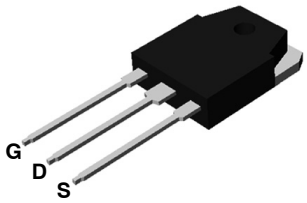
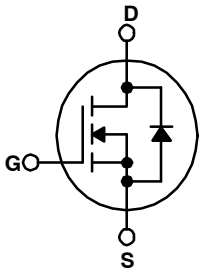
# MOSFET – N-Channel, QFET

## 600 V, 23.5 A, 240 mΩ

# FQA24N60




TO−3P−3L
CASE 340BZ




### Description

This N−Channel Enhancement Mode power MOSFET is produced using **onsemi**'s proprietary planar stripe and DMOS technology.

This advanced MOSFET technology has been especially tailored to reduce on−state resistance, and to provide superior switching performance and high avalanche energy strength. These devices are suitable for switched mode power supplies, active power factor correction (PFC), and electronic lamp ballasts.

### Features

- 23.5 A, 600 V, $R_{DS(on)}$ = 240 mΩ (Max.) @ $V_{GS}$ = 10 V, $I_D$ = 11.8 A
- Low Gate Charge (Typ. 110 nC)
- Low $C_{rss}$ (Typ. 56 pF)
- 100% Avalanche Tested
- This Device is Pb−Free

### ABSOLUTE MAXIMUM RATINGS

($T_C$ = 25°C unless otherwise noted.)

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{DSS}$ | Drain to Source Voltage | 600 | V |
| $I_D$ | Drain Current<br>− Continuous ($T_C$ = 25°C)<br>− Continuous ($T_C$ = 100°C) | <br>23.5<br>14.9 | A |
| $I_{DM}$ | Drain Current − Pulsed (Note 1) | 94 | A |
| $V_{GSS}$ | Gate to Source Voltage | ±30 | V |
| $E_{AS}$ | Single Pulse Avalanche Energy (Note 2) | 1300 | mJ |
| $I_{AR}$ | Avalanche Current (Note 1) | 23.5 | A |
| $E_{AR}$ | Repetitive Avalanche Energy (Note 1) | 31 | mJ |
| dv/dt | Peak Diode Recovery dv/dt (Note 3) | 4.5 | V/ns |
| $P_D$ | Power Dissipation<br>− ($T_C$ = 25°C)<br>− Derate Above 25°C | <br>310<br>2.5 | <br>W<br>W/°C |
| $T_J$,$T_{STG}$ | Operating and Storage Temperature Range | −55 to +150 | °C |
| $T_L$ | Maximum Lead Temperature for Soldering Purpose, 1/8" from Case for 5 Seconds | 300 | °C |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### MARKING DIAGRAM

| | |
|---|---|
| FQA24N60 | = Specific Device Code |
| A | = Assembly Location |
| YWW | = Date Code (Year & Week) |
| ZZ | = Assembly Lot |

### ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| FQA24N60 | TO−3P−3L<br>(Pb−Free) | 450<br>Units / Tube |

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## THERMAL CHARACTERISTICS

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{\theta JC}$ | Thermal Resistance, Junction−to−Case, Max | 0.4 | °C/W |
| $R_{\theta CS}$ | Thermal Resistance, Case−to−Sink, Typ. | 0.24 | |
| $R_{\theta JA}$ | Thermal Resistance, Junction−to−Ambient, Max. | 40 | |

