# MOSFET – N-Channel, SUPERFET® II, Easy-Drive

## 600 V, 23 A, 165 mΩ

## FCH165N60E

### Description

SUPERFET II MOSFET is ON Semiconductor's brand−new high voltage super−junction (SJ) MOSFET family that is utilizing charge balance technology for outstanding low on−resistance and lower gate charge performance. This technology is tailored to minimize conduction loss, provide superior switching performance, dv/dt rate and higher avalanche energy. Consequently, SUPERFET II MOSFET easy−drive series offers slightly slower rise and fall times compared to the SUPERFET II MOSFET series. Noted by the "E" part number suffix, this family helps manage EMI issues and allows for easier design implementation. For faster switching in applications where switching losses must be at an absolute minimum, please consider the SUPERFET II MOSFET series.
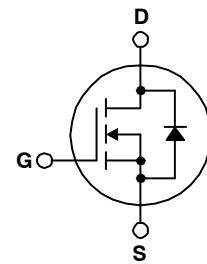
### Features

- Typ. $R_{DS(on)}$ = 132 mΩ
- 650 V @ $T_J$ = 150°C
- Ultra Low Gate Charge (Typ. $Q_g$ = 57 nC)
- Low Effective Output Capacitance (Typ. $C_{oss(eff.)}$ = 204 pF)
- 100% Avalanche Tested
- These Devices are Pb−Free and are RoHS Compliant

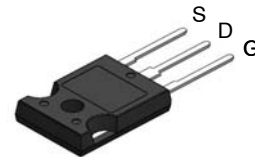### Applications

- Telecom / Sever Power Supplies
- Industrial Power Supplies

## ON Semiconductor®

| $V_{DS}$ | $R_{DS(ON)}$ MAX | $I_D$ MAX |
|---|---|---|
| 600 V | 165 mΩ @ 10 V | 23 A |



**N-CHANNEL MOSFET**



**TO−247−3LD**
**CASE 340CK**

### MARKING DIAGRAM



$Y&Z&3&K
FCH
165N60E
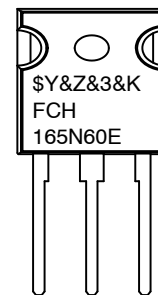
| | |
|---|---|
| $Y | = ON Semiconductor Logo |
| &Z | = Assembly Plant Code |
| &3 | = Numeric Date Code |
| &K | = Lot Code |
| FCH165N60E | = Specific Device Code |

### ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

December, 2019 – Rev. 3

Publication Order Number:
FCH165N60E/D

# FCH165N60E

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

| Symbol | Parameter | | FCH165N60E | Unit |
|---|---|---|---|---|
| $V_{DSS}$ | Drain to Source Voltage | | 600 | V |
| $V_{GSS}$ | Gate to Source Voltage | – DC | ±20 | V |
| | | – AC (f > 1 Hz) | ±30 | |
| $I_D$ | Drain Current: | – Continuous ($T_C$ = 25°C) | 23 | A |
| | | – Continuous ($T_C$ = 100°C) | 14 | |
| $I_{DM}$ | Drain Current: | – Pulsed (Note 1) | 69 | A |
| $E_{AS}$ | Single Pulsed Avalanche Energy (Note 2) | | 525 | mJ |
| $I_{AR}$ | Avalanche Current (Note 1) | | 5 | A |
| $E_{AR}$ | Repetitive Avalanche Energy (Note 1) | | 2.27 | mJ |
| dv/dt | MOSFET dv/dt | | 100 | V/ns |
| | Peak Diode Recovery dv/dt (Note 3) | | 20 | |
| $P_D$ | Power Dissipation | ($T_C$ = 25°C) | 227 | W |
| | | – Derate Above 25°C | 1.82 | W/°C |
| $T_J$, $T_{STG}$ | Operating and Storage Temperature Range | | –55 to + 150 | °C |
| $T_L$ | Maximum Lead Temperature for Soldering, 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.
1. Repetitive rating: pulse−width limited by maximum junction temperature.
2. $I_{AS}$ = 5.0 A, $R_G$ = 25 Ω, Starting $T_J$ = 25 °C.
3. $I_{SD} \leq$ 11.5 A, di/dt $\leq$ 200 A/μs, $V_{DD} \leq$ 380 V, Starting $T_J$ = 25 °C.

