# THE DATASHEET OF

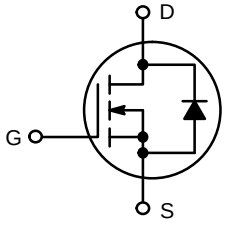
# NTPF250N65S3H

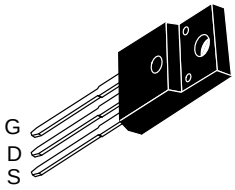
# MOSFET – Power, N-Channel, SUPERFET® III, FAST

## 650 V, 250 mΩ, 13 A

# NTPF250N65S3H

| $V_{DSS}$ | $R_{DS(ON)}$ MAX | $I_D$ MAX |
|---|---|---|
| 650 V | 250 mΩ @ 10 V | 13 A |




**TO−220 FULLPAK**
**CASE 221D**

### Description

SUPERFET III MOSFET is **onsemi**'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 advanced technology is tailored to minimize conduction loss, provides superior switching performance, and withstand extreme dv/dt rate.

Consequently, SUPERFET III FAST MOSFET series helps minimize various power systems and improve system efficiency.

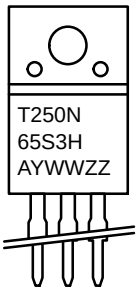
### Features

- 700 V @ $T_J$ = 150°C
- Typ. $R_{DS(on)}$ = 201 mΩ
- Ultra Low Gate Charge (Typ. $Q_g$ = 24 nC)
- Low Effective Output Capacitance (Typ. $C_{oss(eff.)}$ = 229 pF)
- 100% Avalanche Tested
- These Devices are Pb−Free and are RoHS Compliant

### Applications

- Computing / Display Power Supplies
- Telecom / Server Power Supplies
- Industrial Power Supplies
- Lighting / Charger / Adapter

### MARKING DIAGRAM




| | |
|---|---|
| T250N65S3H | = Specific Device Code |
| A | = Assembly Location |
| YWW | = Date Code (Year & Week) |
| ZZ | = Assembly Lot |

### ORDERING INFORMATION

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

**ABSOLUTE MAXIMUM RATINGS** ($T_C$ = 25°C, Unless otherwise specified)

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_{DSS}$ | Drain to Source Voltage | | 650 | V |
| $V_{GSS}$ | Gate to Source Voltage | DC | ±30 | V |
| | | AC (f > 1 Hz) | ±30 | V |
| $I_D$ | Drain Current | Continuous ($T_C$ = 25°C) | 13* | A |
| | | Continuous ($T_C$ = 100°C) | 8* | |
| $I_{DM}$ | Drain Current | Pulsed (Note 1) | 36* | A |
| $E_{AS}$ | Single Pulsed Avalanche Energy (Note 2) | | 108 | mJ |
| $I_{AS}$ | Avalanche Current (Note 2) | | 2.9 | A |
| $E_{AR}$ | Repetitive Avalanche Energy (Note 1) | | 1.06 | mJ |
| dv/dt | MOSFET dv/dt | | 120 | V/ns |
| | Peak Diode Recovery dv/dt (Note 3) | | 20 | |
| $P_D$ | Power Dissipation | ($T_C$ = 25°C) | 29 | W |
| | | Derate Above 25°C | 0.23 | 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 s | | 260 | °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.
*Drain current limited by maximum junction temperature.
1. Repetitive rating: pulse-width limited by maximum junction temperature.
2. $I_{AS}$ = 2.9 A, $R_G$ = 25 Ω, starting $T_J$ = 25°C.
3. $I_{SD}$ ≤ 6.5 A, di/dt ≤ 200 A/μs, $V_{DD}$ ≤ 400 V, starting $T_J$ = 25°C.

