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

## 650 V, 360 mΩ, 10 A



ON Semiconductor<sup>®</sup>

[www.onsemi.com](http://www.onsemi.com)

## NVD360N65S3

### Features

- Ultra Low Gate Charge & Low Effective Output Capacitance
- Lower FOM ( $R_{DS(on) \text{ max.}} \times Q_{g \text{ typ.}}$  &  $R_{DS(on) \text{ max.}} \times E_{OSS}$ )
- 100% Avalanche Tested
- AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free and are RoHS Compliant

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

| Parameter   | Symbol         | Value       | Unit                |
|---|----------------|-------------|---------------------|
| Drain-to-Source Voltage   | $V_{DSS}$      | 650         | V                   |
| Gate-to-Source Voltage – DC   | $V_{GSS}$      | $\pm 30$    | V                   |
| Gate-to-Source Voltage – AC ( $f > 1 \text{ Hz}$ )                    | $V_{GSS}$      | $\pm 30$    | V                   |
| Drain Current – Continuous ( $T_C = 25^\circ\text{C}$ )               | $I_D$          | 10          | A                   |
| Drain Current – Continuous ( $T_C = 100^\circ\text{C}$ )              | $I_D$          | 6           | A                   |
| Drain Current – Pulsed (Note 3)                                       | $I_{DM}$       | 25          | A                   |
| Power Dissipation ( $T_C = 25^\circ\text{C}$ )                        | $P_D$          | 83          | W                   |
| Power Dissipation – Derate Above $25^\circ\text{C}$                   | $P_D$          | 0.67        | W/ $^\circ\text{C}$ |
| Operating Junction and Storage Temperature Range                      | $T_J, T_{STG}$ | -55 to +150 | $^\circ\text{C}$    |
| Single Pulsed Avalanche Energy (Note 4)                               | $E_{AS}$       | 40          | mJ                  |
| Repetitive Avalanche Energy (Note 3)                                  | $E_{AR}$       | 0.83        | mJ                  |
| MOSFET $dv/dt$  | $dv/dt$        | 100         | V/ns                |
| Peak Diode Recovery $dv/dt$ (Note 5)                                  | $dv/dt$        | 20          | V/ns                |
| Max. Lead Temperature for Soldering Purposes (1/8" from case for 5 s) | $T_L$          | 300         | $^\circ\text{C}$    |

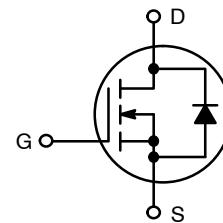
### THERMAL CHARACTERISTICS

| Parameter   | Symbol          | Value | Unit                      |
|---|-----------------|-------|---------------------------|
| Thermal Resistance, Junction-to-Case, Max. (Notes 1, 2)       | $R_{\theta JC}$ | 1.5   | $^\circ\text{C}/\text{W}$ |
| Thermal Resistance, Junction-to-Ambient, Max. (Notes 1, 2, 6) | $R_{\theta JA}$ | 52    |                           |

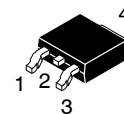
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. The entire application environment impacts the thermal resistance values shown. They are not constants and are only valid for the particular conditions noted.
2. Assembled to an infinite heatsink with perfect heat transfer from the case (assumes 0 K/W thermal interface).
3. Repetitive rating: pulse-width limited by maximum junction temperature.
4.  $I_{AS} = 2.1 \text{ A}$ ,  $R_G = 25 \Omega$ , starting  $T_J = 25^\circ\text{C}$ .
5.  $I_{SD} = 5 \text{ A}$ ,  $di/dt \leq 200 \text{ A}/\mu\text{s}$ ,  $V_{DD} \leq 400 \text{ V}$ , starting  $T_J = 25^\circ\text{C}$ .
6. Device on 1 in<sup>2</sup> pad 2 oz copper pad on 1.5 x 1.5 in. board of FR-4 material.

| $V_{DSS}$ | $R_{DS(on) \text{ MAX}}$ | $I_D \text{ MAX}$ |
|-----------|--------------------------|-------------------|
| 650 V     | 360 mΩ @ 10 V            | 10 A              |

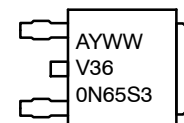


POWER MOSFET



DPAK  
CASE 369C

### MARKING DIAGRAM



A = Assembly Location  
Y = Year  
WW = Work Week  
V360N65S3 = Specific Device Code

