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# NTB5860N, NTP5860N, NVB5860N

## N-Channel Power MOSFET 60 V, 220 A, 3.0 mΩ

### Features

- Low  $R_{DS(on)}$
- High Current Capability
- 100% Avalanche Tested
- These Devices are Pb-Free, Halogen Free and are RoHS Compliant
- NVB Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable

**MAXIMUM RATINGS** ( $T_J = 25^\circ\text{C}$  Unless otherwise specified)

| Parameter   |              | Symbol                    | Value       | Unit |
|---|--------------|---------------------------|-------------|------|
| Drain-to-Source Voltage   |              | $V_{DSS}$                 | 60          | V    |
| Gate-to-Source Voltage – Continuous                                     |              | $V_{GS}$                  | $\pm 20$    | V    |
| Continuous Drain Current, $R_{\theta JC}$                               | Steady State | $T_C = 25^\circ\text{C}$  | $I_D$       | A    |
|   |              | $T_C = 100^\circ\text{C}$ | 156         |      |
| Power Dissipation, $R_{\theta JC}$                                      | Steady State | $T_C = 25^\circ\text{C}$  | $P_D$       | 283  |
| Pulsed Drain Current  |              | $t_p = 10 \mu\text{s}$    | $I_{DM}$    | 660  |
| Current Limited by Package  |              | $I_{DMmax}$               | 130         | A    |
| Operating and Storage Temperature Range                                 |              | $T_J, T_{stg}$            | -55 to +175 | °C   |
| Source Current (Body Diode)   |              | $I_S$                     | 130         | A    |
| Single Pulse Drain-to-Source Avalanche Energy ( $L = 0.3 \text{ mH}$ )  |              | $E_{AS}$                  | 735         | mJ   |
| Lead Temperature for Soldering Purposes (1/8" from Case for 10 Seconds) |              | $T_L$                     | 260         | °C   |

### THERMAL RESISTANCE RATINGS

| Parameter                                   | Symbol          | Max  | Unit |
|---|-----------------|------|------|
| Junction-to-Case (Drain) Steady State       | $R_{\theta JC}$ | 0.53 | °C/W |
| Junction-to-Ambient – Steady State (Note 1) | $R_{\theta JA}$ | 28   |      |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

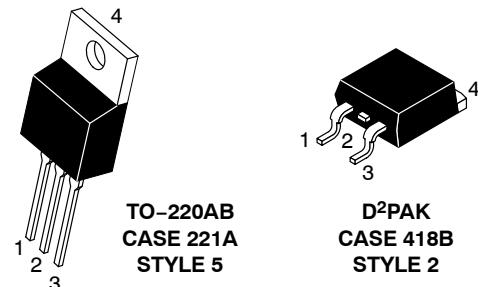
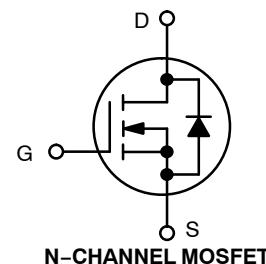
1. Surface mounted on FR4 board using 1 sq in pad size, (Cu Area 1.127 sq in [2 oz] including traces).



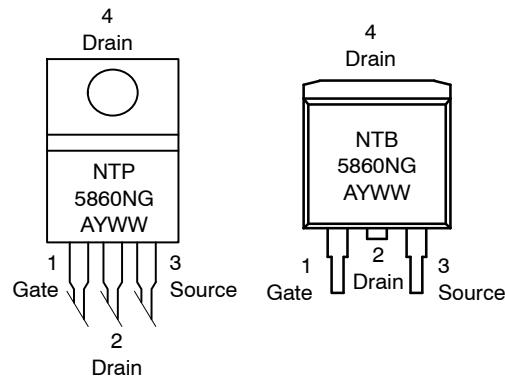
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| $V_{(BR)DSS}$ | $R_{DS(on)} \text{ MAX}$ | $I_D \text{ MAX}$ |
|---------------|--------------------------|-------------------|
| 60 V          | 3.0 mΩ @ 10 V            | 220 A             |



### MARKING DIAGRAMS & PIN ASSIGNMENTS



G = Pb-Free Device

A = Assembly Location\*

Y = Year

WW = Work Week

\*Could be one or two digit alpha or numeric code

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 5 of this data sheet.

