

# MOSFET – Power, N-Channel, SUPERFET<sup>®</sup> III, FAST

**650 V, 165 mΩ, 19 A**

**NTPF165N65S3H**

## 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 MOSFET FAST series helps minimize various power systems and improve system efficiency.

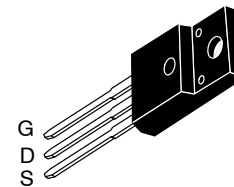
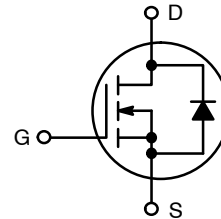
## Features

- 700 V @  $T_J = 150^{\circ}\text{C}$
- Typ.  $R_{DS(on)} = 132\text{ m}\Omega$
- Ultra Low Gate Charge (Typ.  $Q_g = 35\text{ nC}$ )
- Low Effective Output Capacitance (Typ.  $C_{oss(eff.)} = 326\text{ pF}$ )
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

## Applications

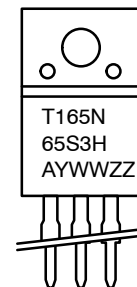
- Computing / Display Power Supplies
- Telecom / Server Power Supplies
- Industrial Power Supplies
- Lighting / Charger / Adapter

| $V_{DSS}$ | $R_{DS(on)}\text{ MAX}$ | $I_D\text{ MAX}$ |
|-----------|-------------------------|------------------|
| 650 V     | 165 mΩ @ 10 V           | 19 A             |



**TO-220 FULLPAK  
CASE 221D**

## MARKING DIAGRAM



T165N65S3H = 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.

# NTPF165N65S3H

## ABSOLUTE MAXIMUM RATINGS (T<sub>C</sub> = 25°C, Unless otherwise specified)

| Symbol                            | Parameter                                                      |                                     | Value       | Unit |
|-----------------------------------|----------------------------------------------------------------|-------------------------------------|-------------|------|
| V <sub>DSS</sub>                  | Drain to Source Voltage                                        |                                     | 650         | V    |
| V <sub>GSS</sub>                  | Gate to Source Voltage                                         | DC                                  | ±30         | V    |
|                                   |                                                                | AC (f > 1 Hz)                       | ±30         | V    |
| I <sub>D</sub>                    | Drain Current                                                  | Continuous (T <sub>C</sub> = 25°C)  | 19*         | A    |
|                                   |                                                                | Continuous (T <sub>C</sub> = 100°C) | 12*         |      |
| I <sub>DM</sub>                   | Drain Current                                                  | Pulsed (Note 1)                     | 53*         | A    |
| E <sub>AS</sub>                   | Single Pulsed Avalanche Energy (Note 2)                        |                                     | 163         | mJ   |
| I <sub>AS</sub>                   | Avalanche Current (Note 2)                                     |                                     | 4           | A    |
| E <sub>AR</sub>                   | Repetitive Avalanche Energy (Note 1)                           |                                     | 1.42        | mJ   |
| dv/dt                             | MOSFET dv/dt                                                   |                                     | 120         | V/ns |
|                                   | Peak Diode Recovery dv/dt (Note 3)                             |                                     | 20          |      |
| P <sub>D</sub>                    | Power Dissipation                                              | (T <sub>C</sub> = 25°C)             | 33          | W    |
|                                   |                                                                | Derate Above 25°C                   | 0.27        | W/°C |
| T <sub>J</sub> , T <sub>STG</sub> | Operating and Storage Temperature Range                        |                                     | –55 to +150 | °C   |
| T <sub>L</sub>                    | 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<sub>AS</sub> = 4 A, R<sub>G</sub> = 25 Ω, starting T<sub>J</sub> = 25°C.