## PACKAGE MARKING AND ORDERING INFORMATION

| Part Number | Top Marking | Package | Packing Method | Reel Size | Tape Width | Quantity |
|---|---|---|---|---|---|---|
| FCH165N60E | FCH165N60E | TO−247 | Tube | N/A | N/A | 30 Units |

## THERMAL CHARACTERISTICS

| Symbol | Parameter | FCH165N60E | Unit |
|---|---|---|---|
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, Max. | 0.55 | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, Max. | 40 | |

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

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|--------|-----------|----------------|------|------|------|------|
| **OFF CHARACTERISTICS** | | | | | | |
| $BV_{DSS}$ | Drain to Source Breakdown Voltage | $I_D$ = 10 mA, $V_{GS}$ = 0 V, $T_J$ = 25°C | 600 | – | – | V |
| | | $I_D$ = 10 mA, $V_{GS}$ = 0 V, $T_J$ = 150°C | 650 | – | – | |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D$ = 10 mA, Referenced to 25°C | – | 0.7 | – | V/°C |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 600 V, $V_{GS}$ = 0 V | – | – | 1 | μA |
| | | $V_{DS}$ = 480 V, $V_{GS}$ = 0 V, $T_C$ = 125 °C | – | 1.46 | – | |
| $I_{GSS}$ | Gate to Body Leakage Current | $V_{GS}$ = ±20 V, $V_{DS}$ = 0 V | – | – | ±100 | nA |
| **ON CHARACTERISTICS** | | | | | | |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{GS}$ = $V_{DS}$, $I_D$ = 250 μA | 2.5 | – | 3.5 | V |
| $R_{DS(on)}$ | Static Drain to Source On Resistance | $V_{GS}$ = 10 V, $I_D$ = 11.5 A | – | 132 | 165 | mΩ |
| $g_{FS}$ | Forward Transconductance | $V_{DS}$ = 20 V, $I_D$ = 11.5 A | – | 20 | – | S |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 380 V, $V_{GS}$ = 0 V, f = 1 MHz | – | 1830 | 2434 | pF |
| $C_{oss}$ | Output Capacitance | | – | 50 | 67 | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | – | 8.6 | – | pF |
| $C_{oss(eff.)}$ | Effective Output Capacitance | $V_{DS}$ = 0 V to 480 V, $V_{GS}$ = 0 V | – | 204 | – | pF |
| $Q_{g(tot)}$ | Total Gate Charge at 10 V | $V_{DS}$ = 380 V, $I_D$ = 11.5 A, $V_{GS}$ = 10 V (Note 4) | – | 57 | 75 | nC |
| $Q_{gs}$ | Gate to Source Gate Charge | | – | 8.3 | – | nC |
| $Q_{gd}$ | Gate to Drain "Miller" Charge | | – | 24 | – | nC |
| ESR | Equivalent Series Resistance | f = 1 MHz | – | 6 | – | Ω |
| **SWITCHING CHARACTERISTICS** | | | | | | |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{DD}$ = 380 V, $I_D$ = 11.5 A, $V_{GS}$ = 10 V, $R_g$ = 4.7 Ω (Note 4) | – | 22 | 55 | ns |
| $t_r$ | Turn–On Rise Time | | – | 18 | 46 | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | – | 100 | 210 | ns |
| $t_f$ | Turn–Off Fall Time | | – | 18 | 47 | ns |
| **DRAIN-SOURCE DIODE CHARACTERISTICS** | | | | | | |
| $I_S$ | Maximum Continuous Source to Drain Diode Forward Current | | – | – | 23 | A |
| $I_{SM}$ | Maximum Pulsed Drain to Source Diode Forward Current | | – | – | 69 | A |
| $V_{SD}$ | Drain to Source Diode Forward Voltage | $V_{GS}$ = 0 V, $I_{SD}$ = 11.5 A | – | – | 1.2 | V |
| $t_{rr}$ | Reverse Recovery Time | $V_{GS}$ = 0 V, $I_{SD}$ = 11.5 A, $dI_F/dt$ = 100 A/μs | – | 326 | – | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | – | 5.3 | – | 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.
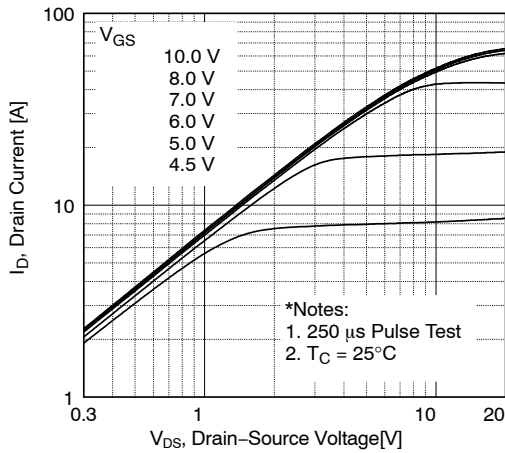4. Essentially independent of operating temperature.
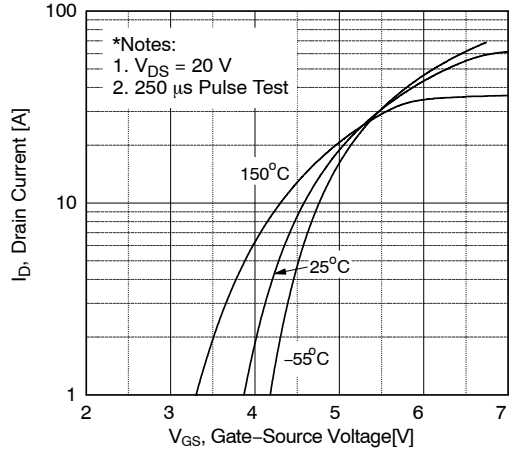
# FCH165N60E