**THERMAL CHARACTERISTICS**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case, Max. | 4.23 | °C/W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient, Max. | 62.5 | |

**PACKAGE MARKING AND ORDERING INFORMATION**

| Part Number | Top Marking | Package | Shipping |
|---|---|---|---|
| NTPF250N65S3H | T250N65S3H | TO−220 FULLPAK | 1000 Units / Tube |

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

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | | |
| $BV_{DSS}$ | Drain to Source Breakdown Voltage | $V_{GS}$ = 0 V, $I_D$ = 1 mA, $T_J$ = 25°C | 650 | | | V |
| | | $V_{GS}$ = 0 V, $I_D$ = 1 mA, $T_J$ = 150°C | 700 | | | V |
| $\Delta BV_{DSS}/\Delta T_J$ | Breakdown Voltage Temperature Coefficient | $I_D$ = 10 mA, Referenced to 25°C | | 0.63 | | V/°C |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 650 V, $V_{GS}$ = 0 V | | | 1 | μA |
| | | $V_{DS}$ = 520 V, $T_C$ = 125°C | | 0.7 | | |
| $I_{GSS}$ | Gate to Body Leakage Current | $V_{GS}$ = ±30 V, $V_{DS}$ = 0 V | | | ±100 | nA |
| **ON CHARACTERISTICS** | | | | | | |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{GS}$ = $V_{DS}$, $I_D$ = 1.1 mA | 2.4 | | 4.0 | V |
| $R_{DS(on)}$ | Static Drain to Source On Resistance | $V_{GS}$ = 10 V, $I_D$ = 6.5 A | | 201 | 250 | mΩ |
| $g_{FS}$ | Forward Transconductance | $V_{DS}$ = 20 V, $I_D$ = 6.5 A | | 14 | | S |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{DS}$ = 400 V, $V_{GS}$ = 0 V, f = 250 kHz | | 1261 | | pF |
| $C_{oss}$ | Output Capacitance | | | 19 | | pF |
| $C_{oss(eff.)}$ | Effective Output Capacitance | $V_{DS}$ = 0 V to 400 V, $V_{GS}$ = 0 V | | 229 | | pF |
| $C_{oss(er.)}$ | Energy Related Output Capacitance | $V_{DS}$ = 0 V to 400 V, $V_{GS}$ = 0 V | | 33 | | pF |
| $Q_{g(tot)}$ | Total Gate Charge at 10 V | $V_{DS}$ = 400 V, $I_D$ = 6.5 A, $V_{GS}$ = 10 V (Note 4) | | 24 | | nC |
| $Q_{gs}$ | Gate to Source Gate Charge | | | 5.9 | | nC |
| $Q_{gd}$ | Gate to Drain “Miller” Charge | | | 6.8 | | nC |
| ESR | Equivalent Series Resistance | f = 1 MHz | | 0.9 | | Ω |
| **SWITCHING CHARACTERISTICS** | | | | | | |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{DD}$ = 400 V, $I_D$ = 6.5 A, $V_{GS}$ = 10 V, $R_g$ = 12 Ω (Note 4) | | 18 | | ns |
| $t_r$ | Turn-On Rise Time | | | 8.2 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 54 | | ns |
| $t_f$ | Turn-Off Fall Time | | | 4.2 | | ns |
| **SOURCE-DRAIN DIODE CHARACTERISTICS** | | | | | | |
| $I_S$ | Maximum Continuous Source to Drain Diode Forward Current | | | | 13 | A |
| $I_{SM}$ | Maximum Pulsed Source to Drain Diode Forward Current | | | | 36 | A |
| $V_{SD}$ | Source to Drain Diode Forward Voltage | $V_{GS}$ = 0 V, $I_{SD}$ = 6.5 A | | | 1.2 | V |
| $t_{rr}$ | Reverse Recovery Time | $V_{DD}$ = 400 V, $I_{SD}$ = 6.5 A, $dI_F/dt$ = 100 A/μs | | 233 | | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | | 2.5 | | 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 typical characteristics.

