

# NTB90N02, NTP90N02

## Power MOSFET 90 Amps, 24 Volts N-Channel D<sup>2</sup>PAK and TO-220

Designed for low voltage, high speed switching applications in power supplies, converters and power motor controls and bridge circuits.

### Features

- Pb-Free Packages are Available

### Typical Applications

- Power Supplies
- Converters
- Power Motor Controls
- Bridge Circuits

### MAXIMUM RATINGS (T<sub>J</sub> = 25°C unless otherwise noted)

| Rating                                                                                                                                                                                                     | Symbol                               | Value       | Unit      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-------------|-----------|
| Drain-to-Source Voltage                                                                                                                                                                                    | V <sub>DSS</sub>                     | 24          | Vdc       |
| Gate-to-Source Voltage<br>– Continuous                                                                                                                                                                     | V <sub>GS</sub>                      | ±20         | Vdc       |
| Drain Current<br>– Continuous @ T <sub>A</sub> = 25°C<br>– Single Pulse (t <sub>p</sub> = 10 μs)                                                                                                           | I <sub>D</sub><br>I <sub>DM</sub>    | 90*<br>200  | A<br>A    |
| Total Power Dissipation @ T <sub>A</sub> = 25°C<br>Derate above 25°C                                                                                                                                       | P <sub>D</sub>                       | 85<br>0.66  | W<br>W/°C |
| Operating and Storage Temperature                                                                                                                                                                          | T <sub>J</sub> , T <sub>stg</sub>    | –55 to +150 | °C        |
| Single Pulse Drain-to-Source Avalanche<br>Energy – Starting T <sub>J</sub> = 25°C<br>(V <sub>DD</sub> = 28 Vdc, V <sub>GS</sub> = 10 Vdc,<br>L = 5.0 mH, I <sub>L(pk)</sub> = 17 A, R <sub>G</sub> = 25 Ω) | E <sub>AS</sub>                      | 733         | mJ        |
| Thermal Resistance<br>Junction-to-Case<br>Junction-to-Ambient (Note 1)                                                                                                                                     | R <sub>θJC</sub><br>R <sub>θJA</sub> | 1.55<br>70  | °C/W      |
| Maximum Lead Temperature for Soldering<br>Purposes, 1/8" from case for 10 seconds                                                                                                                          | T <sub>L</sub>                       | 260         | °C        |

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. When surface mounted to an FR4 board using 1" pad size, (Cu Area 1.127 in<sup>2</sup>).
2. When surface mounted to an FR4 board using minimum recommended pad size, (Cu Area 0.412 in<sup>2</sup>).

\*Chip current capability limited by package.

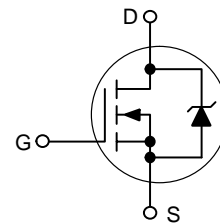


**ON Semiconductor®**

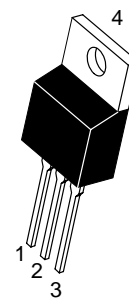
<http://onsemi.com>

| V <sub>(BR)DSS</sub> | R <sub>DS(on)</sub> TYP | I <sub>D</sub> MAX |
|----------------------|-------------------------|--------------------|
| 24 V                 | 5.0 mΩ @ 10 V           | 90 A               |
|                      | 7.5 mΩ @ 4.5 V          |                    |

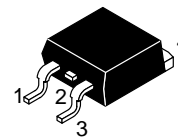
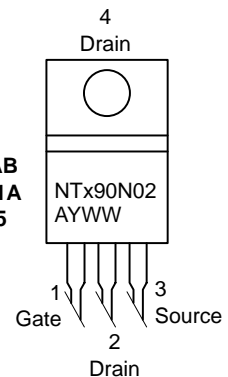
### N-Channel



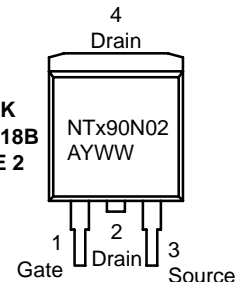
### MARKING DIAGRAMS



**TO-220AB  
CASE 221A  
STYLE 5**



**D<sup>2</sup>PAK  
CASE 418B  
STYLE 2**



NTx90N02 = Device Code  
x = P or B  
A = Assembly Location  
Y = Year  
WW = Work Week

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 4 of this data sheet.