Figure 1. On−Region Characteristics

$V_{GS}$
10.0 V
8.0 V
7.0 V
6.0 V
5.0 V
4.5 V

*Notes:
1. 250 μs Pulse Test
2. $T_C$ = 25°C

$I_D$, Drain Current [A]
$V_{DS}$, Drain−Source Voltage[V]



Figure 2. Transfer Characteristics

*Notes:
1. $V_{DS}$ = 20 V
2. 250 μs Pulse Test

150°C
25°C
−55°C

$I_D$, Drain Current [A]
$V_{GS}$, Gate−Source Voltage[V]
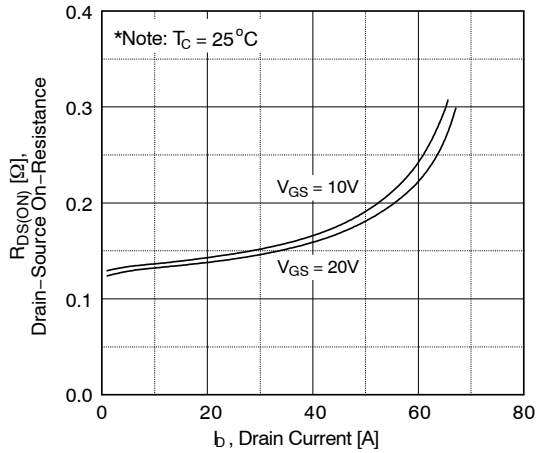


Figure 3. On−Resistance Variation vs. Drain Current and Gate Voltage

*Note: $T_C$ = 25°C

$V_{GS}$ = 10V
$V_{GS}$ = 20V

$R_{DS(ON)}$ [Ω], Drain−Source On−Resistance
$I_D$, Drain Current [A]
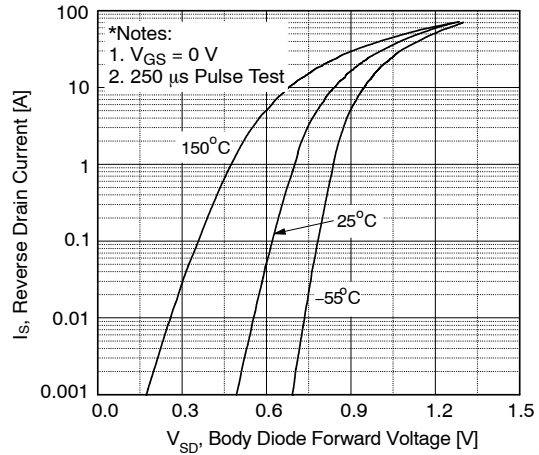


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

*Notes:
1. $V_{GS}$ = 0 V
2. 250 μs Pulse Test

150°C
25°C
−55°C

$I_S$, Reverse Drain Current [A]
$V_{SD}$, Body Diode Forward Voltage [V]
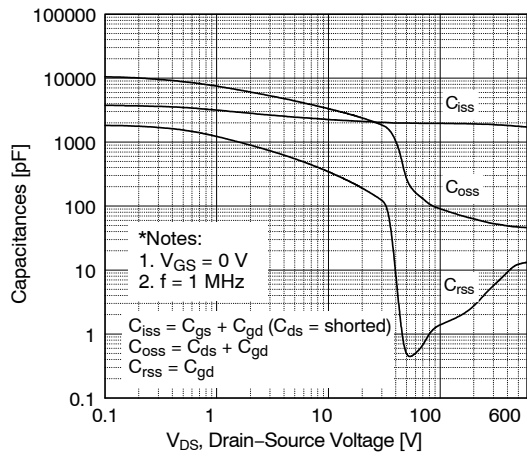