### ORDERING INFORMATION

| Device      | Package         | Shipping <sup>†</sup> |
|-------------|-----------------|-----------------------|
| NVD360N65S3 | DPAK3 (Pb-Free) | 2500 / Tape & Reel    |

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# NVD360N65S3

## ELECTRICAL CHARACTERISTICS (T<sub>C</sub> = 25°C unless otherwise noted)

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

### OFF CHARACTERISTICS

|   |                              |  |     |      |      |       |
|---|------------------------------|--|-----|------|------|-------|
| Drain-to-Source Breakdown Voltage         | BV <sub>DSS</sub>            | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 25°C  | 650 |      |      | V     |
| Drain-to-Source Breakdown Voltage         | BV <sub>DSS</sub>            | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 1 mA, T <sub>J</sub> = 150°C | 700 |      |      | V     |
| Breakdown Voltage Temperature Coefficient | $\Delta BV_{DSS}/\Delta T_J$ | I <sub>D</sub> = 1 mA, Referenced to 25°C                            |     | 650  |      | mV/°C |
| Zero Gate Voltage Drain Current           | I <sub>DSS</sub>             | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 650 V                       |     |      | 1    | μA    |
|   |                              | V <sub>DS</sub> = 520 V, T <sub>C</sub> = 125°C                      |     | 0.33 |      |       |
| Gate-to-Body Leakage Current              | I <sub>GSS</sub>             | V <sub>GS</sub> = ±30 V, V <sub>DS</sub> = 0 V                       |     |      | ±100 | nA    |

### ON CHARACTERISTICS

|                                      |                                |   |     |      |     |       |
|--------------------------------------|--------------------------------|---|-----|------|-----|-------|
| Gate Threshold Voltage               | V <sub>GS(th)</sub>            | V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 0.2 mA | 2.5 |      | 4.5 | V     |
| Threshold Temperature Coefficient    | $\Delta V_{GS(th)}/\Delta T_J$ | V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 0.2 mA |     | -8.8 |     | mV/°C |
| Static Drain-to-Source On Resistance | R <sub>DS(on)</sub>            | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 5 A                |     | 314  | 360 | mΩ    |
| Forward Transconductance             | g <sub>FS</sub>                | V <sub>DS</sub> = 20 V, I <sub>D</sub> = 5 A                |     | 6    |     | S     |

### DYNAMIC CHARACTERISTICS

|                                   |                        |   |  |      |  |    |
|-----------------------------------|------------------------|---|--|------|--|----|
| Input Capacitance                 | C <sub>iss</sub>       | V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 400 V, f = 1 MHz                         |  | 756  |  | pF |
| Output Capacitance                | C <sub>oss</sub>       |   |  | 17.4 |  |    |
| Reverse Transfer Capacitance      | C <sub>rss</sub>       |   |  | 1.53 |  |    |
| Effective Output Capacitance      | C <sub>oss(eff.)</sub> | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                             |  | 179  |  | pF |
| Energy Related Output Capacitance | C <sub>oss(er.)</sub>  | V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V                             |  | 29.3 |  | pF |
| Total Gate Charge at 10 V         | Q <sub>G(TOT)</sub>    | V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 400 V, I <sub>D</sub> = 5 A<br>(Note 7) |  | 16.8 |  | nC |
| Threshold Gate Charge             | Q <sub>G(TH)</sub>     |   |  | 2.8  |  |    |
| Gate-to-Source Gate Charge        | Q <sub>GS</sub>        |   |  | 4.6  |  |    |
| Gate-to-Drain "Miller" Charge     | Q <sub>GD</sub>        |   |  | 7    |  |    |
| Equivalent Series Resistance      | ESR                    | f = 1 MHz   |  | 1    |  | Ω  |

### SWITCHING CHARACTERISTICS

|                     |                     |  |  |      |  |    |
|---------------------|---------------------|--|--|------|--|----|
| Turn-On Delay Time  | t <sub>d(on)</sub>  | V <sub>GS</sub> = 10 V, V <sub>DD</sub> = 400 V,<br>I <sub>D</sub> = 5 A, R <sub>g</sub> = 4.7 Ω<br>(Note 7) |  | 13.6 |  | ns |
| Turn-On Rise Time   | t <sub>r</sub>      |  |  | 9.44 |  | ns |
| Turn-Off Delay Time | t <sub>d(off)</sub> |  |  | 33.9 |  | ns |
| Turn-Off Fall Time  | t <sub>f</sub>      |  |  | 11.2 |  | ns |