## TYPICAL CHARACTERISTICS

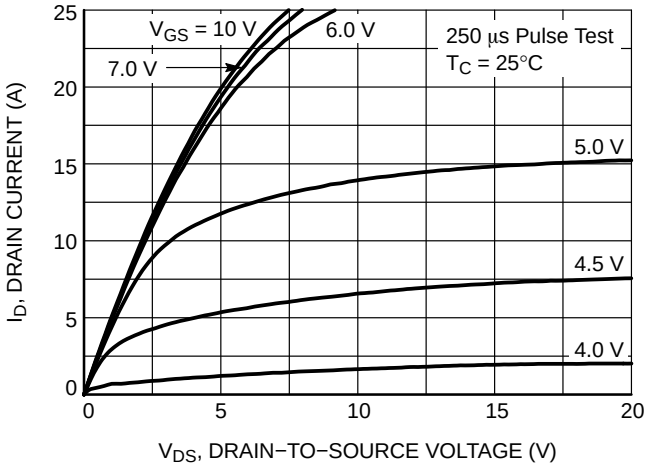



**Figure 1. On−Region Characteristics**

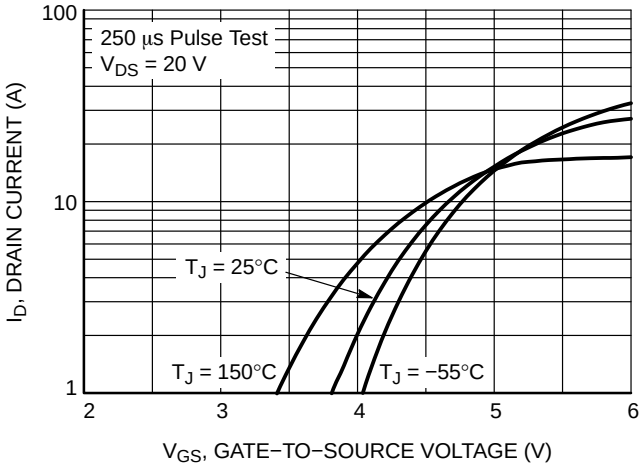



**Figure 2. Transfer Characteristics**

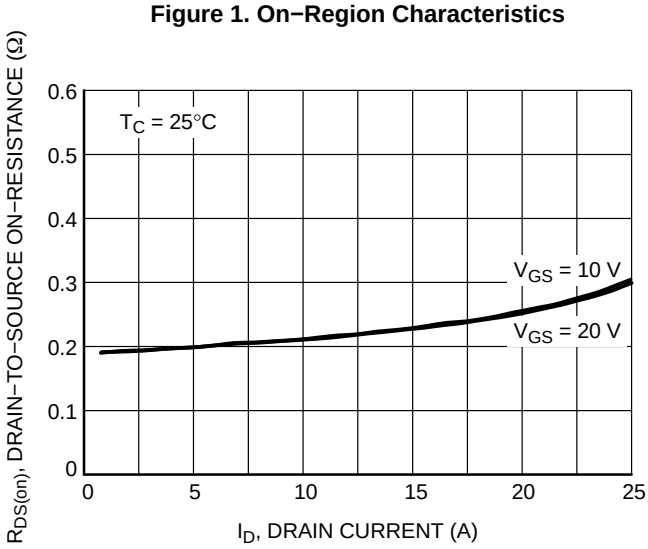



**Figure 3. On Resistance Variation vs. Drain Current and Gate Voltage**

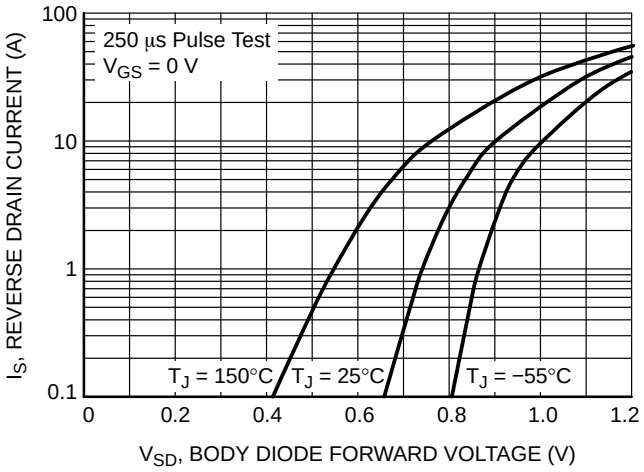



**Figure 4. Diode Forward Voltage Variation vs. Source Current and Temperature**

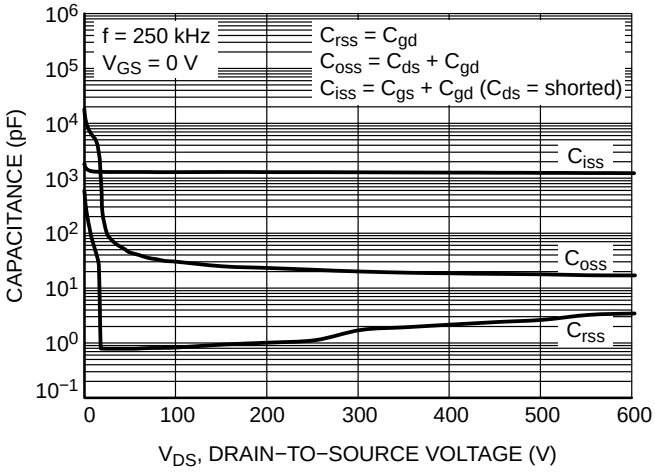



**Figure 5. Capacitance Characteristics**

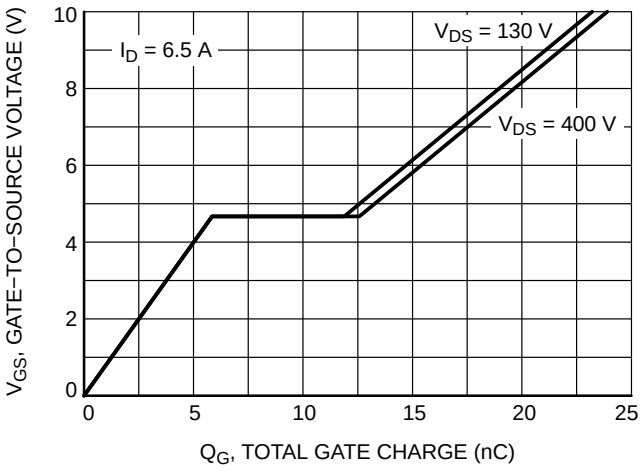