Figure 5. Capacitance Characteristics

$C_{iss}$
$C_{oss}$
$C_{rss}$

*Notes:
1. $V_{GS}$ = 0 V
2. f = 1 MHz

$C_{iss} = C_{gs} + C_{gd}$ ($C_{ds}$ = shorted)
$C_{oss} = C_{ds} + C_{gd}$
$C_{rss} = C_{gd}$

Capacitances [pF]
$V_{DS}$, Drain−Source Voltage [V]
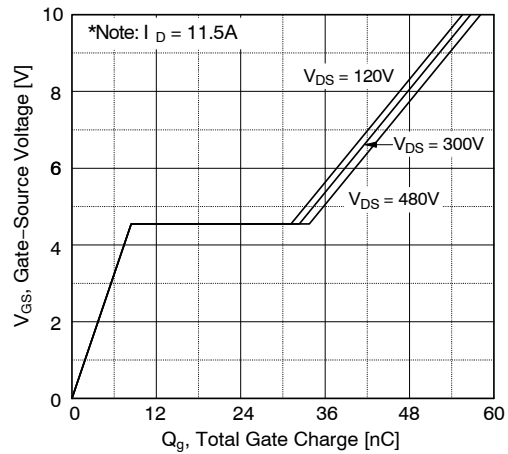


Figure 6. Gate Charge Characteristics

*Note: $I_D$ = 11.5A

$V_{DS}$ = 120V
$V_{DS}$ = 300V
$V_{DS}$ = 480V

$V_{GS}$, Gate−Source Voltage [V]
$Q_g$, Total Gate Charge [nC]

## TYPICAL CHARACTERISTICS
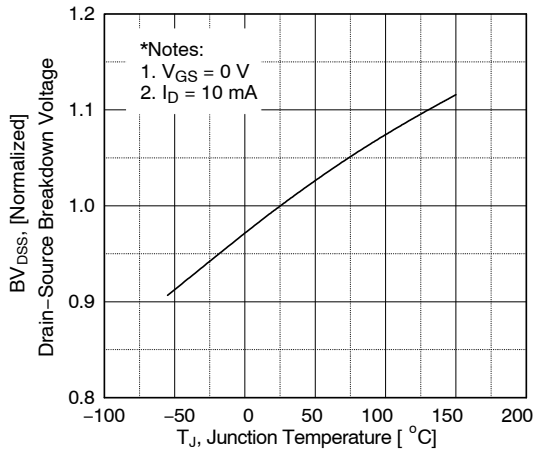
Figure 7. Breakdown Voltage Variation vs. Temperature
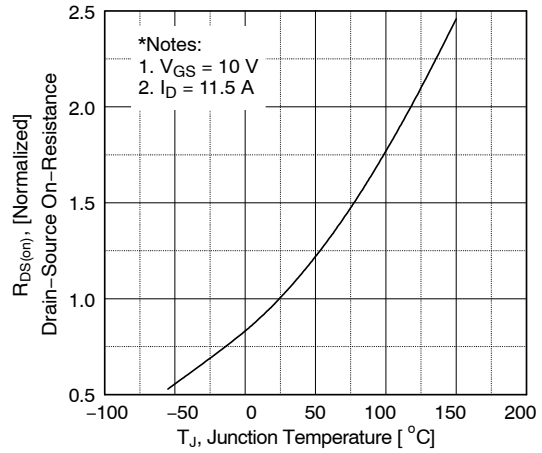
Figure 8. On−Resistance Variation vs. Temperature
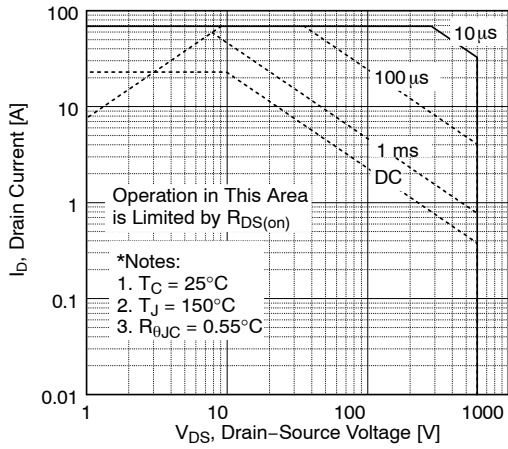
Figure 9. Maximum Safe Operating Area
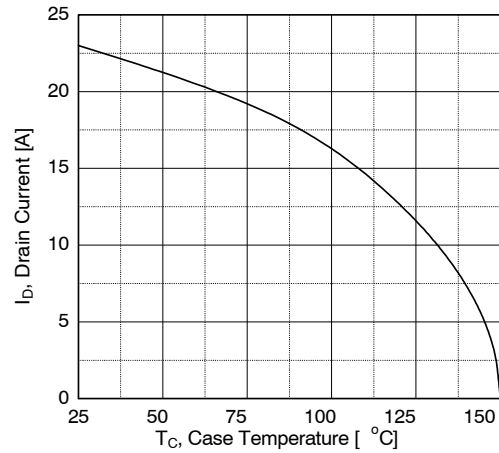
Figure 10. Maximum Drain Current vs. Case Temperature
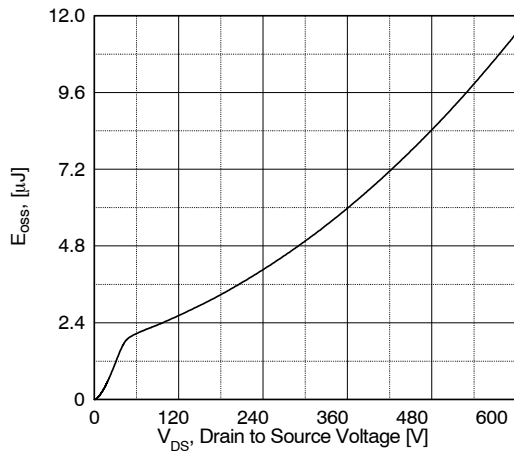
Figure 11. Eoss vs. Drain to Source Voltage