## ELECTRICAL CHARACTERISTICS ($T_C$ = 25°C unless otherwise noted)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Off Characteristics** | | | | | | |
| $BV_{DSS}$ | Drain−Source Breakdown Voltage | $V_{GS}$ = 0 V, $I_D$ = 250 μA | 600 | – | – | V |
| $\frac{\Delta BV_{DSS}}{\Delta T_J}$ | Breakdown Voltage Temperature Coefficient | $I_D$ = 250 μA, Referenced to 25°C | – | 0.6 | – | V/°C |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 600 V, $V_{GS}$ = 0 V | – | – | 10 | μA |
| | | $V_{DS}$ = 480 V, $T_C$ = 125°C | – | – | 100 | μA |
| $I_{GSSF}$ | Gate−Body Leakage Current, Forward | $V_{GS}$ = 30 V, $V_{DS}$ = 0 V | – | – | 100 | nA |
| $I_{GSSR}$ | Gate−Body Leakage Current, Reverse | $V_{GS}$ = −30 V, $V_{DS}$ = 0 V | – | – | −100 | nA |
| **On Characteristics** | | | | | | |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 μA | 3.0 | – | 5.0 | V |
| $R_{DS(on)}$ | Static Drain−Source On−Resistance | $V_{GS}$ = 10 V, $I_D$ = 11.8 A | – | 0.18 | 0.24 | Ω |
| $g_{FS}$ | Forward Transconductance | $V_{DS}$ = 50 V, $I_D$ = 11.8 A | – | 22.5 | – | S |
| **Dynamic Characteristics** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 25 V, $V_{GS}$ = 0 V, f = 1.0 MHz | – | 4200 | 5500 | pF |
| $C_{oss}$ | Output Capacitance | | – | 550 | 720 | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | – | 56 | 75 | pF |
| **Switching Characteristics** | | | | | | |
| $t_{d(on)}$ | Turn−On Delay Time | $V_{DD}$ = 300 V, $I_D$ = 23.5 A, $R_G$ = 25 Ω (Note 4) | – | 90 | 190 | ns |
| $t_r$ | Turn−On Rise Time | | – | 270 | 550 | ns |
| $t_{d(off)}$ | Turn−Off Delay Time | | – | 200 | 410 | ns |
| $t_f$ | Turn−Off Fall Time | | – | 170 | 350 | ns |
| $Q_g$ | Total Gate Charge | $V_{DS}$ = 480 V, $I_D$ = 23.5 A, $V_{GS}$ = 10 V (Note 4) | – | 110 | 145 | nC |
| $Q_{gs}$ | Gate−Source Charge | | – | 25 | – | nC |
| $Q_{gd}$ | Gate−Drain Charge | | – | 53 | – | nC |
| **Drain−Source Diode Characteristics and Maximum Ratings** | | | | | | |
| $I_S$ | Maximum Continuous Drain−Source Diode Forward Current | | – | – | 23.5 | A |
| $I_{SM}$ | Maximum Pulsed Drain to Source Diode Forward Current | | – | – | 94 | A |
| $V_{SD}$ | Drain−Source Diode Forward Voltage | $V_{GS}$ = 0 V, $I_S$ = 23.5 A | – | – | 1.4 | V |
| $t_{rr}$ | Reverse Recovery Time | $V_{GS}$ = 0 V, $I_S$ = 23.5 A, $dI_F/dt$ = 100 A/μs | – | 470 | – | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | – | 6.2 | – | μC |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

NOTES:

1. Repetitive Rating: Pulse width−limited by maximum junction temperature.
2. L = 4.3 mH, $I_{AS}$ = 23.5 A, $V_{DD}$ = 50 V, $R_G$ = 25 Ω, starting $T_J$ = 25°C.
3. $I_{SD} \leq$ 23.5 A, di/dt ≤ 200 A/μs, $V_{DD} \leq BV_{DSS}$, starting $T_J$ = 25°C.
4. Essentially independent of operating temperature.