# NTB5860N, NTP5860N, NVB5860N

## ELECTRICAL CHARACTERISTICS ( $T_J = 25^\circ\text{C}$ Unless otherwise specified)

| Characteristics | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------------|--------|----------------|-----|-----|-----|------|
|-----------------|--------|----------------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|   |                                 |   |                           |     |           |                            |
|---|---------------------------------|---|---------------------------|-----|-----------|----------------------------|
| Drain-to-Source Breakdown Voltage                         | $V_{(\text{BR})\text{DSS}}$     | $V_{\text{DS}} = 0 \text{ V}, I_{\text{D}} = 250 \mu\text{A}$   | 60                        |     |           | V                          |
| Drain-to-Source Breakdown Voltage Temperature Coefficient | $V_{(\text{BR})\text{DSS}/T_J}$ | $I_{\text{D}} = 250 \mu\text{A}$                                |                           | 5.0 |           | $\text{mV}/^\circ\text{C}$ |
| Zero Gate Voltage Drain Current                           | $I_{\text{DSS}}$                | $V_{\text{GS}} = 0 \text{ V}$                                   | $T_J = 25^\circ\text{C}$  |     | 1.0       | $\mu\text{A}$              |
|   |                                 | $V_{\text{DS}} = 60 \text{ V}$                                  | $T_J = 125^\circ\text{C}$ |     | 100       |                            |
| Gate-Source Leakage Current                               | $I_{\text{GSS}}$                | $V_{\text{DS}} = 0 \text{ V}, V_{\text{GS}} = \pm 20 \text{ V}$ |                           |     | $\pm 100$ | nA                         |

### ON CHARACTERISTICS (Note 2)

|                                   |                                |   |     |       |     |                            |
|-----------------------------------|--------------------------------|---|-----|-------|-----|----------------------------|
| Gate Threshold Voltage            | $V_{\text{GS}(\text{th})}$     | $V_{\text{GS}} = V_{\text{DS}}, I_{\text{D}} = 250 \mu\text{A}$ | 2.0 |       | 4.0 | V                          |
| Threshold Temperature Coefficient | $V_{\text{GS}(\text{th})/T_J}$ |   |     | -10.1 |     | $\text{mV}/^\circ\text{C}$ |
| Drain-to-Source On-Resistance     | $R_{\text{DS}(\text{on})}$     | $V_{\text{GS}} = 10 \text{ V}, I_{\text{D}} = 75 \text{ A}$     |     | 2.5   | 3.0 | $\text{m}\Omega$           |
| Forward Transconductance          | $g_{\text{FS}}$                | $V_{\text{DS}} = 15 \text{ V}, I_{\text{D}} = 30 \text{ A}$     |     | 38    |     | S                          |

### CHARGES, CAPACITANCES & GATE RESISTANCE

|                       |                            |   |  |       |  |    |
|-----------------------|----------------------------|---|--|-------|--|----|
| Input Capacitance     | $C_{\text{iss}}$           | $V_{\text{DS}} = 25 \text{ V}, V_{\text{GS}} = 0 \text{ V}, f = 1 \text{ MHz}$            |  | 10760 |  | pF |
| Output Capacitance    | $C_{\text{oss}}$           |   |  | 1125  |  |    |
| Transfer Capacitance  | $C_{\text{rss}}$           |   |  | 700   |  |    |
| Total Gate Charge     | $Q_{\text{G}(\text{TOT})}$ | $V_{\text{GS}} = 10 \text{ V}, V_{\text{DS}} = 48 \text{ V}, I_{\text{D}} = 65 \text{ A}$ |  | 180   |  | nC |
| Threshold Gate Charge | $Q_{\text{G}(\text{TH})}$  |   |  | 11    |  |    |
| Gate-to-Source Charge | $Q_{\text{GS}}$            |   |  | 45    |  |    |
| Gate-to-Drain Charge  | $Q_{\text{GD}}$            |   |  | 57    |  |    |