3. I<sub>SD</sub> ≤ 9.5 A, di/dt ≤ 200 A/μs, V<sub>DD</sub> ≤ 400 V, starting T<sub>J</sub> = 25°C.

## THERMAL CHARACTERISTICS

| Symbol           | Parameter                                     | Value | Unit |
|------------------|-----------------------------------------------|-------|------|
| R <sub>θJC</sub> | Thermal Resistance, Junction to Case, Max.    | 3.69  | °C/W |
| R <sub>θJA</sub> | Thermal Resistance, Junction to Ambient, Max. | 62.5  |      |

## PACKAGE MARKING AND ORDERING INFORMATION

| Part Number   | Top Marking | Package           | Shipping          |
|---------------|-------------|-------------------|-------------------|
| NTPF165N65S3H | T165N65S3H  | TO-220<br>FULLPAK | 1000 Units / Tube |

# NTPF165N65S3H

## ELECTRICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ unless otherwise noted)

| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|--------|-----------|-----------------|-----|-----|-----|------|
|--------|-----------|-----------------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|                                     |                                           |                                                                      |     |      |      |      |
|-------------------------------------|-------------------------------------------|----------------------------------------------------------------------|-----|------|------|------|
| BV <sub>DSS</sub>                   | Drain to Source Breakdown Voltage         | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 25°C  | 650 |      |      | V    |
|                                     |                                           | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 150°C | 700 |      |      | V    |
| ΔBV <sub>DSS</sub> /ΔT <sub>J</sub> | Breakdown Voltage Temperature Coefficient | I <sub>D</sub> = 10 mA, Referenced to 25°C                           |     | 0.63 |      | V/°C |
| I <sub>DSS</sub>                    | Zero Gate Voltage Drain Current           | V <sub>DS</sub> = 650 V, V <sub>GS</sub> = 0 V                       |     |      | 1    | μA   |
|                                     |                                           | V <sub>DS</sub> = 520 V, T <sub>C</sub> = 125°C                      |     | 1.0  |      |      |
| I <sub>GSS</sub>                    | Gate to Body Leakage Current              | V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V                       |     |      | ±100 | nA   |

### ON CHARACTERISTICS

|                     |                                      |                                                             |     |     |     |    |
|---------------------|--------------------------------------|-------------------------------------------------------------|-----|-----|-----|----|
| V <sub>GS(th)</sub> | Gate Threshold Voltage               | V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 1.6 mA | 2.4 |     | 4.0 | V  |
| R <sub>DS(on)</sub> | Static Drain to Source On Resistance | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 9.5 A              |     | 132 | 165 | mΩ |
| g <sub>FS</sub>     | Forward Transconductance             | V <sub>DS</sub> = 20 V, I <sub>D</sub> = 9.5 A              |     | 24  |     | S  |

### DYNAMIC CHARACTERISTICS

|                        |                                   |                                                                                     |  |      |  |    |
|------------------------|-----------------------------------|-------------------------------------------------------------------------------------|--|------|--|----|
| C <sub>iss</sub>       | Input Capacitance                 | V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V, f = 250 kHz                         |  | 1808 |  | pF |
| C <sub>oss</sub>       | Output Capacitance                |                                                                                     |  | 27   |  | pF |
| C <sub>oss(eff.)</sub> | Effective Output Capacitance      | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                               |  | 326  |  | pF |
| C <sub>oss(er.)</sub>  | Energy Related Output Capacitance | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                               |  | 47   |  | pF |
| Q <sub>g(tot)</sub>    | Total Gate Charge at 10 V         | V <sub>DS</sub> = 400 V, I <sub>D</sub> = 9.5 A, V <sub>GS</sub> = 10 V<br>(Note 4) |  | 35   |  | nC |
| Q <sub>gs</sub>        | Gate to Source Gate Charge        |                                                                                     |  | 8.4  |  | nC |
| Q <sub>gd</sub>        | Gate to Drain "Miller" Charge     |                                                                                     |  | 9.2  |  | nC |
| ESR                    | Equivalent Series Resistance      | f = 1 MHz                                                                           |  | 1.1  |  | Ω  |

### SWITCHING CHARACTERISTICS

|                     |                     |                                                                                                               |  |     |  |    |
|---------------------|---------------------|---------------------------------------------------------------------------------------------------------------|--|-----|--|----|
| t <sub>d(on)</sub>  | Turn-On Delay Time  | V <sub>DD</sub> = 400 V, I <sub>D</sub> = 9.5 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 10 Ω<br>(Note 4) |  | 20  |  | ns |
| t <sub>r</sub>      | Turn-On Rise Time   |                                                                                                               |  | 8.5 |  | ns |
| t <sub>d(off)</sub> | Turn-Off Delay Time |                                                                                                               |  | 68  |  | ns |
| t <sub>f</sub>      | Turn-Off Fall Time  |                                                                                                               |  | 3   |  | ns |