## TYPICAL CHARACTERISTICS
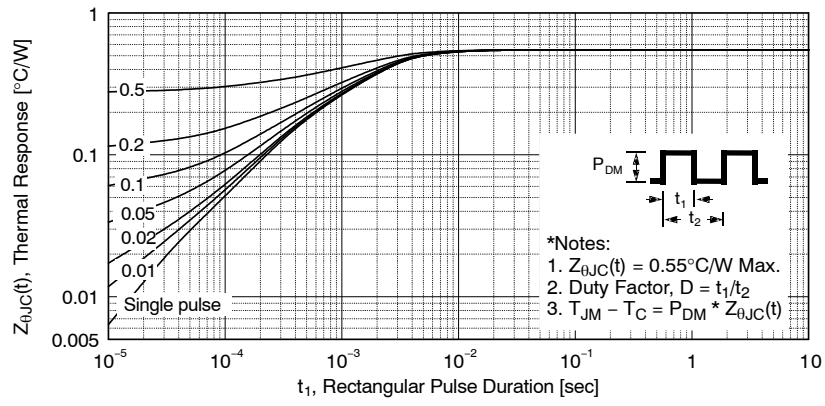


**Figure 12. Transient Thermal Response Curve**

*Notes:
1. $Z_{\theta JC}(t) = 0.55°C/W$ Max.
2. Duty Factor, $D = t_1/t_2$
3. $T_{JM} - T_C = P_{DM} * Z_{\theta JC}(t)$
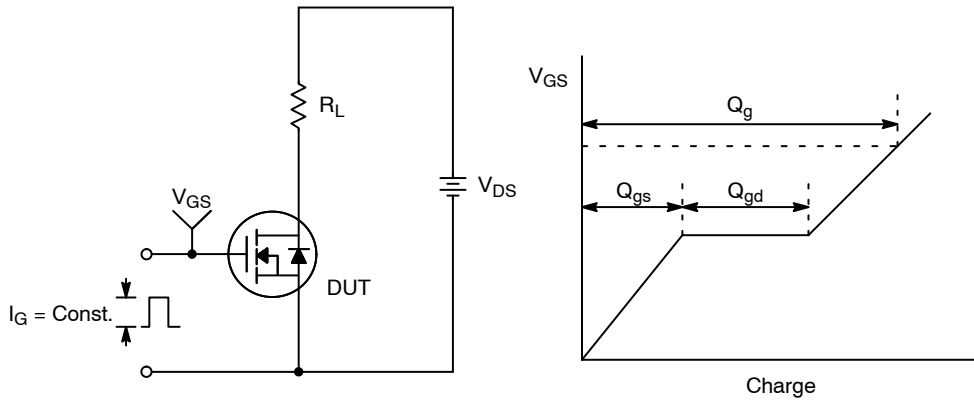
**FCH165N60E**