### SWITCHING CHARACTERISTICS, $V_{\text{GS}} = 10 \text{ V}$ (Note 3)

|                     |                            |  |  |     |  |    |
|---------------------|----------------------------|--|--|-----|--|----|
| Turn-On Delay Time  | $t_{\text{d}(\text{on})}$  | $V_{\text{GS}} = 10 \text{ V}, V_{\text{DD}} = 48 \text{ V}, I_{\text{D}} = 65 \text{ A}, R_{\text{G}} = 2.5 \Omega$ |  | 27  |  | ns |
| Rise Time           | $t_{\text{r}}$             |  |  | 117 |  |    |
| Turn-Off Delay Time | $t_{\text{d}(\text{off})}$ |  |  | 66  |  |    |
| Fall Time           | $t_{\text{f}}$             |  |  | 150 |  |    |

### DRAIN-SOURCE DIODE CHARACTERISTICS

|                                |                 |  |                           |  |      |     |                 |
|--------------------------------|-----------------|--|---------------------------|--|------|-----|-----------------|
| Forward Diode Voltage          | $V_{\text{SD}}$ | $V_{\text{GS}} = 0 \text{ V}$  | $T_J = 25^\circ\text{C}$  |  | 0.76 | 1.1 | $V_{\text{dc}}$ |
|                                |                 |  | $T_J = 125^\circ\text{C}$ |  | 0.63 |     |                 |
| Reverse Recovery Time          | $t_{\text{rr}}$ | $V_{\text{GS}} = 0 \text{ V}, I_{\text{S}} = 65 \text{ A}, dI_{\text{S}}/dt = 100 \text{ A}/\mu\text{s}$ |                           |  | 55   |     | ns              |
| Charge Time                    | $t_{\text{a}}$  |  |                           |  | 29   |     |                 |
| Discharge Time                 | $t_{\text{b}}$  |  |                           |  | 26   |     |                 |
| Reverse Recovery Stored Charge | $Q_{\text{RR}}$ |  |                           |  | 76   |     |                 |