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## TYPICAL CHARACTERISTICS

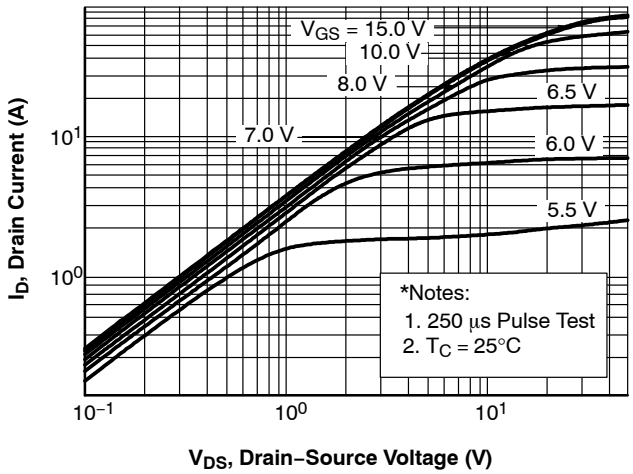


Figure 1. On−Region Characteristics

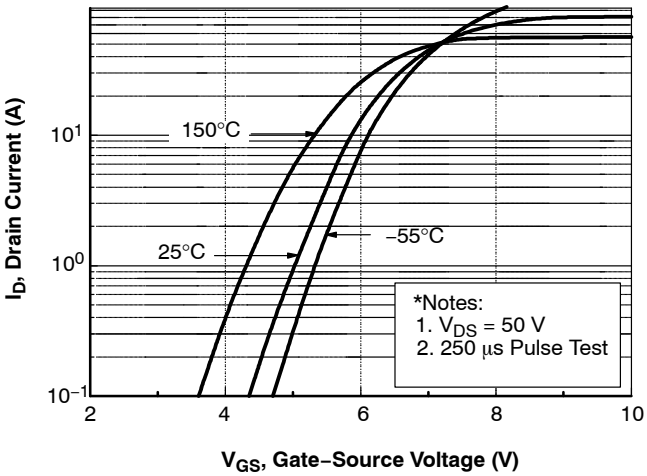


Figure 2. Transfer Characteristics

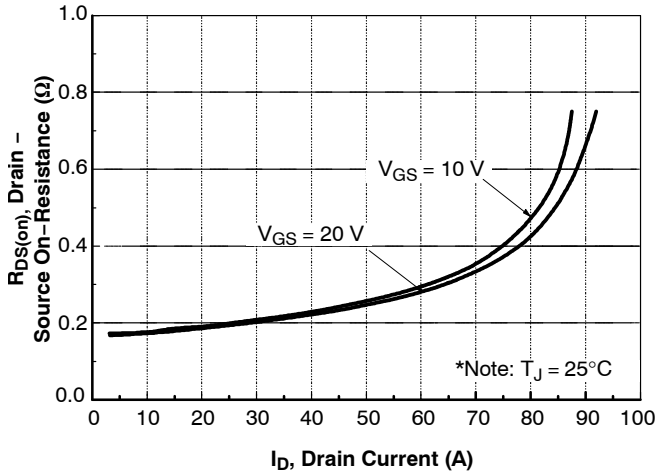


Figure 3. On−Resistance Variation vs Drain Current and Gate Voltage

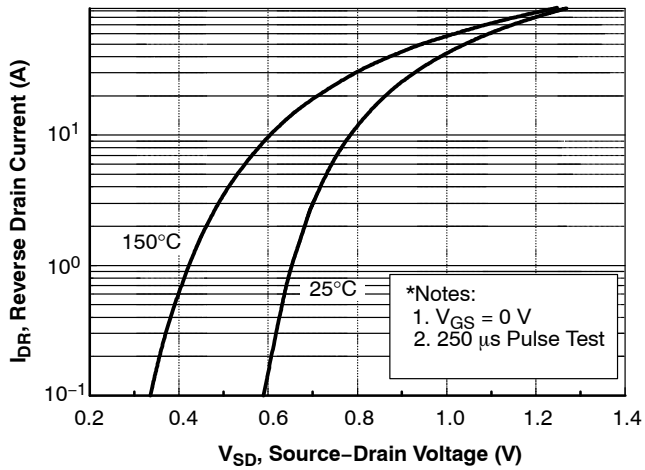


Figure 4. Body Diode Forward Voltage Variation vs Source Current and Temperature

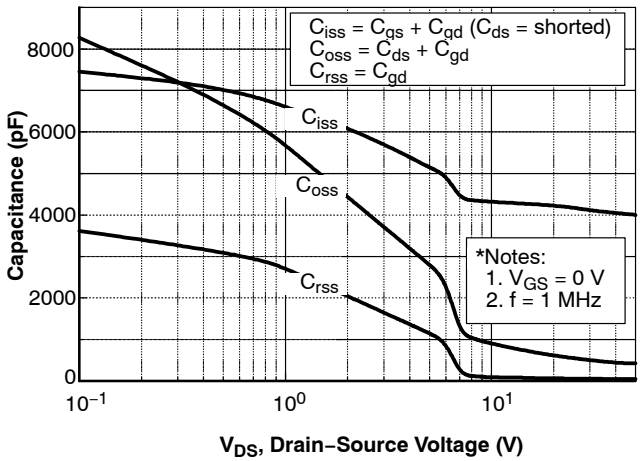


Figure 5. Capacitance Characteristics

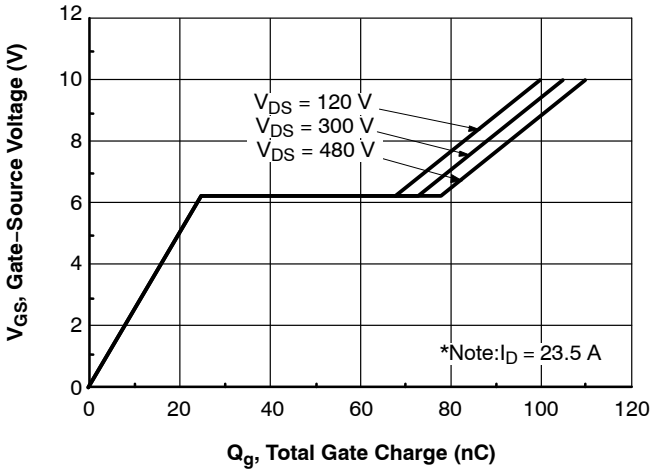


Figure 6. Gate Charge Characteristics



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## TYPICAL CHARACTERISTICS (CONTINUED)

