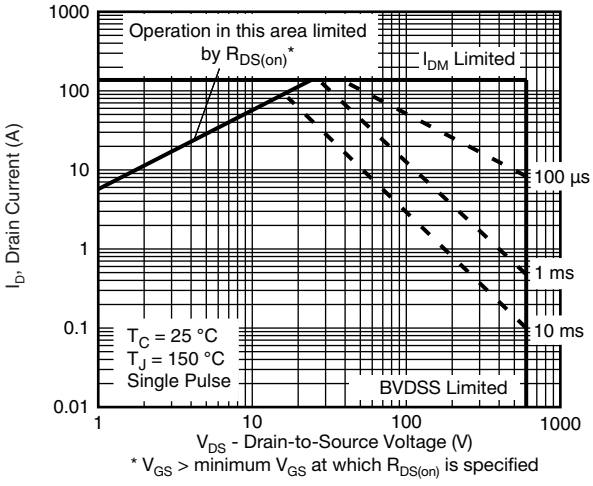



**Fig. 9 - Maximum Safe Operating Area**

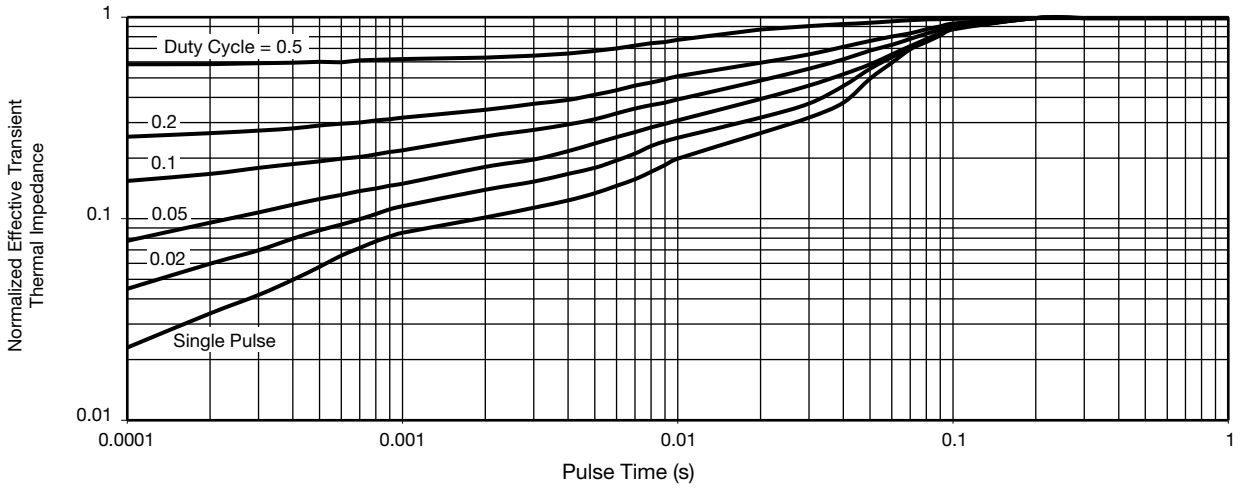



**Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case**

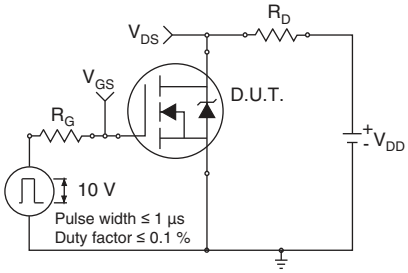



**Fig. 13 - Switching Time Test Circuit**

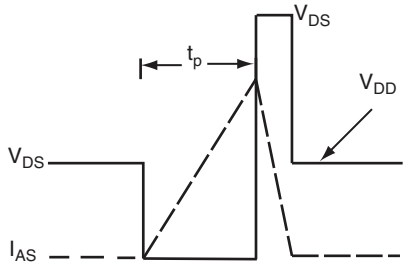



**Fig. 16 - Unclamped Inductive Waveforms**

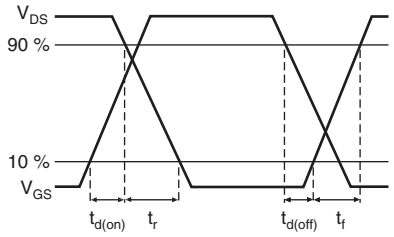



**Fig. 14 - Switching Time Waveforms**

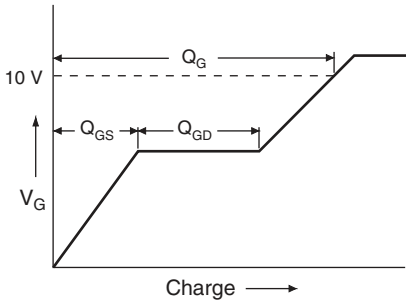



**Fig. 17 - Basic Gate Charge Waveform**

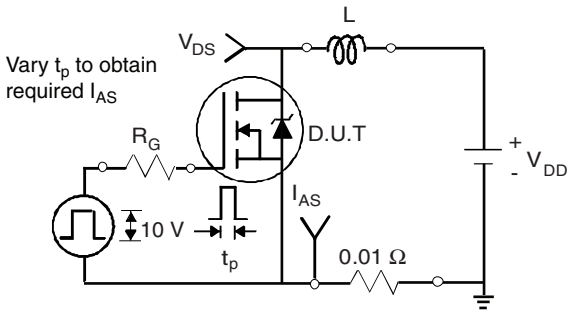