2. Pulse Test: Pulse Width  $\leq 300 \mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

3. Switching characteristics are independent of operating junction temperatures.

# NTB5860N, NTP5860N, NVB5860N

## TYPICAL CHARACTERISTICS

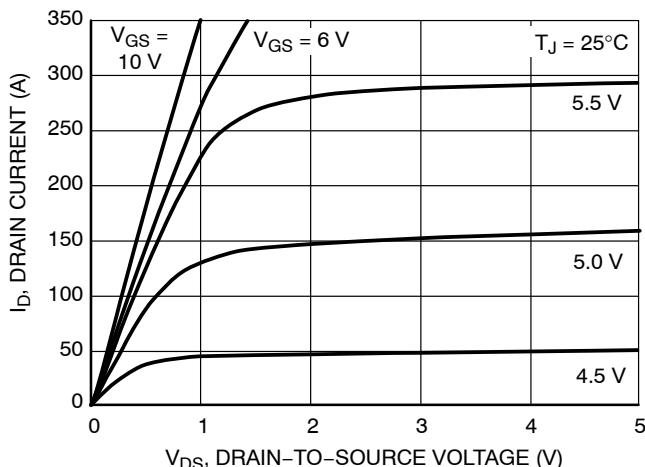


Figure 1. On-Region Characteristics

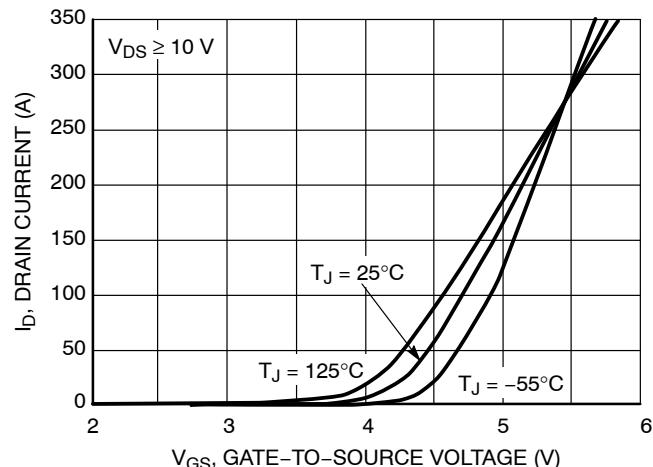


Figure 2. Transfer Characteristics

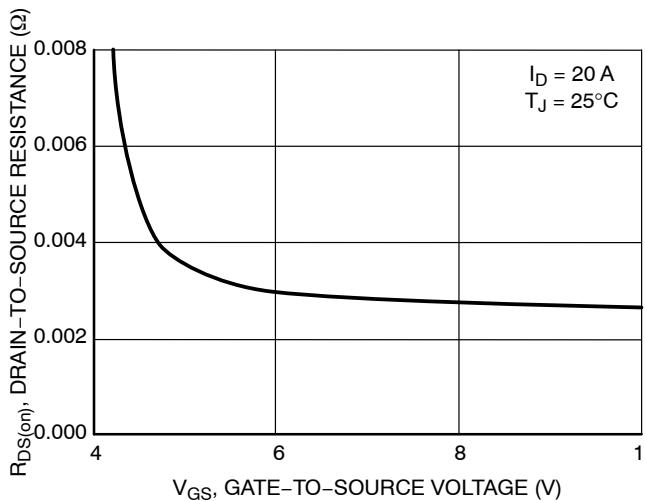