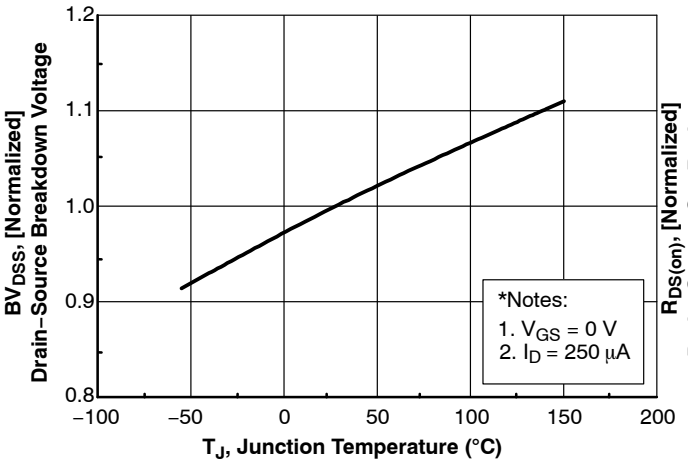


Figure 7. Breakdown Voltage Variation vs Temperature

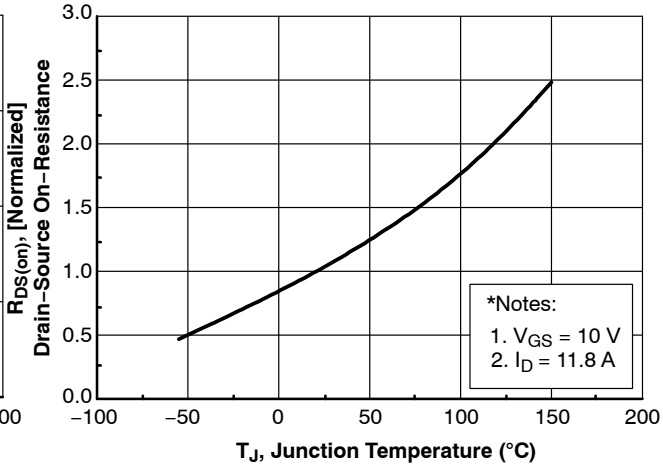


Figure 8. On−Resistance Variation vs Temperature

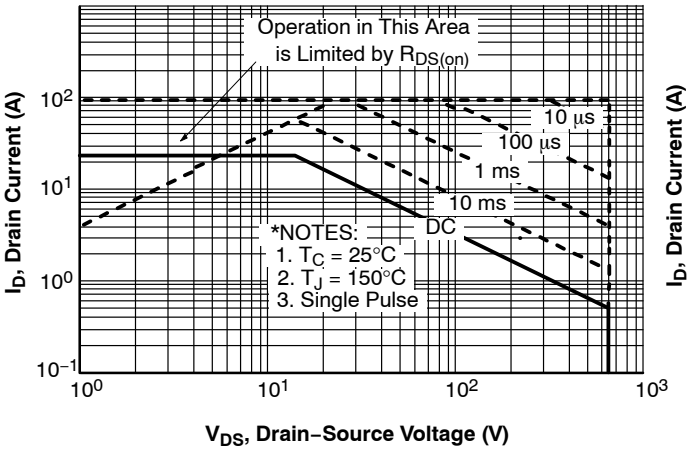


Figure 9. Maximum Safe Operating Area