### SOURCE-DRAIN DIODE CHARACTERISTICS

|                 |                                                          |                                                                                     |  |     |    |
|-----------------|----------------------------------------------------------|-------------------------------------------------------------------------------------|--|-----|----|
| I <sub>S</sub>  | Maximum Continuous Source to Drain Diode Forward Current |                                                                                     |  | 19  | A  |
| I <sub>SM</sub> | Maximum Pulsed Source to Drain Diode Forward Current     |                                                                                     |  | 53  | A  |
| V <sub>SD</sub> | Source to Drain Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 9.5 A                                      |  | 1.2 | V  |
| t <sub>rr</sub> | Reverse Recovery Time                                    | V <sub>DD</sub> = 400 V, I <sub>SD</sub> = 9.5 A,<br>dI <sub>F</sub> /dt = 100 A/μs |  | 264 | ns |
| Q <sub>rr</sub> | Reverse Recovery Charge                                  |                                                                                     |  | 3.6 | 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 ( $T_C = 25^\circ\text{C}$  unless otherwise noted)

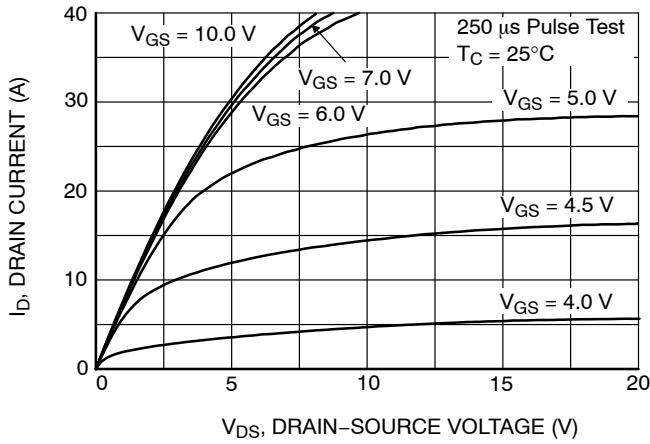


Figure 1. On-Region Characteristics

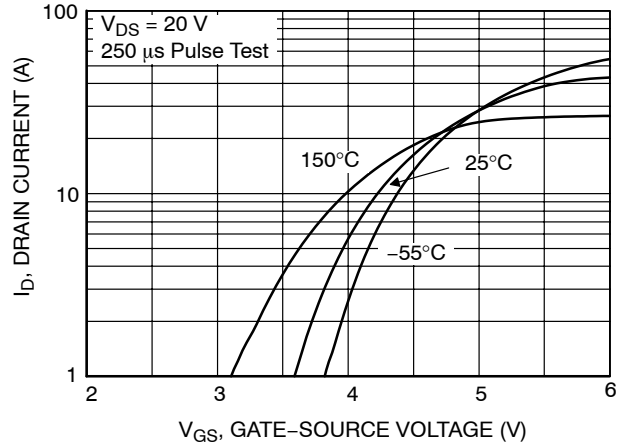


Figure 2. Transfer Characteristics

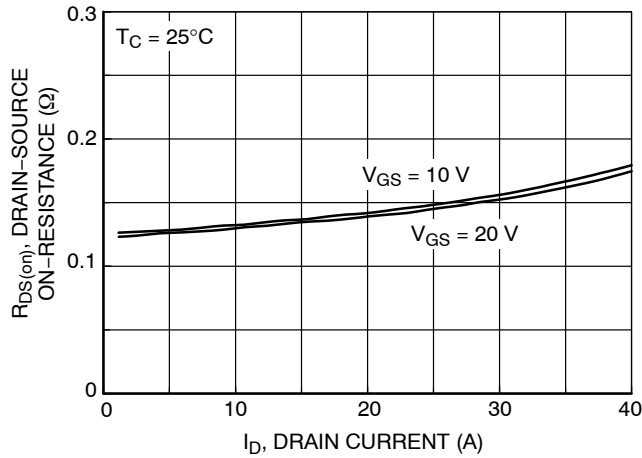


Figure 3. On-Resistance Variation vs. Drain Current and Gate Voltage

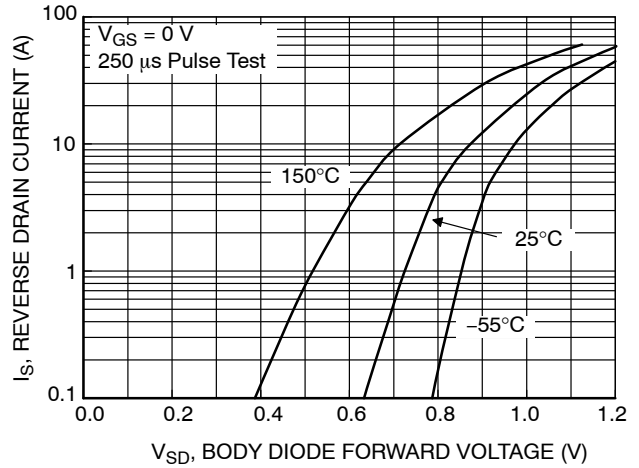


Figure 4. Body Diode Forward Voltage Variation vs. Source Current and Temperature

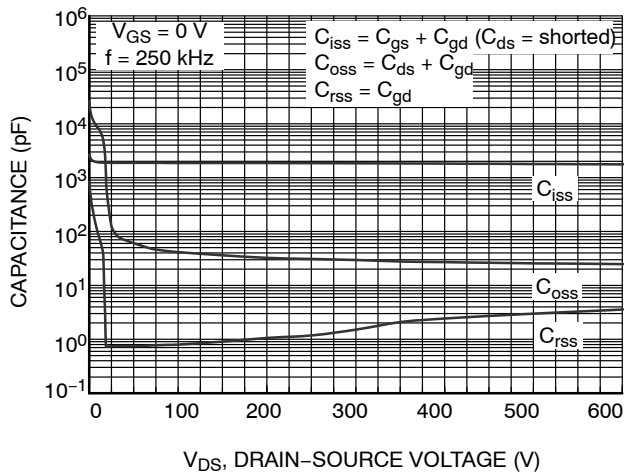


Figure 5. Capacitance Characteristics

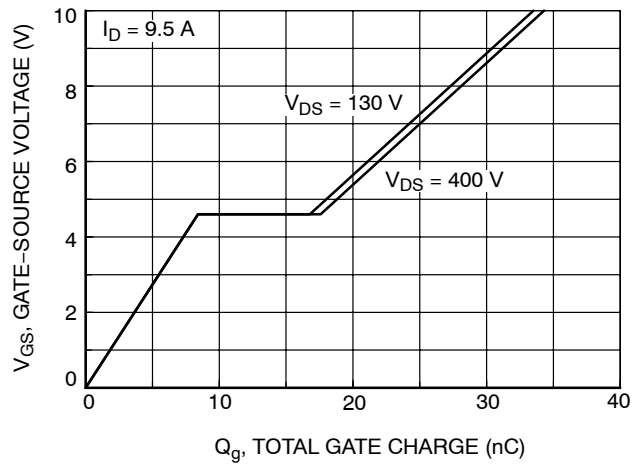


Figure 6. Gate Charge Characteristics

TYPICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$  unless otherwise noted) (continued)