Figure 3. On-Resistance vs. Gate Voltage

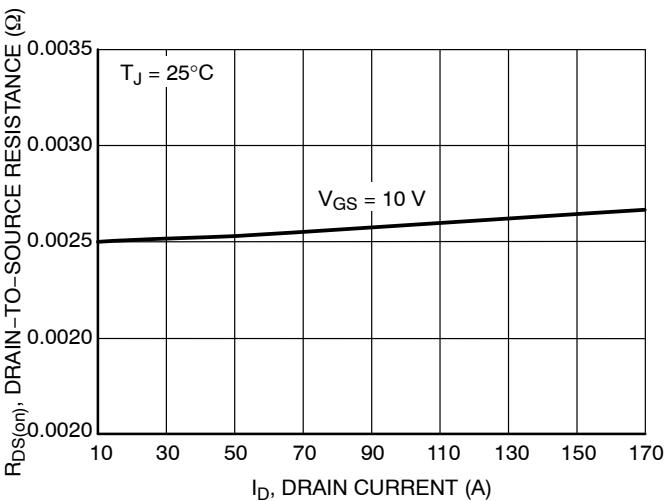


Figure 4. On-Resistance vs. Drain Current

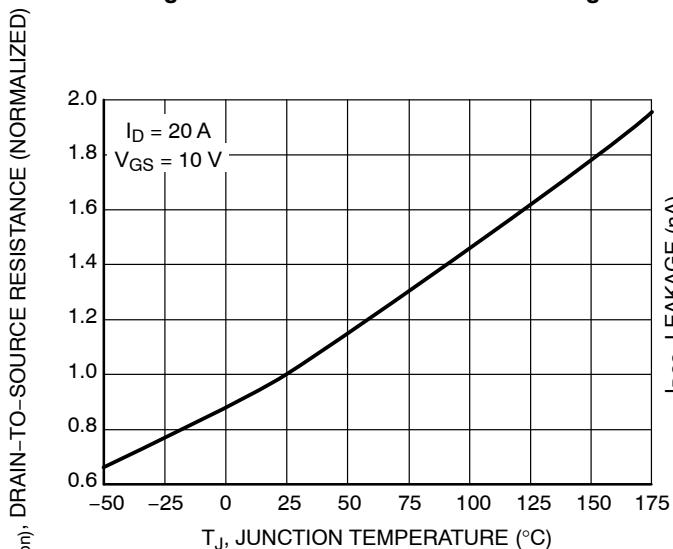


Figure 5. On-Resistance Variation with Temperature

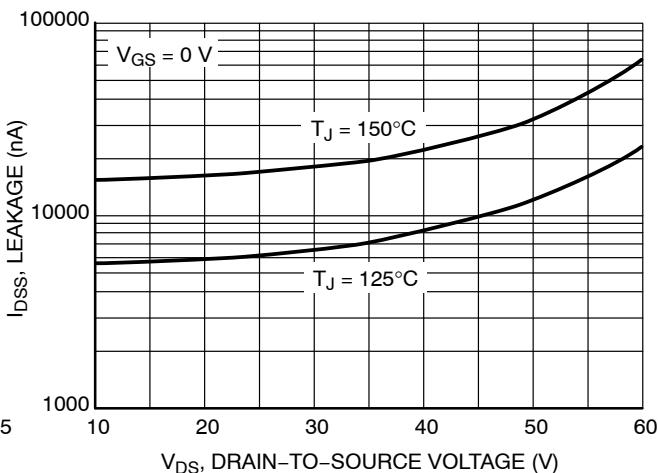
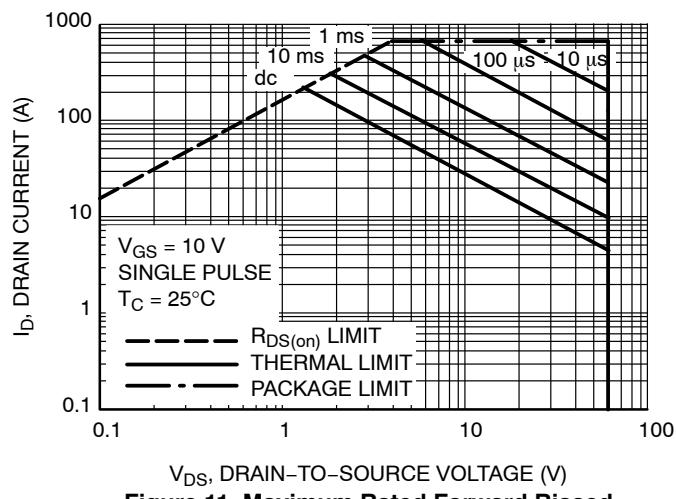
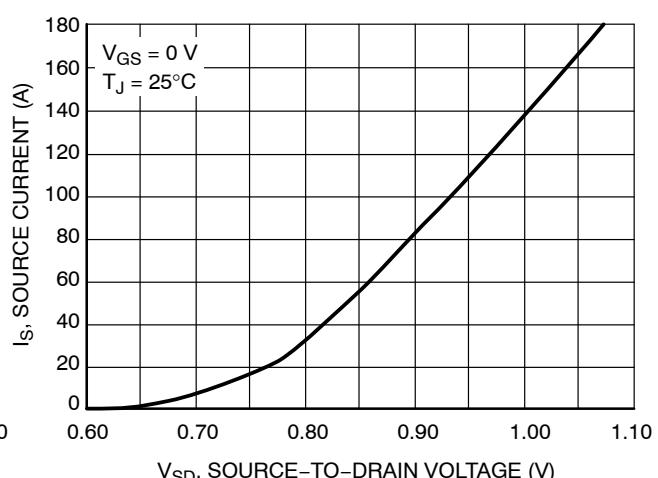
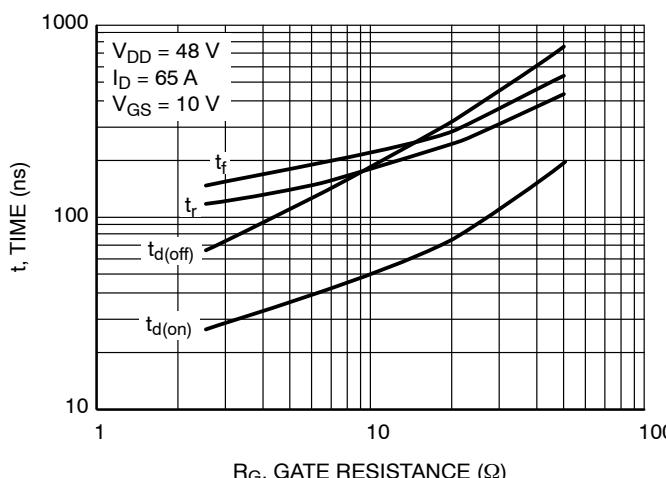
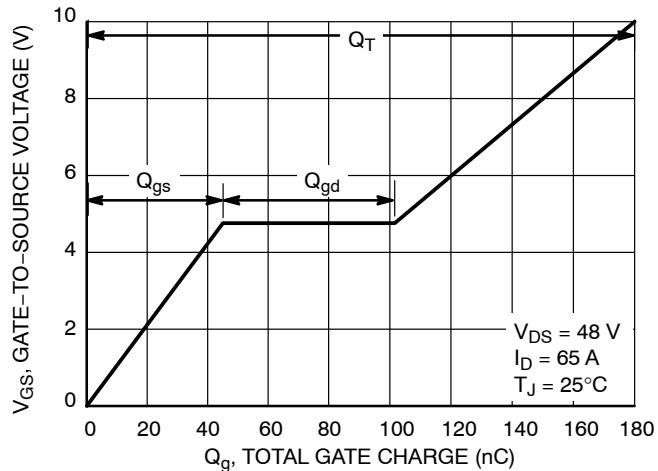
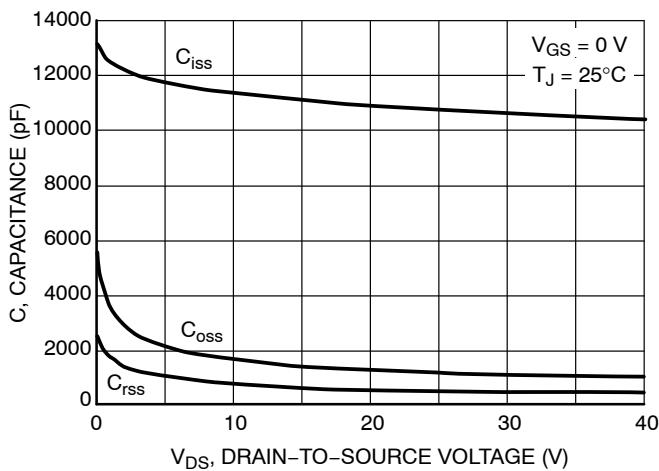