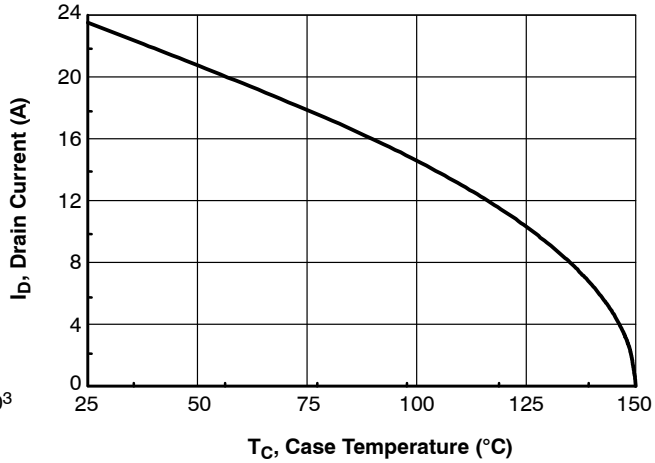


Figure 10. Maximum Drain Current vs. Case Temperature

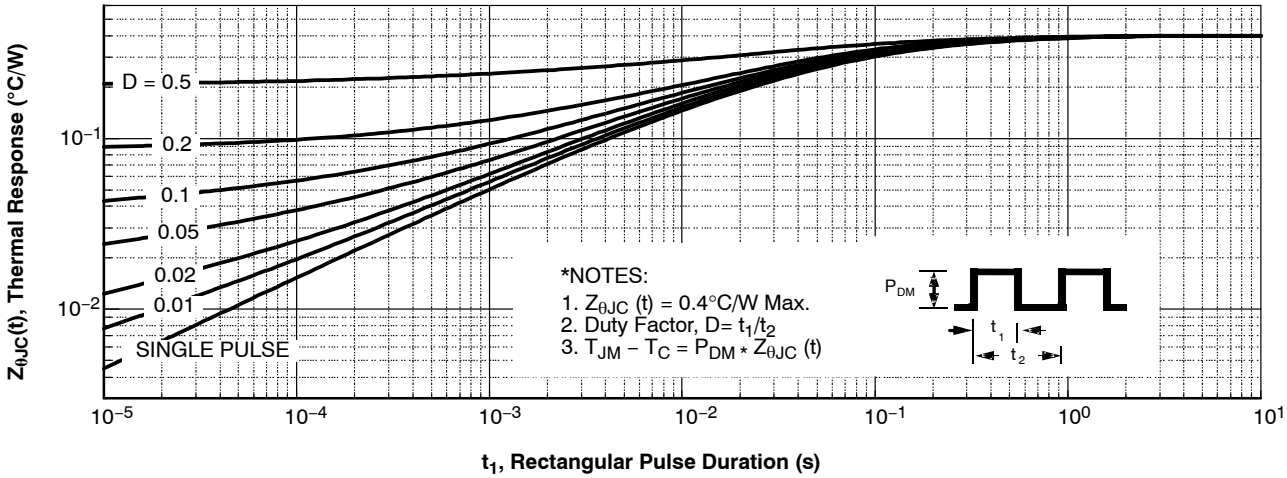


Figure 11. Transient Thermal Response Curve



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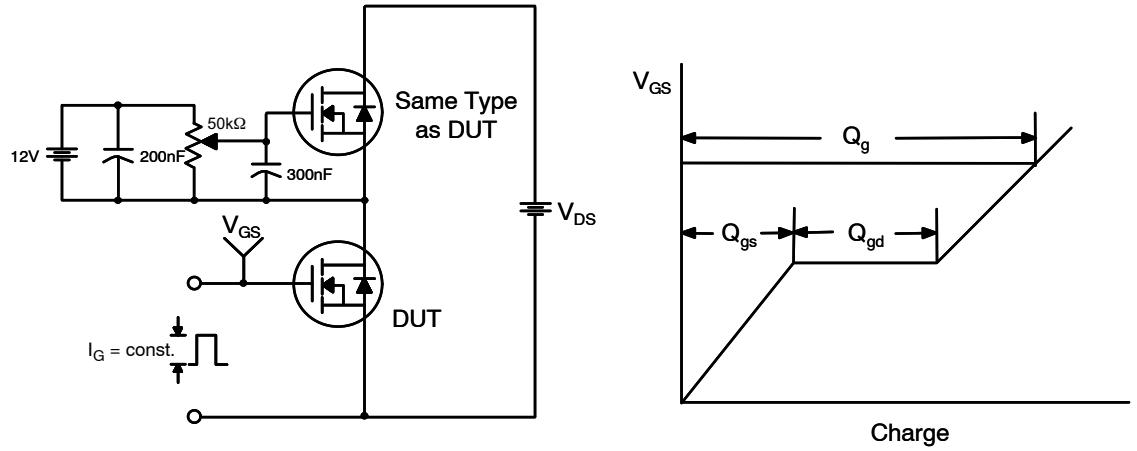