**Figure 6. Gate Charge Characteristics**

## TYPICAL CHARACTERISTICS

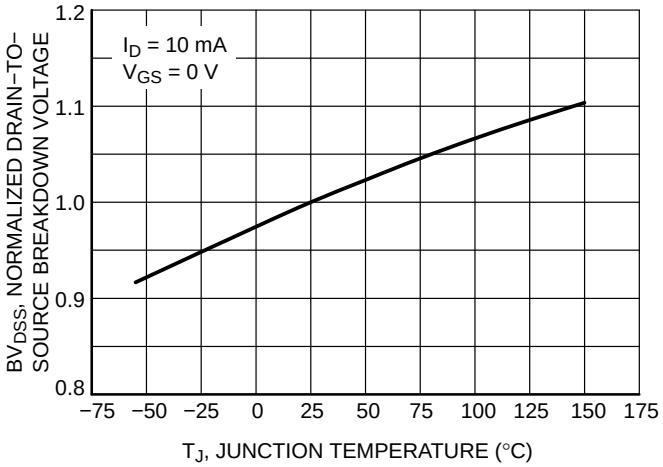



**Figure 7. Breakdown Voltage Variation vs. Temperature**

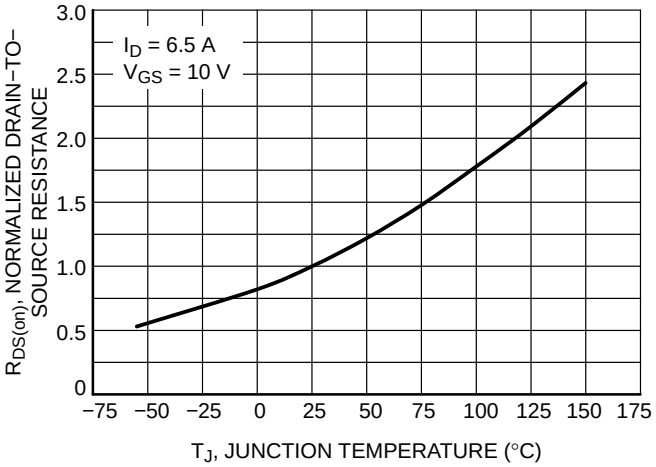



**Figure 8. On−Resistance Variation vs. Temperature**

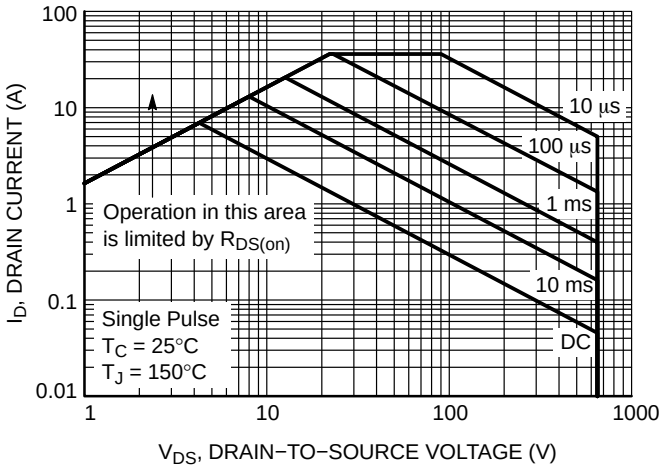



**Figure 9. Maximum Safe Operating Area**

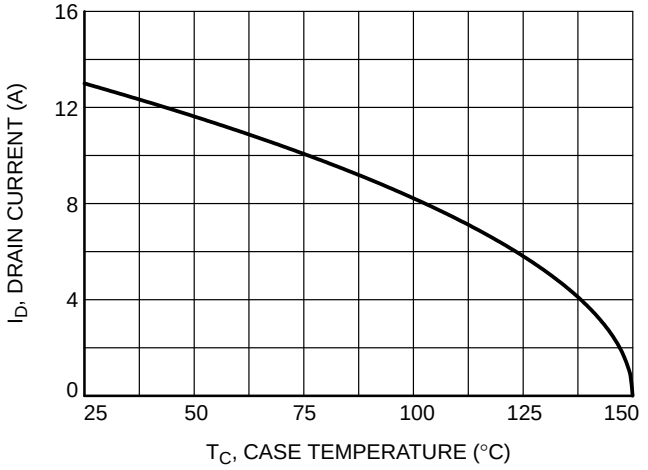



**Figure 10. Maximum Drain Current vs. Case Temperature**

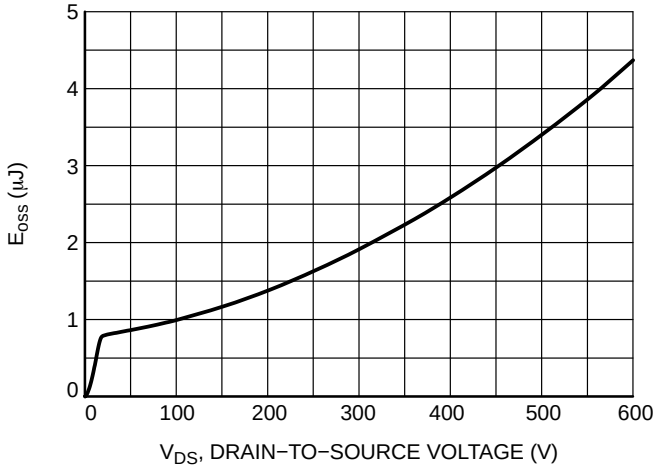



**Figure 11. $E_{oss}$ vs. Drain−to−Source Voltage**

## TYPICAL CHARACTERISTICS

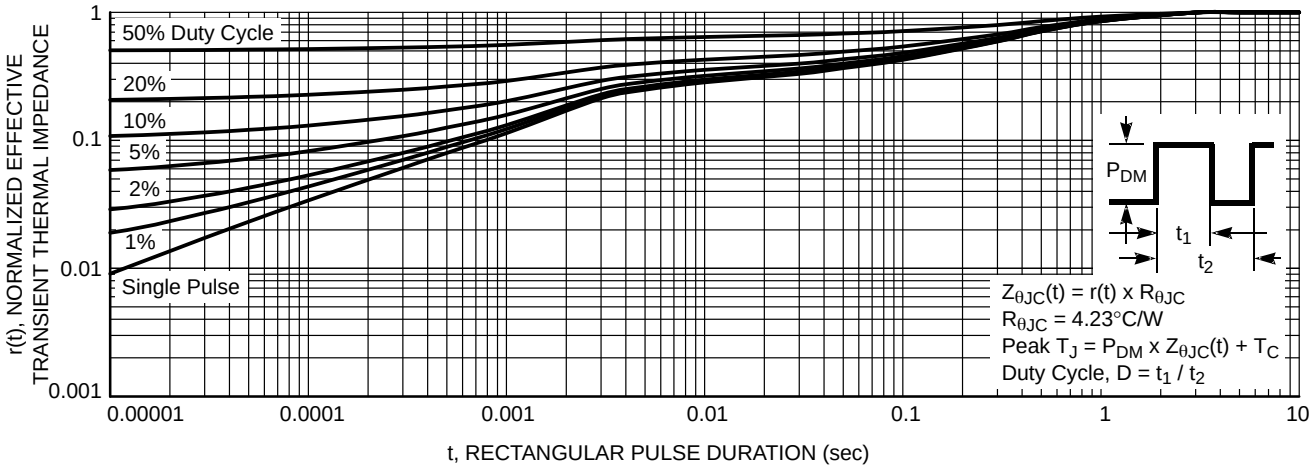