Figure 6. Drain-to-Source Leakage Current vs. Voltage

# NTB5860N, NTP5860N, NVB5860N

## TYPICAL CHARACTERISTICS



# NTB5860N, NTP5860N, NVB5860N

## TYPICAL CHARACTERISTICS

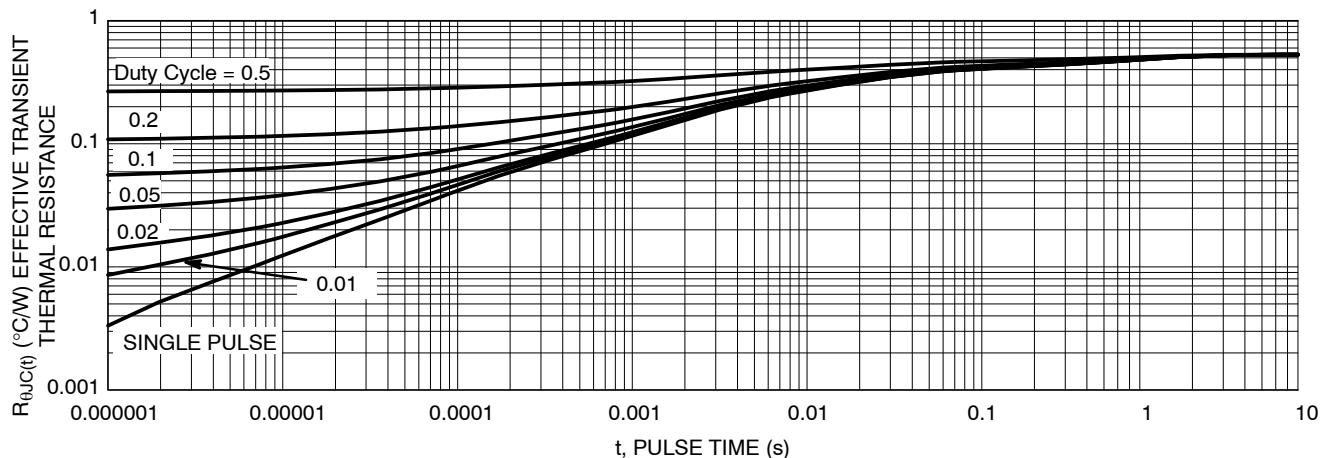


Figure 12. Thermal Response

## ORDERING INFORMATION

| Device       | Package                         | Shipping <sup>†</sup> |
|--------------|---------------------------------|-----------------------|
| NTP5860NG    | TO-220AB<br>(Pb-Free)           | 50 Units / Rail       |
| NTB5860NT4G  | D <sup>2</sup> PAK<br>(Pb-Free) | 800 / Tape & Reel     |
| NVB5860NT4G* | D <sup>2</sup> PAK<br>(Pb-Free) | 800 / Tape & Reel     |