### SOURCE-DRAIN DIODE CHARACTERISTICS

|  |                 |   |  |      |     |    |
|--|-----------------|---|--|------|-----|----|
| Maximum Continuous Source-to-Drain Diode Forward Current | I <sub>S</sub>  | V <sub>GS</sub> = 0 V   |  |      | 10  | A  |
| Maximum Pulsed Source-to-Drain Diode Forward Current     | I <sub>SM</sub> | V <sub>GS</sub> = 0 V   |  |      | 25  | A  |
| Source-to-Drain Diode Forward Voltage                    | V <sub>SD</sub> | V <sub>GS</sub> = 0 V, I <sub>SD</sub> = 5 A                                    |  |      | 1.2 | V  |
| Reverse Recovery Time                                    | t <sub>rr</sub> | V <sub>GS</sub> = 0 V, dI <sub>F</sub> /dt = 100 A/μs,<br>I <sub>SD</sub> = 5 A |  | 197  |     | ns |
| Charge Time  | t <sub>a</sub>  |   |  | 18   |     |    |
| Discharge Time   | t <sub>b</sub>  |   |  | 10   |     |    |
| Reverse Recovery Charge                                  | Q <sub>rr</sub> |   |  | 2089 |     |    |

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.

7. Essentially independent of operating temperature typical characteristics.

# NVD360N65S3

## TYPICAL CHARACTERISTICS

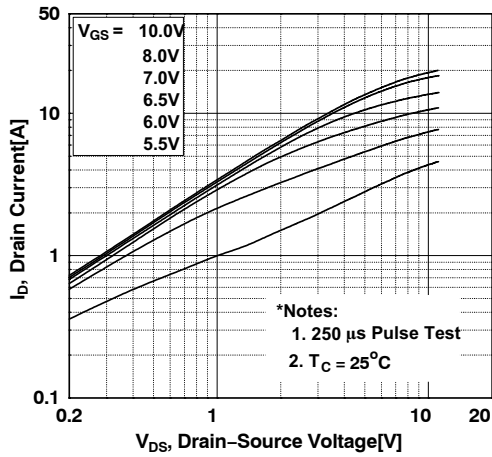


Figure 1. On-Region Characteristics 25°C

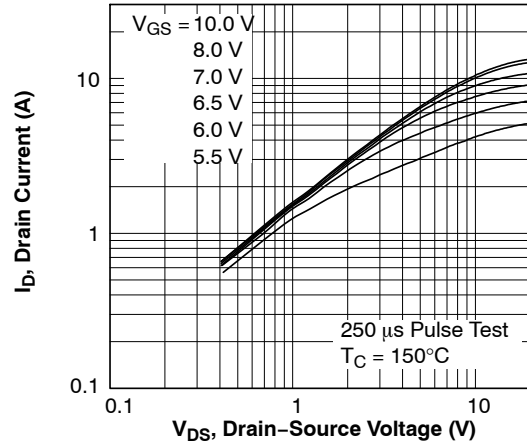


Figure 2. On-Region Characteristics 150°C

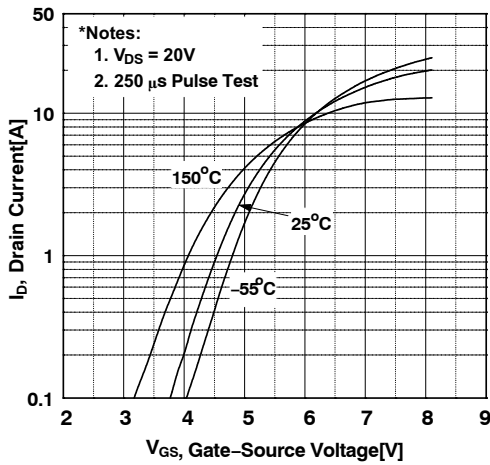


Figure 3. Transfer Characteristics

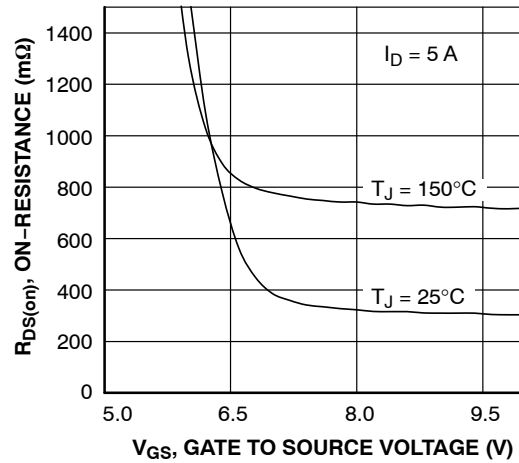


Figure 4.  $R_{DS(on)}$  vs. Gate Voltage

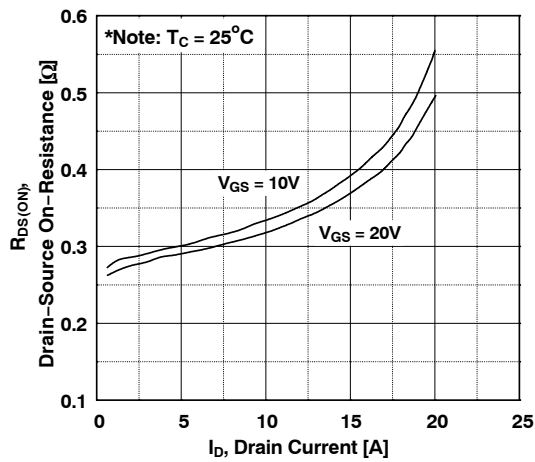


Figure 5. On-Resistance Variation vs. Drain Current and Gate Voltage

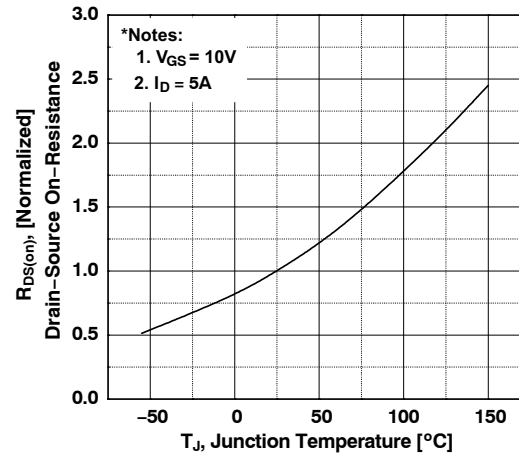


Figure 6. On-Resistance Variation vs. Temperature

TYPICAL CHARACTERISTICS

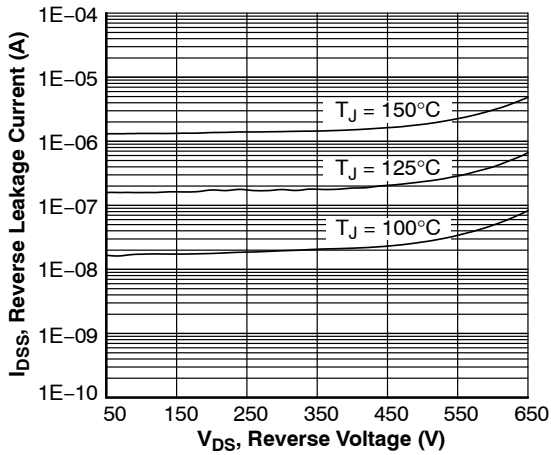


Figure 7. Drain-to-Source Leakage Current vs. Voltage

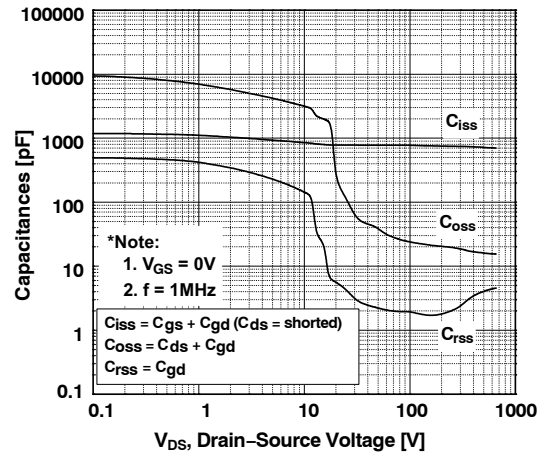


Figure 8. Capacitance Characteristics

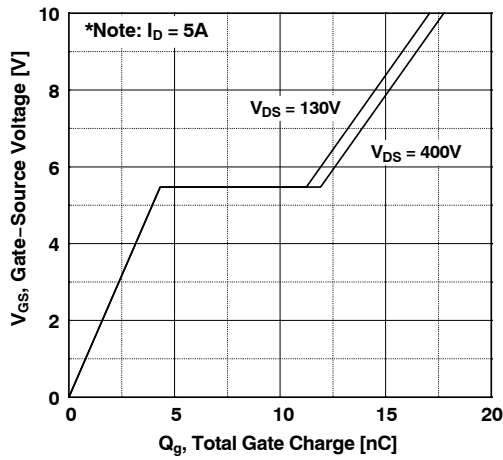


Figure 9. Gate Charge Characteristics

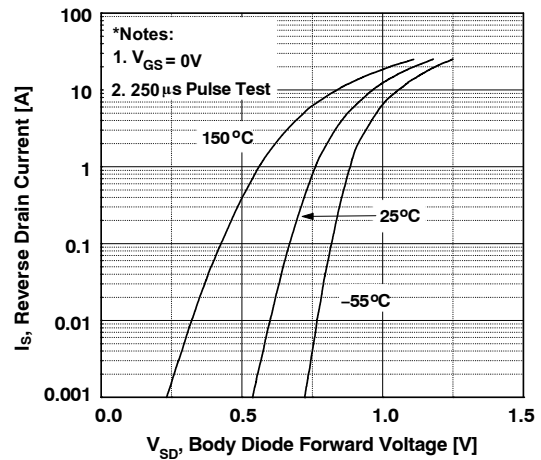


Figure 10. Body Diode Forward Voltage Variation vs. Source Current and Temperature