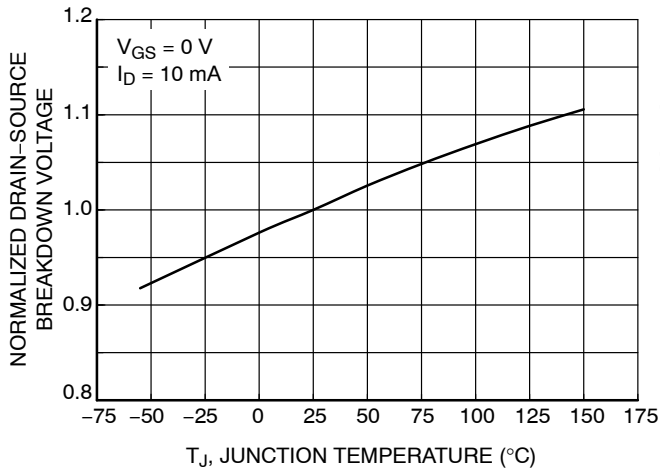


Figure 7. Breakdown Voltage Variation vs. Temperature

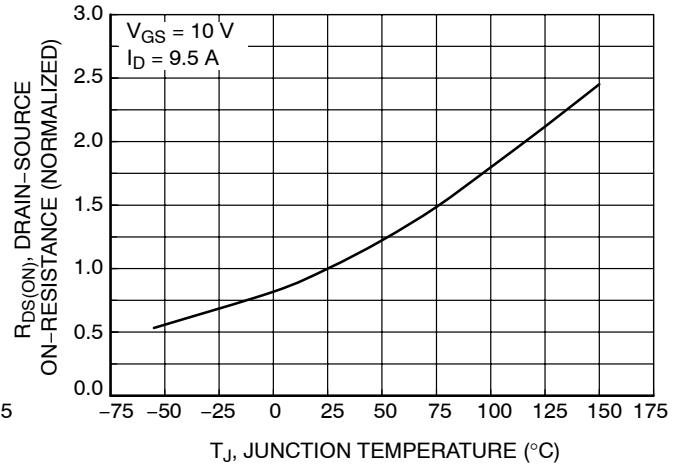


Figure 8. On-Resistance Variation vs. Temperature

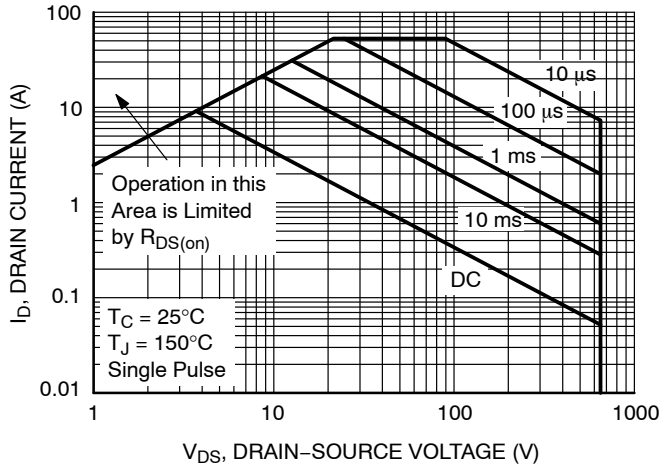