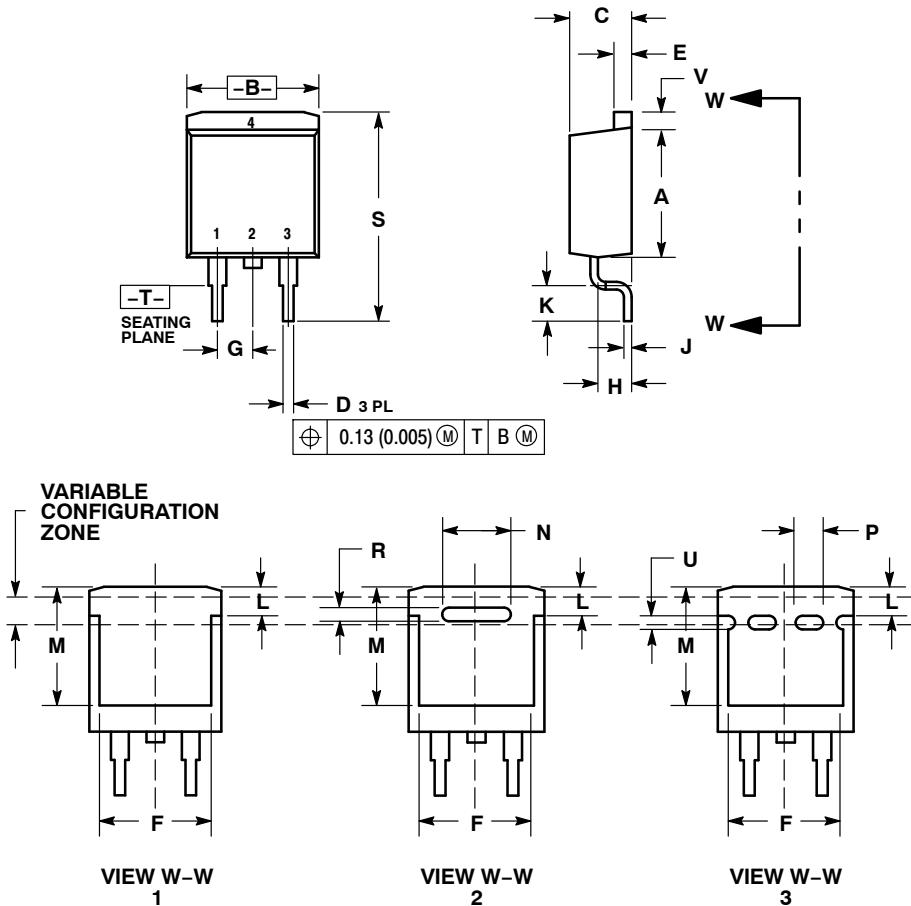
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

\*NVB Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable.

# NTB5860N, NTP5860N, NVB5860N

## PACKAGE DIMENSIONS

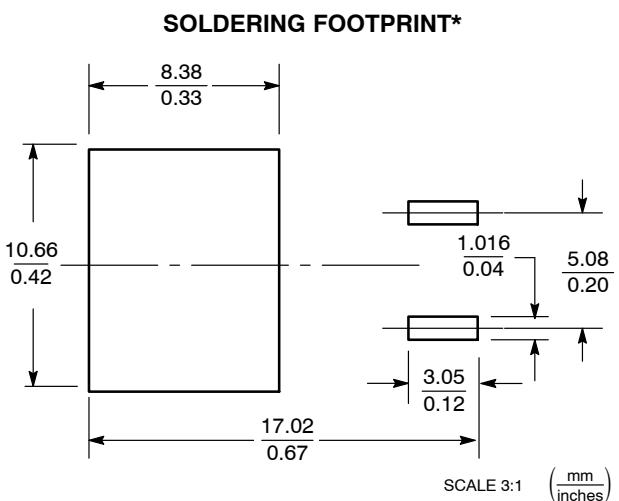
### D<sup>2</sup>PAK CASE 418B-04 ISSUE J