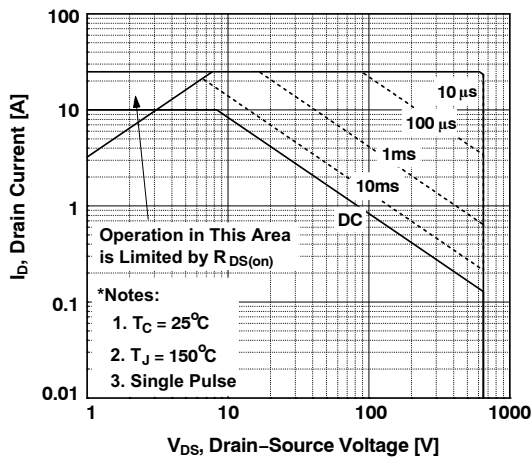


Figure 11. Maximum Safe Operating Area

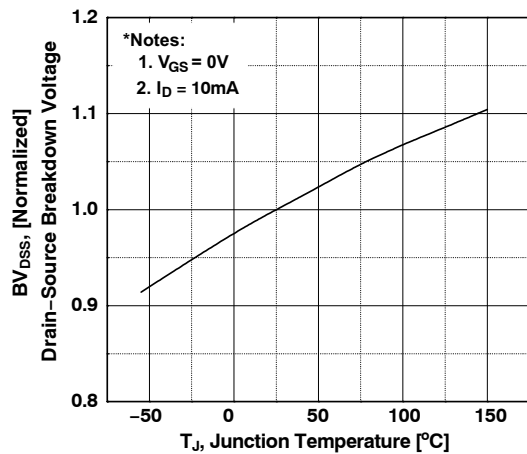


Figure 12. Breakdown Voltage Variation vs. Temperature

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## TYPICAL CHARACTERISTICS

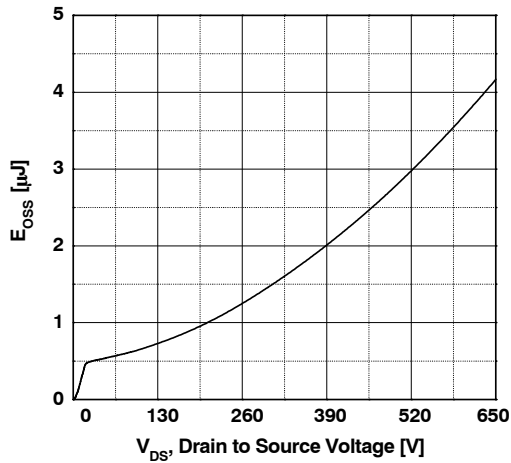


Figure 13.  $E_{OSS}$  vs. Drain to Source Voltage