**Figure 13. Gate Charge Test Circuit & Waveform**
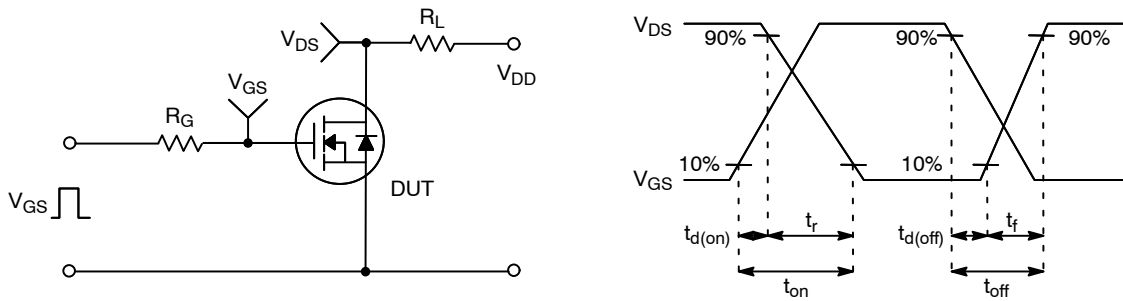


**Figure 14. Resistive Switching Test Circuit & Waveforms**



$$E_{AS} = \frac{1}{2} \cdot L I_{AS}{}^2$$
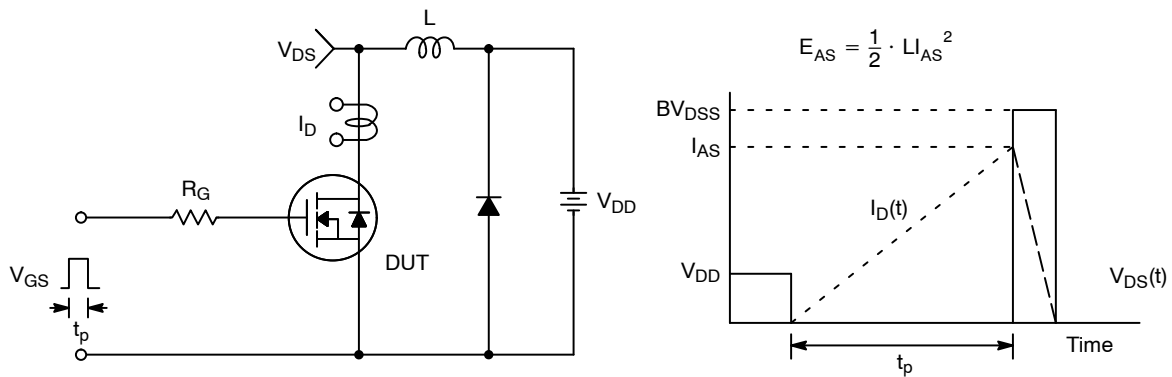
**Figure 15. Unclamped Inductive Switching Test Circuit & Waveforms**