Figure 9. Maximum Safe Operating Area

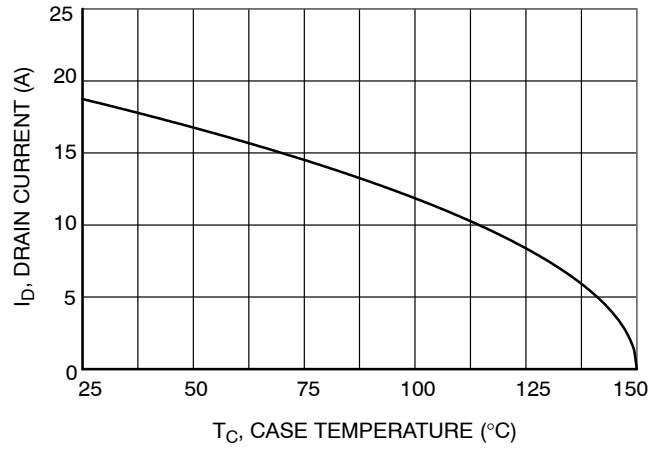


Figure 10. Maximum Drain Current vs. Case Temperature

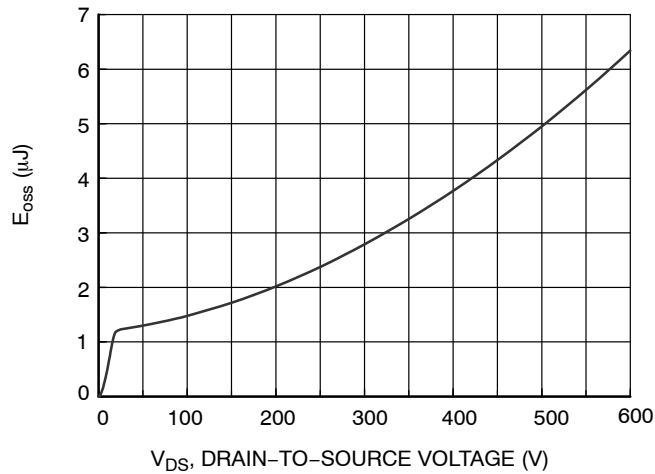


Figure 11.  $E_{OSS}$  vs. Drain to Source Voltage