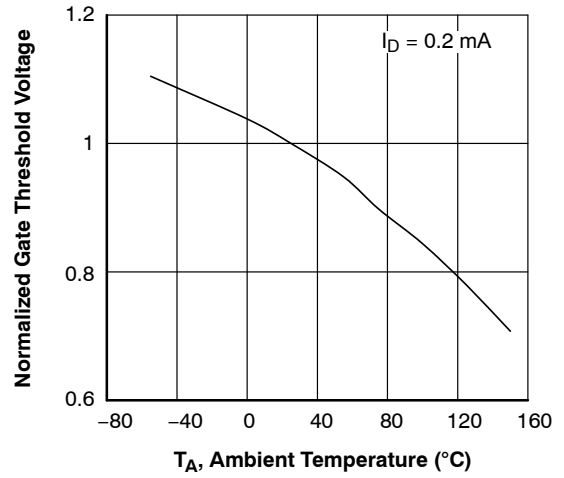


Figure 14. Normalized Gate Threshold Voltage vs. Temperature

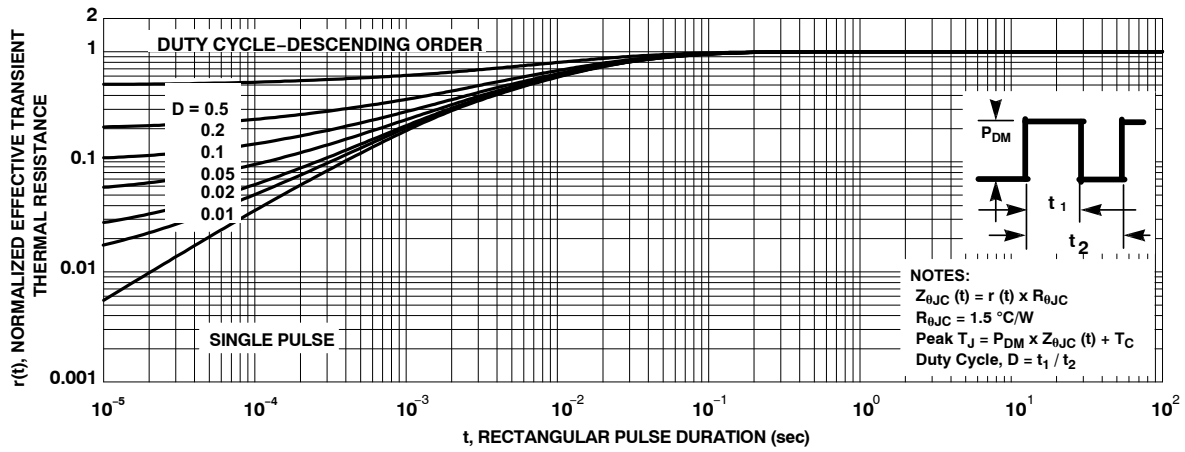


Figure 15. Transient Thermal Response Curve

# NVD360N65S3



Figure 16. Gate Charge Test Circuit & Waveform

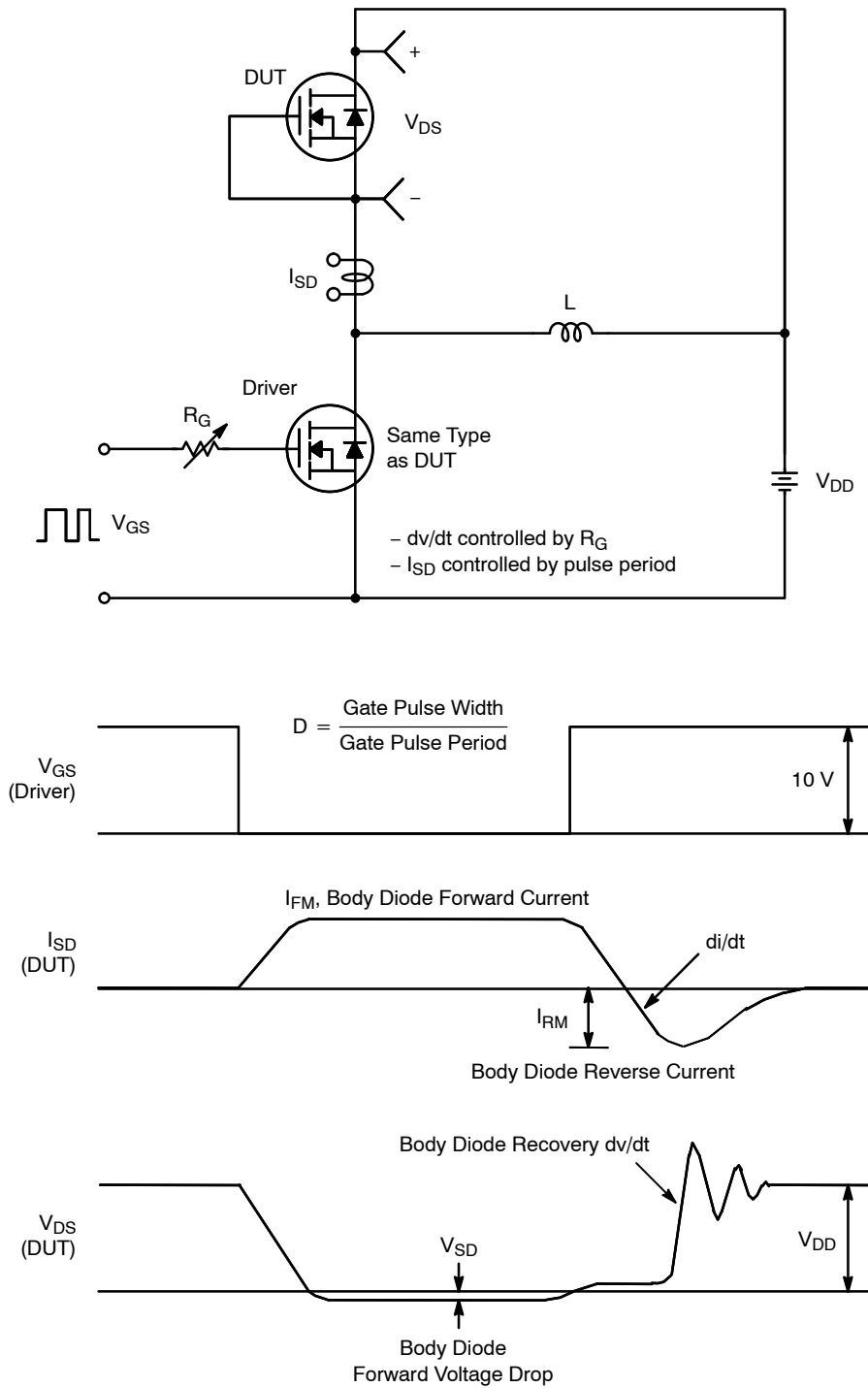