$$D = \frac{\text{Gate Pulse Width}}{\text{Gate Pulse Period}}$$
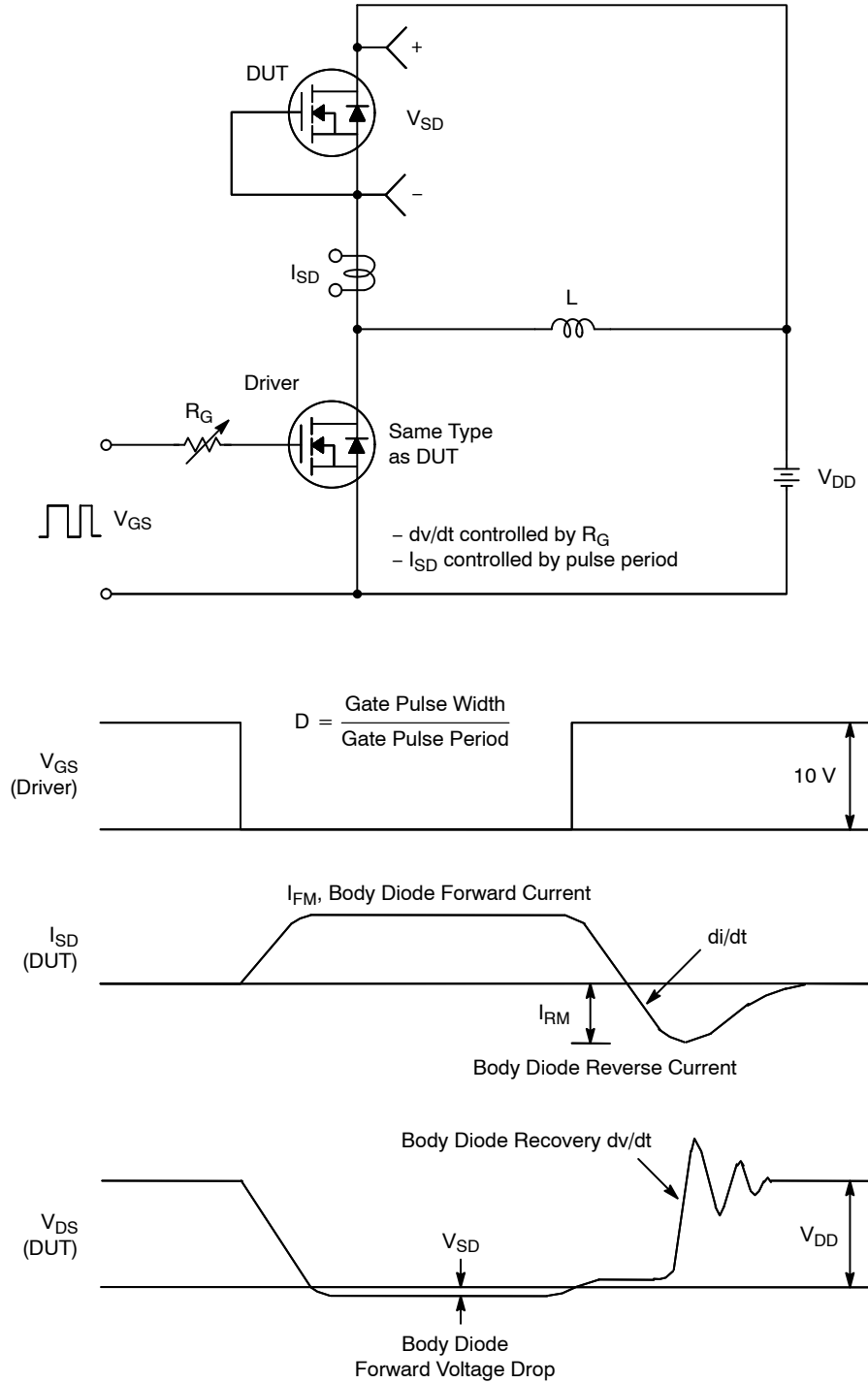
**Figure 16. Peak Diode Recovery dv/dt Test Circuit & Waveforms**