**Fig. 15 - Unclamped Inductive Test Circuit**

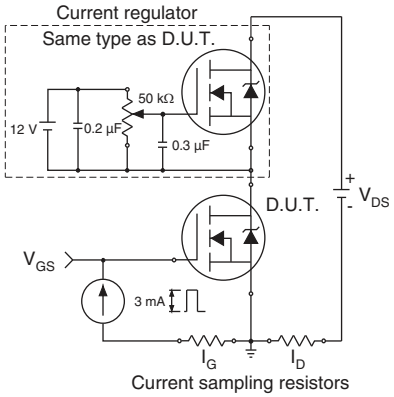
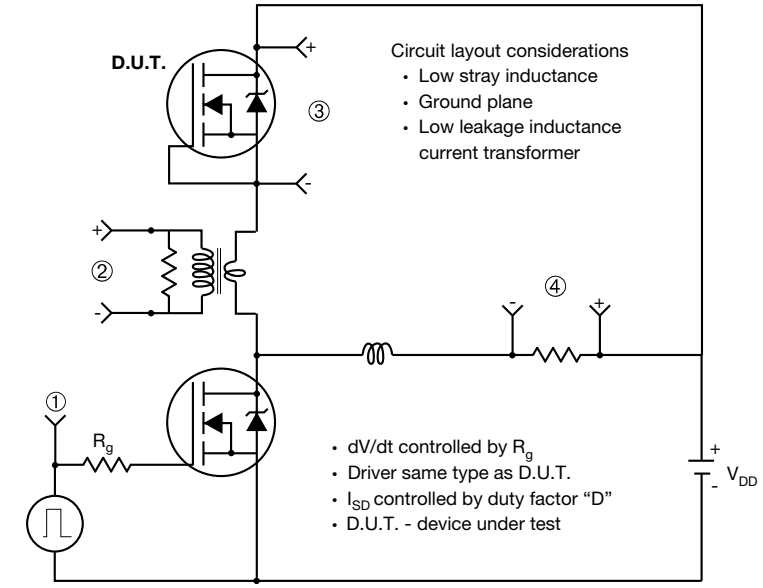
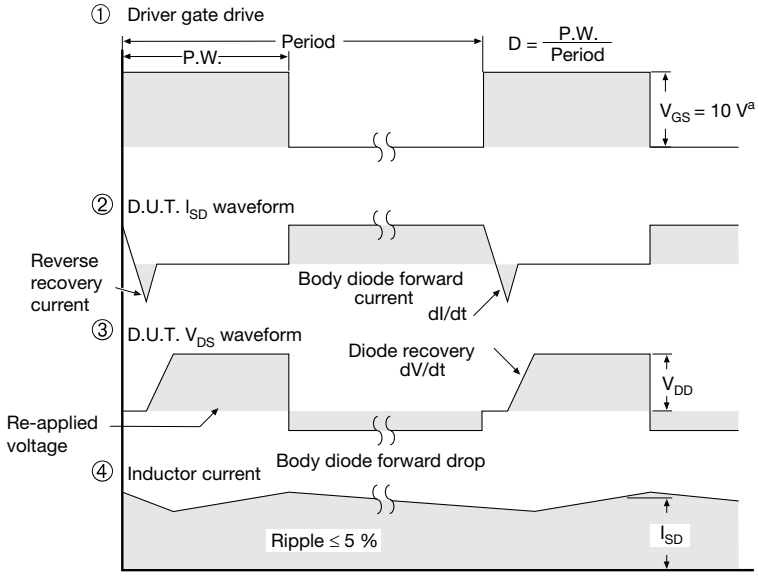



**Fig. 18 - Gate Charge Test Circuit**

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



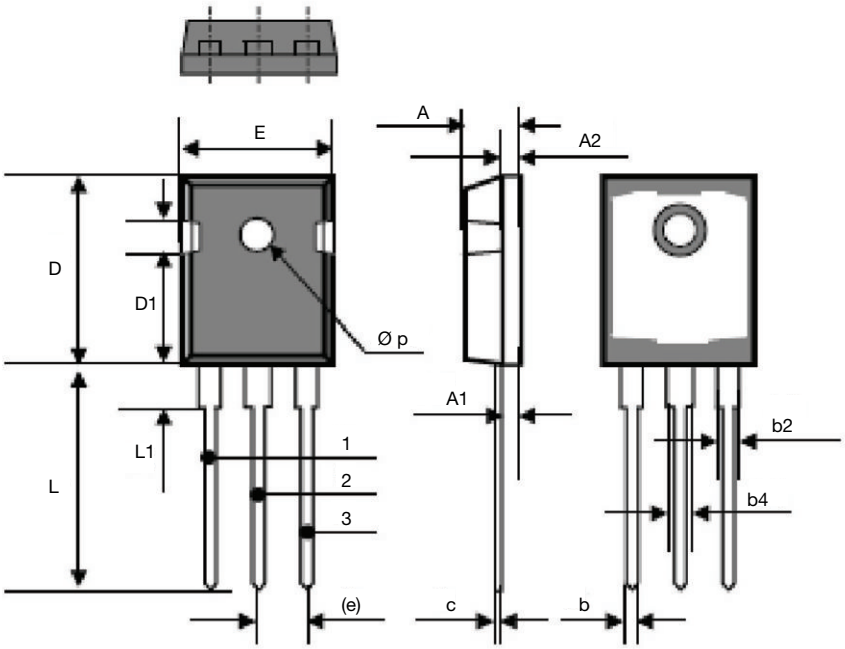




**Note**

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

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

# 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 |
| Ø p | 3.51 | 3.66 | 0.138 | 0.144 |
| ECN: S17-0178-Rev. B, 06-Feb-17<br>DWG: 6010 | | | | |

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