# NTPF165N65S3H

## TYPICAL CHARACTERISTICS ( $T_C = 25^\circ\text{C}$ unless otherwise noted) (continued)

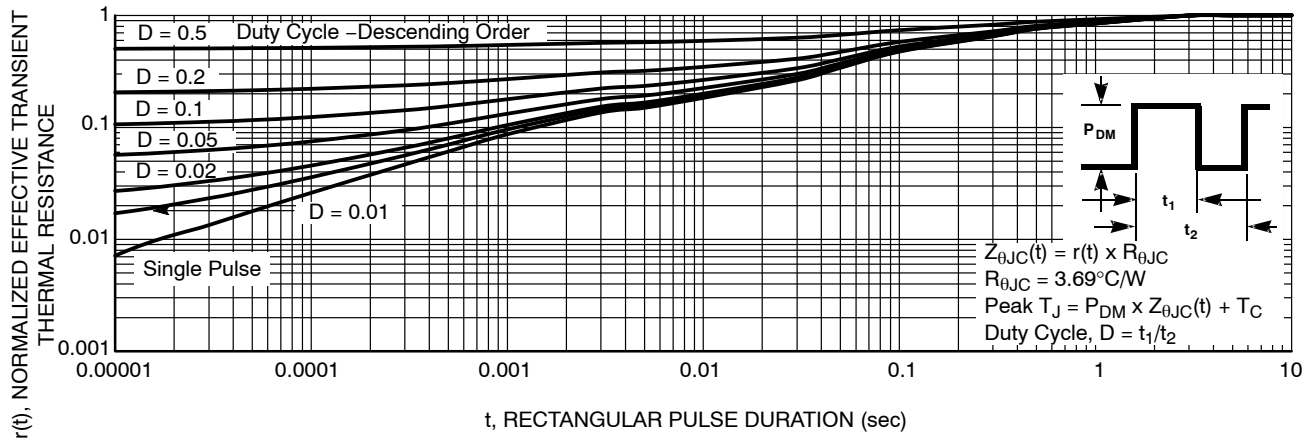


Figure 12. Transient Thermal Response Curve

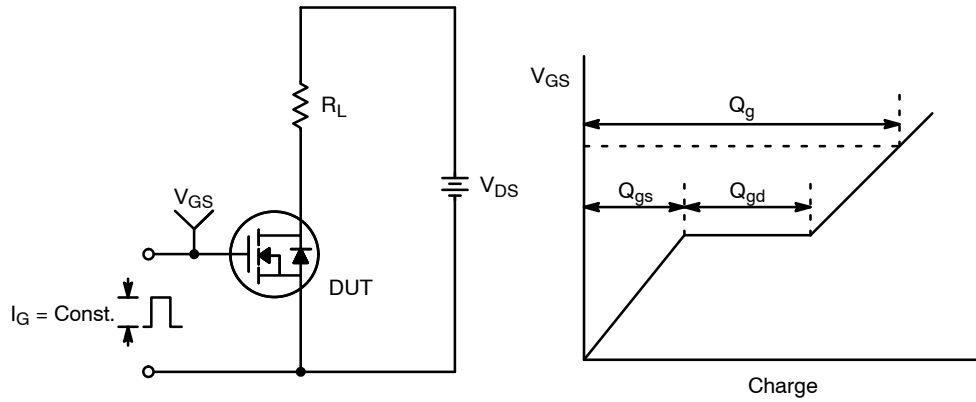