**Figure 12. Gate Charge Test Circuit & Waveform**

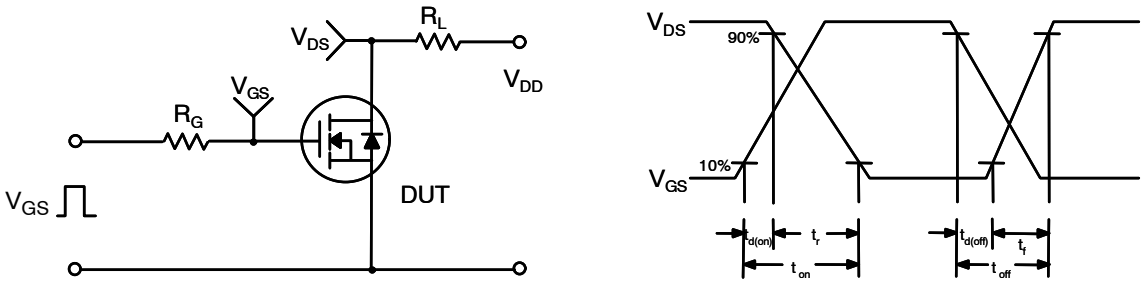


**Figure 13. Resistive Switching Test Circuit & Waveforms**

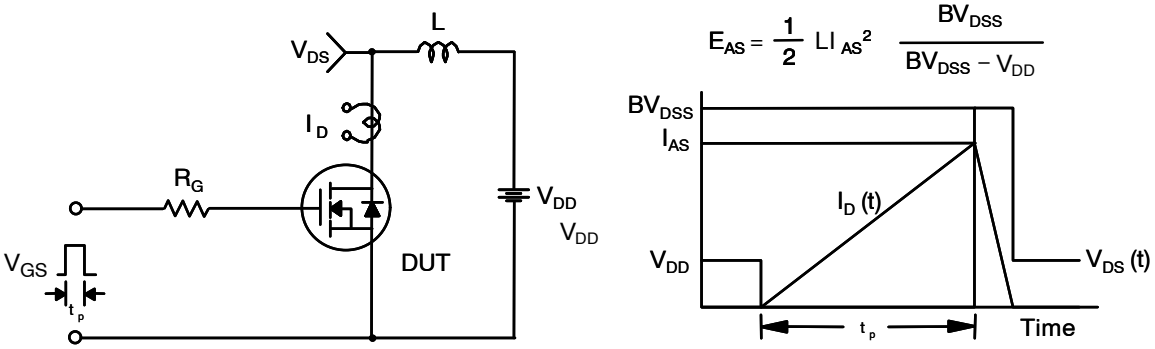