Figure 17. Resistive Switching Test Circuit & Waveforms



Figure 18. Unclamped Inductive Switching Test Circuit & Waveforms

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**Figure 19. Peak Diode Recovery  $dv/dt$  Test Circuit & Waveforms**

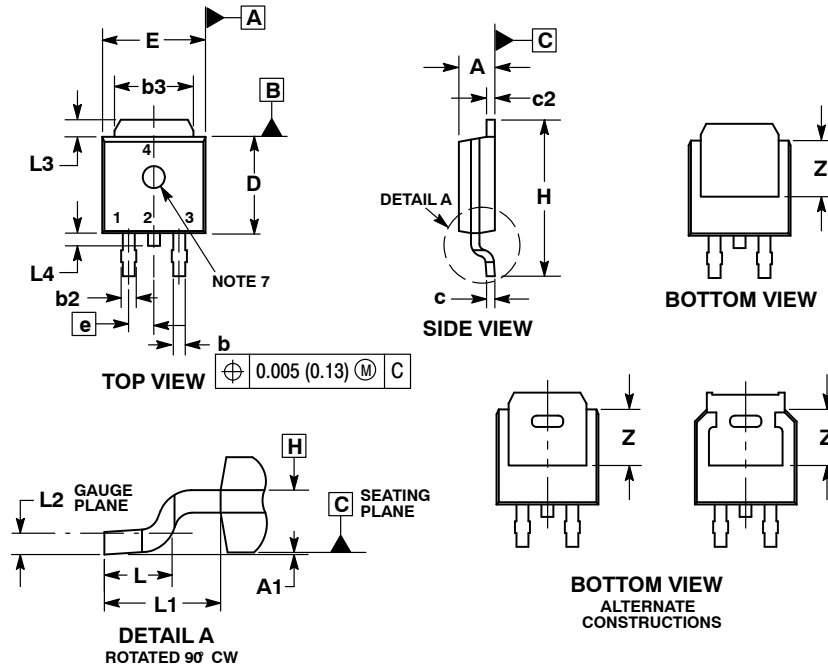
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# NVD360N65S3