NOTES:  
 1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
 2. CONTROLLING DIMENSION: INCH.  
 3. 418B-01 THRU 418B-03 OBSOLETE, NEW STANDARD 418B-04.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.340  | 0.380 | 8.64        | 9.65  |
| B   | 0.380  | 0.405 | 9.65        | 10.29 |
| C   | 0.160  | 0.190 | 4.06        | 4.83  |
| D   | 0.020  | 0.035 | 0.51        | 0.89  |
| E   | 0.045  | 0.055 | 1.14        | 1.40  |
| F   | 0.310  | 0.350 | 7.87        | 8.89  |
| G   | 0.100  | BSC   | 2.54        | BSC   |
| H   | 0.080  | 0.110 | 2.03        | 2.79  |
| J   | 0.018  | 0.025 | 0.46        | 0.64  |
| K   | 0.090  | 0.110 | 2.29        | 2.79  |
| L   | 0.052  | 0.072 | 1.32        | 1.83  |
| M   | 0.280  | 0.320 | 7.11        | 8.13  |
| N   | 0.197  | REF   | 5.00        | REF   |
| P   | 0.079  | REF   | 2.00        | REF   |
| R   | 0.039  | REF   | 0.99        | REF   |
| S   | 0.575  | 0.625 | 14.60       | 15.88 |
| V   | 0.045  | 0.055 | 1.14        | 1.40  |

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

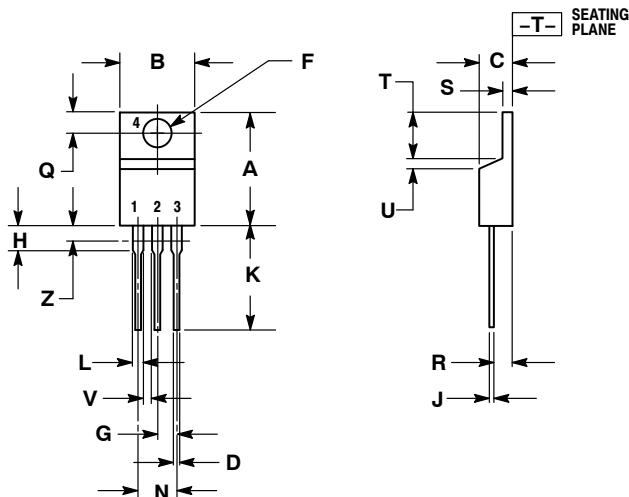


\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# NTB5860N, NTP5860N, NVB5860N

## PACKAGE DIMENSIONS

### TO-220 CASE 221A-09 ISSUE AF



#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.570  | 0.620 | 14.48       | 15.75 |
| B   | 0.380  | 0.405 | 9.66        | 10.28 |
| C   | 0.160  | 0.190 | 4.07        | 4.82  |
| D   | 0.025  | 0.035 | 0.64        | 0.88  |
| F   | 0.142  | 0.161 | 3.61        | 4.09  |
| G   | 0.095  | 0.105 | 2.42        | 2.66  |
| H   | 0.110  | 0.155 | 2.80        | 3.93  |
| J   | 0.014  | 0.025 | 0.36        | 0.64  |
| K   | 0.500  | 0.562 | 12.70       | 14.27 |
| L   | 0.045  | 0.061 | 1.15        | 1.52  |
| N   | 0.190  | 0.210 | 4.83        | 5.33  |
| Q   | 0.100  | 0.120 | 2.54        | 3.04  |
| R   | 0.080  | 0.110 | 2.04        | 2.79  |
| S   | 0.045  | 0.055 | 1.15        | 1.39  |
| T   | 0.235  | 0.255 | 5.97        | 6.47  |
| U   | 0.000  | 0.050 | 0.00        | 1.27  |
| V   | 0.045  | ---   | 1.15        | ---   |
| Z   | ---    | 0.080 | ---         | 2.04  |

#### STYLE 5:

1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

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