**Figure 14. Unclamped Inductive Switching Test Circuit & Waveforms**



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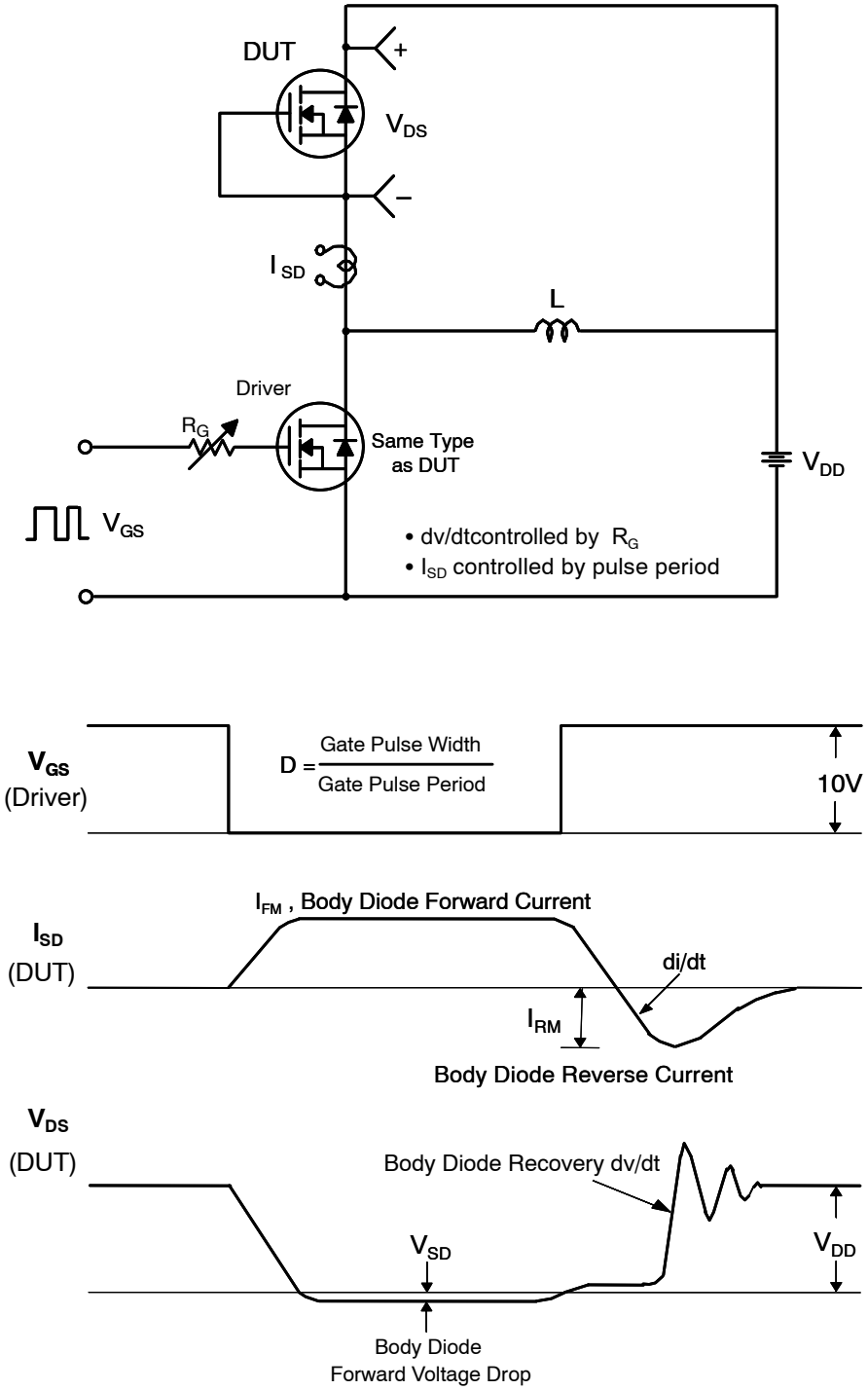