Figure 13. Gate Charge Test Circuit & Waveform

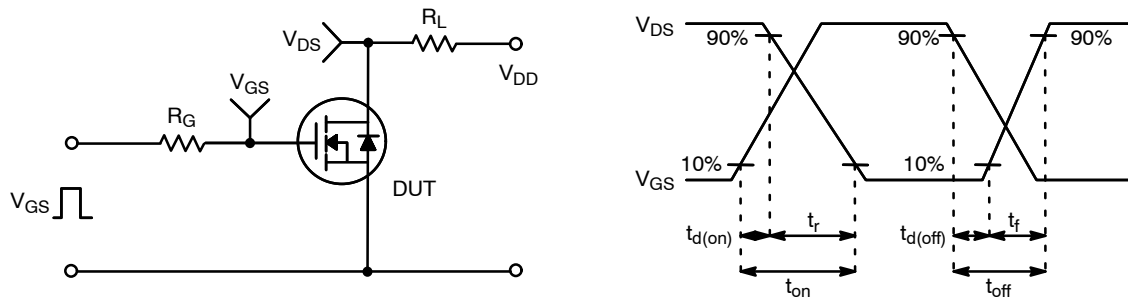


Figure 14. Resistive Switching Test Circuit & Waveforms

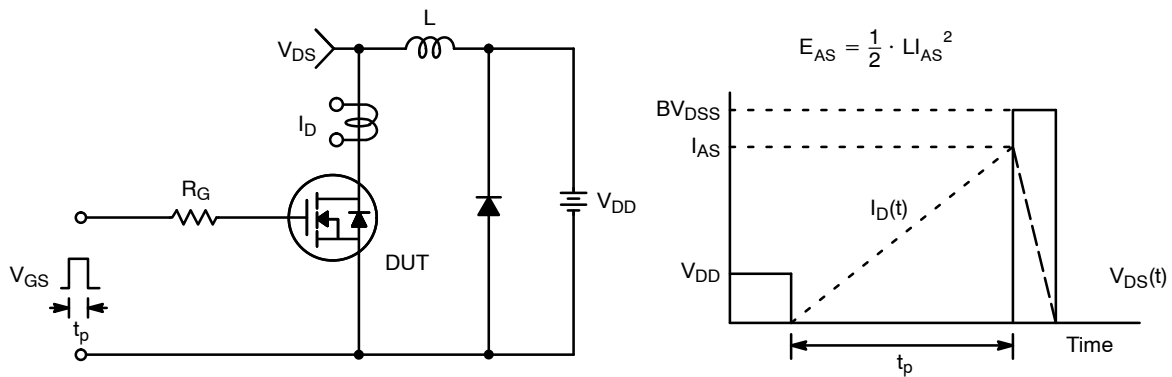
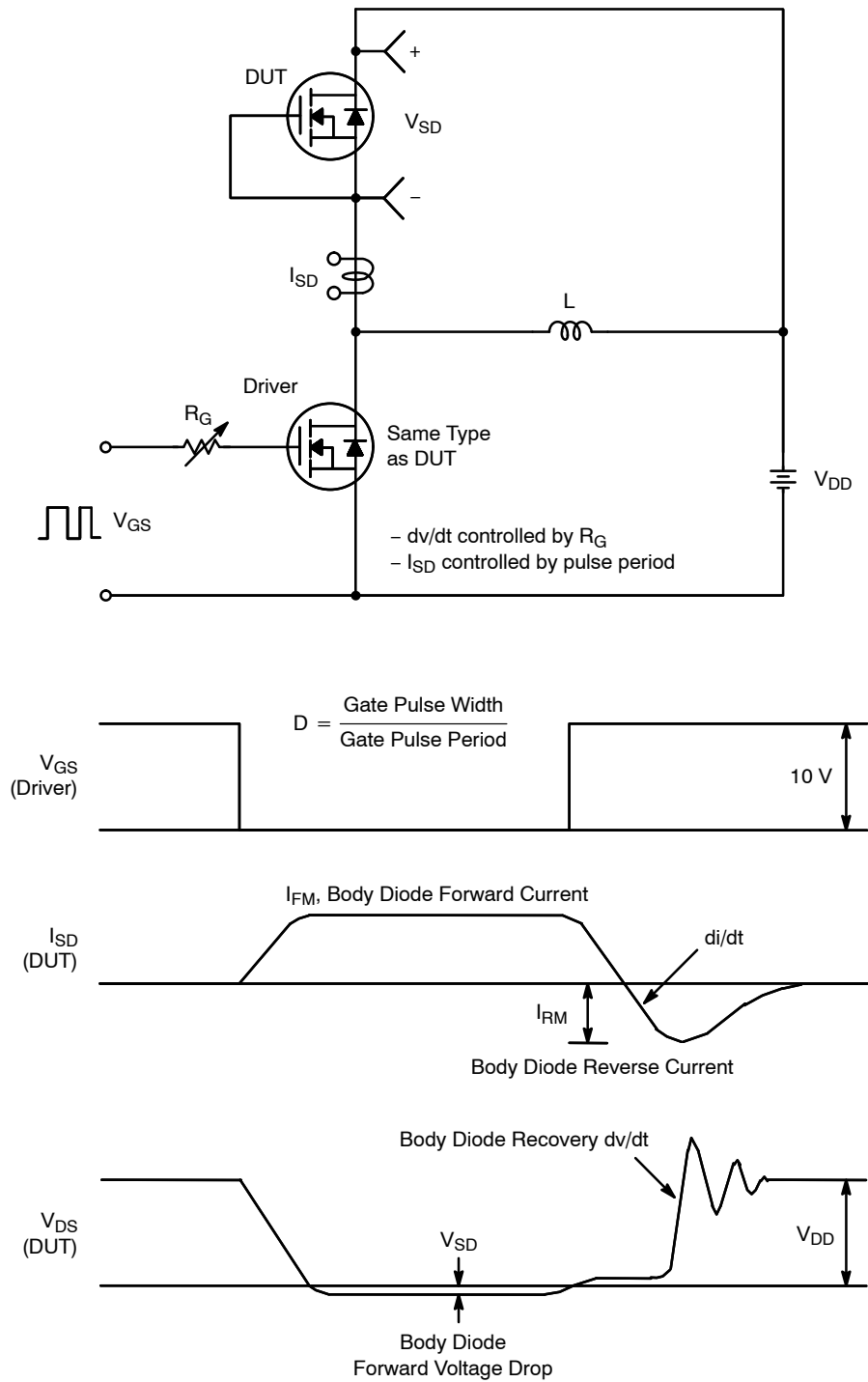