**Figure 12. Transient Thermal Response Curve**

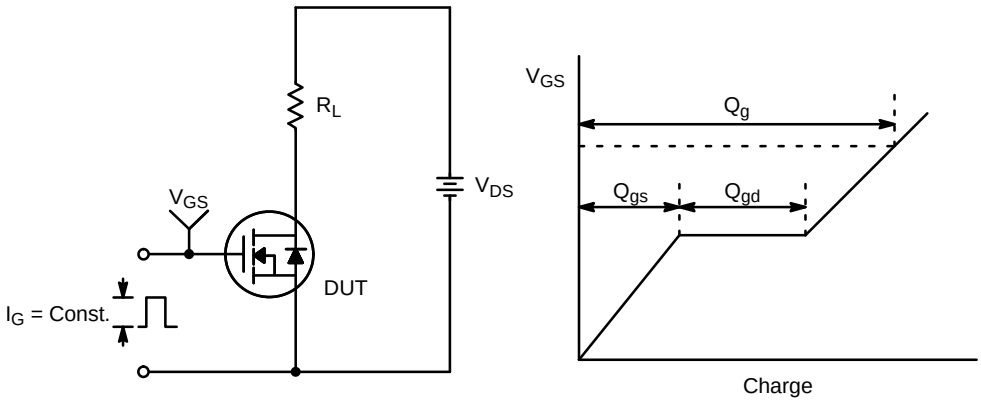



**Figure 13. Gate Charge Test Circuit & Waveform**

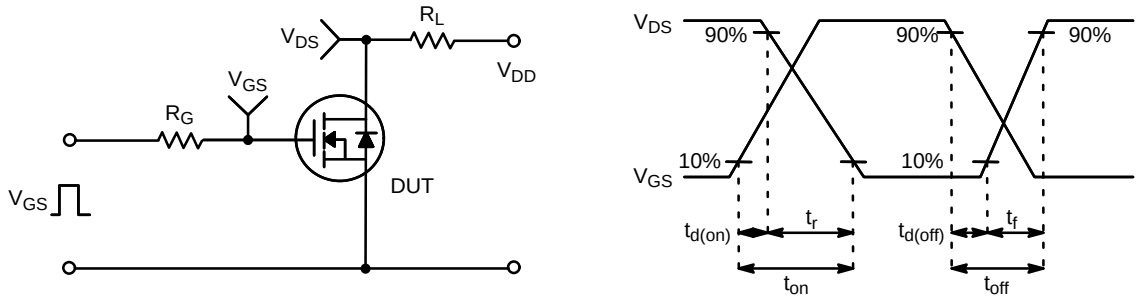



**Figure 14. Resistive Switching Test Circuit & Waveforms**

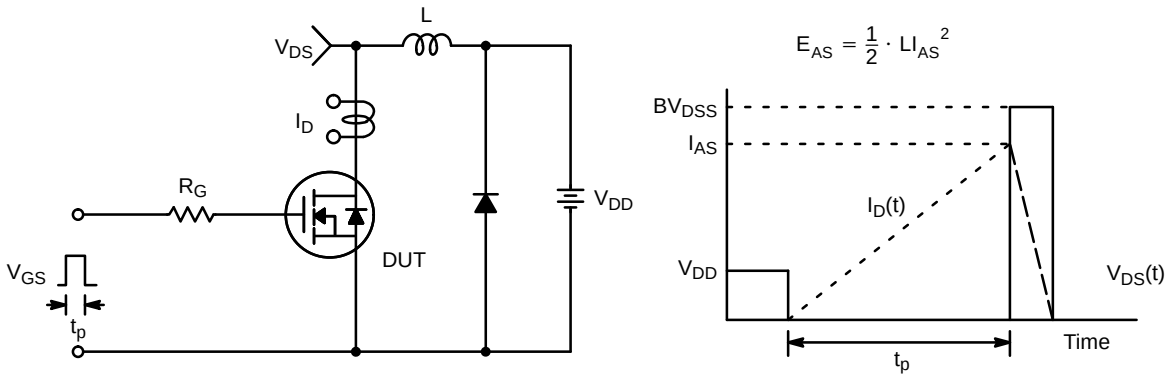



**Figure 15. Unclamped Inductive Switching Test Circuit & Waveforms**

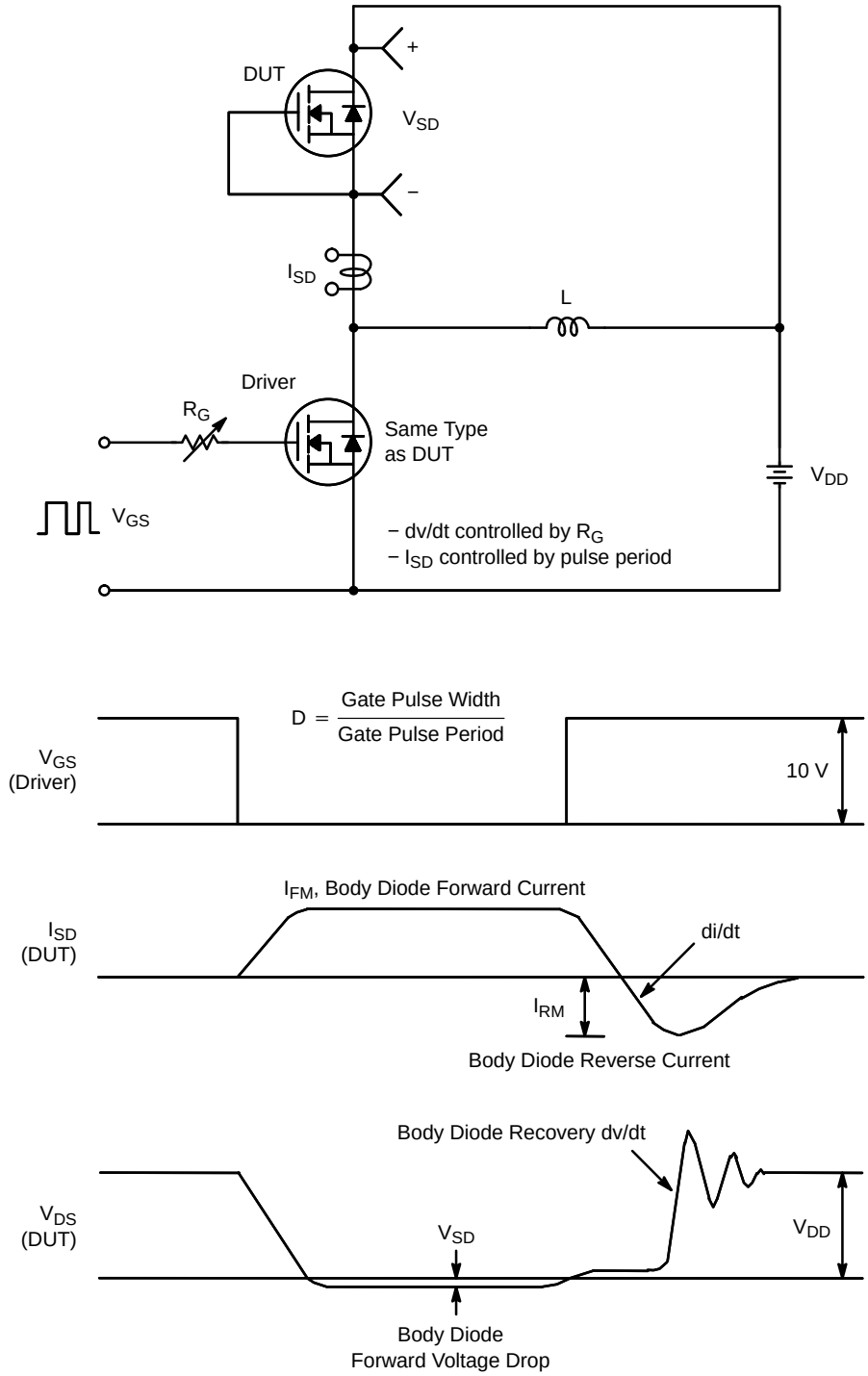


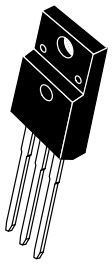

**Figure 16. Peak Diode Recovery dv/dt Test Circuit & Waveforms**

# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS

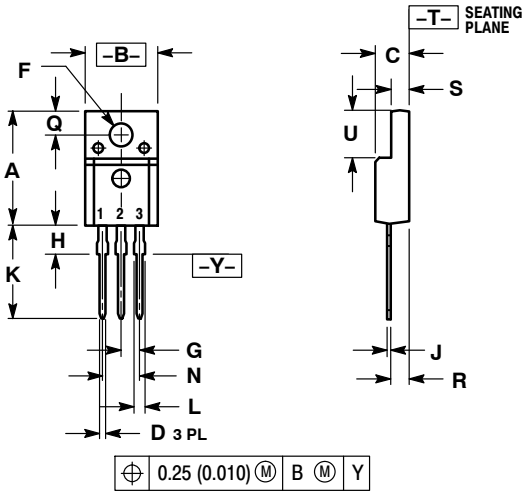
ON Semiconductor®

**TO−220 FULLPAK**
CASE 221D−03
ISSUE K

DATE 27 FEB 2009



SCALE 1:1




NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH
3. 221D−01 THRU 221D−02 OBSOLETE, NEW STANDARD 221D−03.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.617 | 0.635 | 15.67 | 16.12 |
| B | 0.392 | 0.419 | 9.96 | 10.63 |
| C | 0.177 | 0.193 | 4.50 | 4.90 |
| D | 0.024 | 0.039 | 0.60 | 1.00 |
| F | 0.116 | 0.129 | 2.95 | 3.28 |
| G | 0.100 BSC | | 2.54 BSC | |
| H | 0.118 | 0.135 | 3.00 | 3.43 |