## PACKAGE DIMENSIONS

### DKPAK (SINGLE GAUGE) CASE 369C ISSUE F



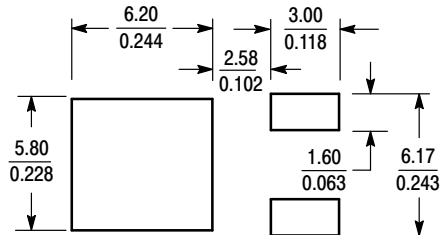
**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3 and Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
5. DIMENSIONS D AND E ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
6. DATUMS A AND B ARE DETERMINED AT DATUM PLANE H.
7. OPTIONAL MOLD FEATURE.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.086     | 0.094 | 2.18        | 2.38  |
| A1  | 0.000     | 0.005 | 0.00        | 0.13  |
| b   | 0.025     | 0.035 | 0.63        | 0.89  |
| b2  | 0.028     | 0.045 | 0.72        | 1.14  |
| b3  | 0.180     | 0.215 | 4.57        | 5.46  |
| c   | 0.018     | 0.024 | 0.46        | 0.61  |
| c2  | 0.018     | 0.024 | 0.46        | 0.61  |
| D   | 0.235     | 0.245 | 5.97        | 6.22  |
| E   | 0.250     | 0.265 | 6.35        | 6.73  |
| e   | 0.090 BSC |       | 2.29 BSC    |       |
| H   | 0.370     | 0.410 | 9.40        | 10.41 |
| L   | 0.055     | 0.070 | 1.40        | 1.78  |
| L1  | 0.114 REF |       | 2.90 REF    |       |
| L2  | 0.020 BSC |       | 0.51 BSC    |       |
| L3  | 0.035     | 0.050 | 0.89        | 1.27  |
| L4  | ---       | 0.040 | ---         | 1.01  |
| Z   | 0.155     | ---   | 3.93        | ---   |

- |   |   |  |  |   |
|---|---|--|--|---|
| <p><b>STYLE 1:</b><br/>PIN 1. BASE<br/>2. COLLECTOR<br/>3. EMITTER<br/>4. COLLECTOR</p> | <p><b>STYLE 2:</b><br/>PIN 1. GATE<br/>2. DRAIN<br/>3. SOURCE<br/>4. DRAIN</p>          | <p><b>STYLE 3:</b><br/>PIN 1. ANODE<br/>2. CATHODE<br/>3. ANODE<br/>4. CATHODE</p> | <p><b>STYLE 4:</b><br/>PIN 1. CATHODE<br/>2. ANODE<br/>3. GATE<br/>4. ANODE</p>              | <p><b>STYLE 5:</b><br/>PIN 1. GATE<br/>2. ANODE<br/>3. CATHODE<br/>4. ANODE</p>     |
| <p><b>STYLE 6:</b><br/>PIN 1. MT1<br/>2. MT2<br/>3. GATE<br/>4. MT2</p>                 | <p><b>STYLE 7:</b><br/>PIN 1. GATE<br/>2. COLLECTOR<br/>3. EMITTER<br/>4. COLLECTOR</p> | <p><b>STYLE 8:</b><br/>PIN 1. N/C<br/>2. CATHODE<br/>3. ANODE<br/>4. CATHODE</p>   | <p><b>STYLE 9:</b><br/>PIN 1. ANODE<br/>2. CATHODE<br/>3. RESISTOR ADJUST<br/>4. CATHODE</p> | <p><b>STYLE 10:</b><br/>PIN 1. CATHODE<br/>2. ANODE<br/>3. CATHODE<br/>4. ANODE</p> |

### SOLDERING FOOTPRINT\*



SCALE 3:1  $\left( \frac{\text{mm}}{\text{inches}} \right)$

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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