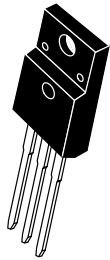
Figure 15. Unclamped Inductive Switching Test Circuit & Waveforms

# NTPF165N65S3H



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

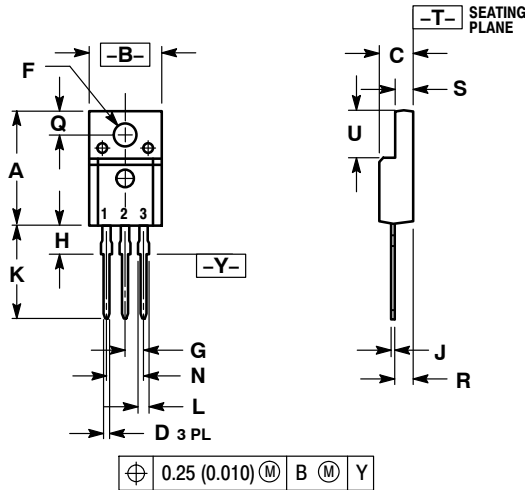




SCALE 1:1

TO-220 FULLPAK  
CASE 221D-03  
ISSUE K

DATE 27 FEB 2009



- 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.

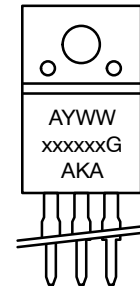
| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.617     | 0.635 | 15.67       | 16.12 |
| B   | 0.392     | 0.419 | 9.96        | 10.63 |
| C   | 0.177     | 0.193 | 4.50        | 4.90  |
| 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  |

MARKING  
DIAGRAMS

- 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



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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