## TO−247−3LD SHORT LEAD
### CASE 340CK
### ISSUE A

DATE 31 JAN 2019



**(3X) b**

$\bigoplus$ 0.25 (M) B A (M)
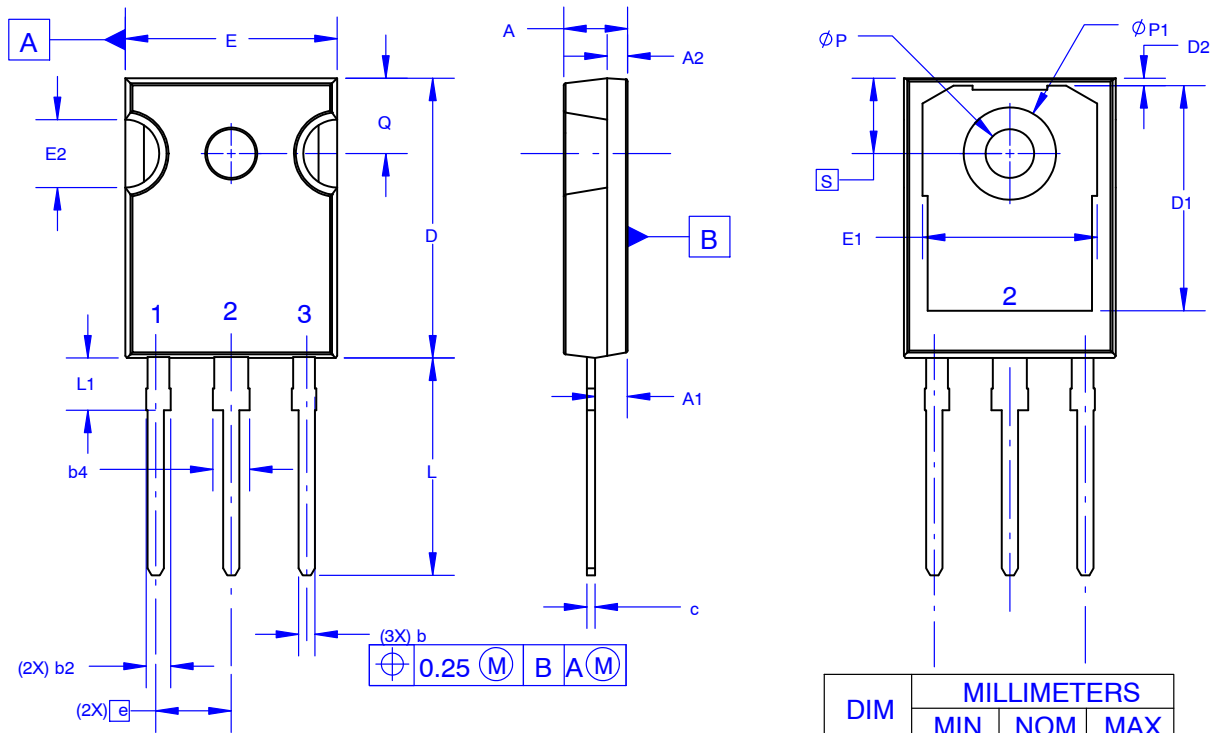
NOTES: UNLESS OTHERWISE SPECIFIED.

A. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD
   FLASH, AND TIE BAR EXTRUSIONS.
B. ALL DIMENSIONS ARE IN MILLIMETERS.
C. DRAWING CONFORMS TO ASME Y14.5 - 2009.
D. DIMENSION A1 TO BE MEASURED IN THE REGION DEFINED BY L1.
E. LEAD FINISH IS UNCONTROLLED IN THE REGION DEFINED BY L1.

### GENERIC MARKING DIAGRAM*

```
AYWWZZ
XXXXXXX
XXXXXXX
  ○
```
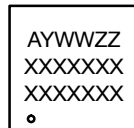
XXXX = Specific Device Code
A    = Assembly Location
Y    = Year
WW   = Work Week
ZZ   = Assembly Lot Code

*This information is generic. Please refer to
device data sheet for actual part marking.
Pb−Free indicator, "G" or microdot "▪", may
or may not be present. Some products may
not follow the Generic Marking.

| DIM | MILLIMETERS | | |
|-----|------|------|------|
|     | MIN | NOM | MAX |
| A | 4.58 | 4.70 | 4.82 |
| A1 | 2.20 | 2.40 | 2.60 |
| A2 | 1.40 | 1.50 | 1.60 |
| b | 1.17 | 1.26 | 1.35 |
| b2 | 1.53 | 1.65 | 1.77 |
| b4 | 2.42 | 2.54 | 2.66 |
| c | 0.51 | 0.61 | 0.71 |
| D | 20.32 | 20.57 | 20.82 |
| D1 | 13.08 | ~ | ~ |
| D2 | 0.51 | 0.93 | 1.35 |
| E | 15.37 | 15.62 | 15.87 |
| E1 | 12.81 | ~ | ~ |
| E2 | 4.96 | 5.08 | 5.20 |
| e | ~ | 5.56 | ~ |
| L | 15.75 | 16.00 | 16.25 |
| L1 | 3.69 | 3.81 | 3.93 |
| $\varnothing$P | 3.51 | 3.58 | 3.65 |
| $\varnothing$P1 | 6.60 | 6.80 | 7.00 |
| Q | 5.34 | 5.46 | 5.58 |
| S | 5.34 | 5.46 | 5.58 |

| DOCUMENT NUMBER: | 98AON13851G | |
|---|---|---|
| **DESCRIPTION:** | **TO−247−3LD SHORT LEAD** | **PAGE 1 OF 1** |

## ADDITIONAL INFORMATION

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