| J | 0.018 | 0.025 | 0.45 | 0.63 |
| K | 0.503 | 0.541 | 12.78 | 13.73 |
| L | 0.048 | 0.058 | 1.23 | 1.47 |
| N | 0.200 BSC | | 5.08 BSC | |
| Q | 0.122 | 0.138 | 3.10 | 3.50 |
| R | 0.099 | 0.117 | 2.51 | 2.96 |
| S | 0.092 | 0.113 | 2.34 | 2.87 |
| U | 0.239 | 0.271 | 6.06 | 6.88 |

STYLE 1:
PIN 1. GATE
2. DRAIN
3. SOURCE

STYLE 2:
PIN 1. BASE
2. COLLECTOR
3. EMITTER

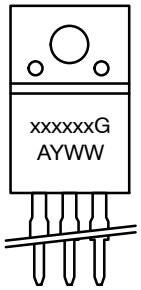
STYLE 3:
PIN 1. ANODE
2. CATHODE
3. ANODE

STYLE 4:
PIN 1. CATHODE
2. ANODE
3. CATHODE

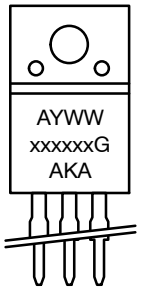
STYLE 5:
PIN 1. CATHODE
2. ANODE
3. GATE

STYLE 6:
PIN 1. MT 1
2. MT 2
3. GATE

### MARKING DIAGRAMS




**Bipolar**




**Rectifier**

| | |
|---|---|
| xxxxxx | = Specific Device Code |
| G | = Pb−Free Package |
| A | = Assembly Location |
| Y | = Year |
| WW | = Work Week |

| | |
|---|---|
| A | = Assembly Location |
| Y | = Year |
| WW | = Work Week |
| xxxxxx | = Device Code |
| G | = Pb−Free Package |
| AKA | = Polarity Designator |

| | | |
|---|---|---|
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| **DESCRIPTION:** | **TO−220 FULLPAK** | **PAGE 1 OF 1** |

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