**Figure 15. Peak Diode Recovery dv/dt Test Circuit & Waveforms**



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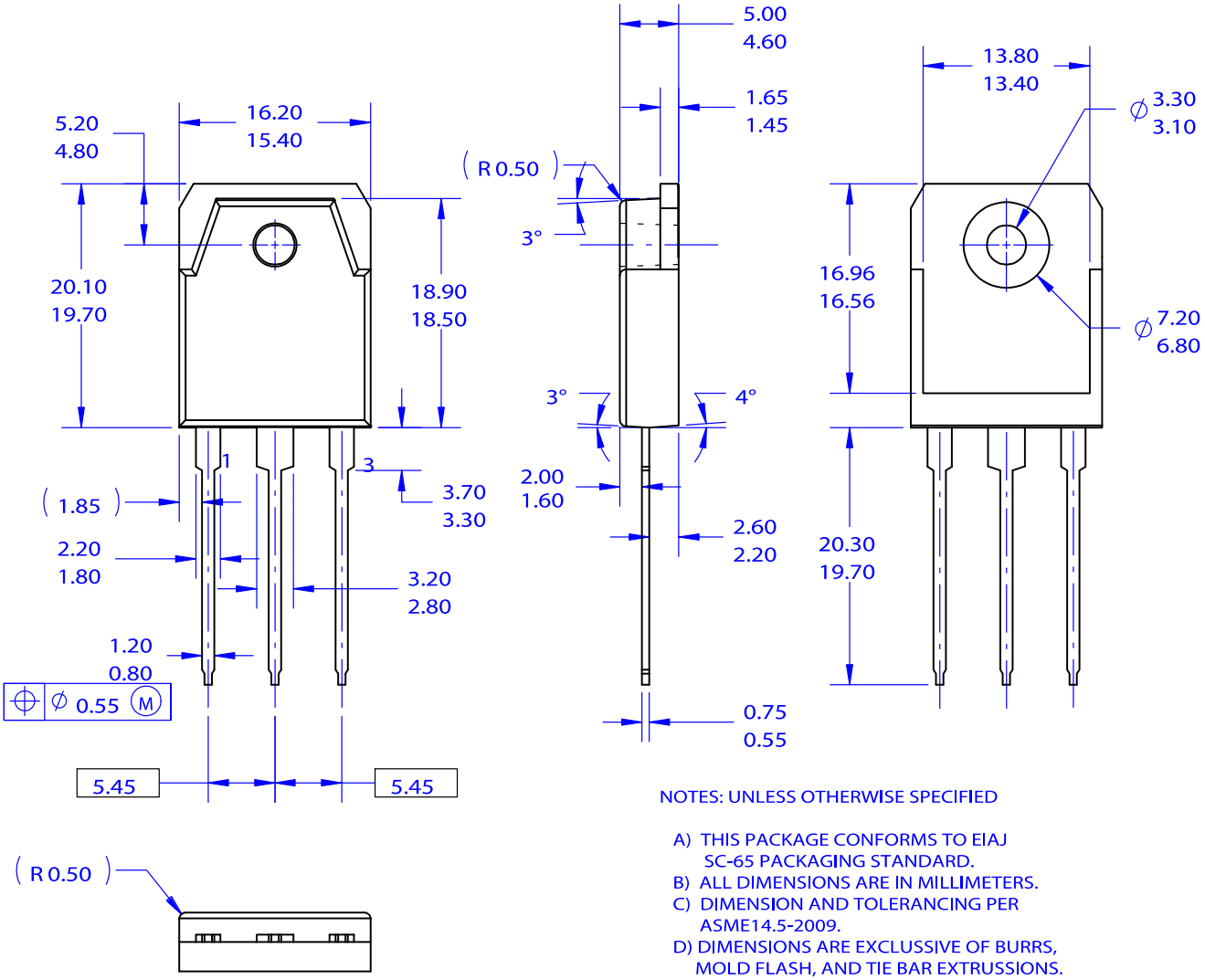


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