# NTB90N02, NTP90N02

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

| Characteristic | Symbol | Min | Typ | Max | Unit |
|----------------|--------|-----|-----|-----|------|
|----------------|--------|-----|-----|-----|------|

### OFF CHARACTERISTICS

|                                                                                                                                                                       |                      |         |          |           |              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------|----------|-----------|--------------|
| Drain-to-Source Breakdown Voltage (Note 3)<br>(V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 250 μAdc)<br>Temperature Coefficient (Positive)                              | V <sub>(BR)DSS</sub> | 24<br>- | 27<br>25 | -<br>-    | Vdc<br>mV/°C |
| Zero Gate Voltage Drain Current<br>(V <sub>DS</sub> = 24 Vdc, V <sub>GS</sub> = 0 Vdc)<br>(V <sub>DS</sub> = 24 Vdc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 150°C) | I <sub>DSS</sub>     | -<br>-  | -<br>-   | 1.0<br>10 | μAdc         |
| Gate-Body Leakage Current (V <sub>GS</sub> = ± 20 Vdc, V <sub>DS</sub> = 0 Vdc)                                                                                       | I <sub>GSS</sub>     | -       | -        | ±100      | nAdc         |

### ON CHARACTERISTICS (Note 3)

|                                                                                                                                                                                                                                                                             |                     |                  |                          |                          |              |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------|--------------------------|--------------------------|--------------|
| Gate Threshold Voltage (Note 3)<br>(V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μAdc)<br>Threshold Temperature Coefficient (Negative)                                                                                                                          | V <sub>GS(th)</sub> | 1.0<br>-         | 1.9<br>-3.8              | 3.0<br>-                 | Vdc<br>mV/°C |
| Static Drain-to-Source On-Resistance (Note 3)<br>(V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 90 Adc)<br>(V <sub>GS</sub> = 4.5 Vdc, I <sub>D</sub> = 40 Adc)<br>(V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 20 Adc)<br>(V <sub>GS</sub> = 4.5 Vdc, I <sub>D</sub> = 20 Adc) | R <sub>DS(on)</sub> | -<br>-<br>-<br>- | 5.0<br>7.5<br>5.0<br>7.5 | 5.8<br>9.0<br>5.8<br>9.0 | mΩ           |
| Forward Transconductance (Note 3) (V <sub>DS</sub> = 15 Vdc, I <sub>D</sub> = 10 Adc)                                                                                                                                                                                       | g <sub>FS</sub>     | -                | 25                       | -                        | mhos         |

### DYNAMIC CHARACTERISTICS

|                      |                                                                     |                  |   |      |   |    |
|----------------------|---------------------------------------------------------------------|------------------|---|------|---|----|
| Input Capacitance    | (V <sub>DS</sub> = 20 Vdc, V <sub>GS</sub> = 0 Vdc,<br>f = 1.0 MHz) | C <sub>ISS</sub> | - | 2120 | - | pF |
| Output Capacitance   |                                                                     | C <sub>OSS</sub> | - | 900  | - |    |
| Transfer Capacitance |                                                                     | C <sub>RSS</sub> | - | 360  | - |    |

### SWITCHING CHARACTERISTICS (Note 4)

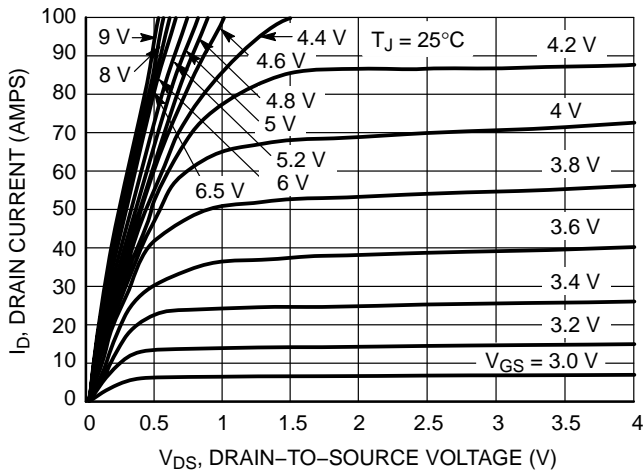
|                     |                                                                                                           |                     |   |     |   |    |
|---------------------|-----------------------------------------------------------------------------------------------------------|---------------------|---|-----|---|----|
| Turn-On Delay Time  | (V <sub>DD</sub> = 20 Vdc, I <sub>D</sub> = 20 Adc,<br>V <sub>GS</sub> = 4.5 Vdc, R <sub>G</sub> = 2.5 Ω) | t <sub>d(on)</sub>  | - | 16  | - | ns |
| Rise Time           |                                                                                                           | t <sub>r</sub>      | - | 90  | - |    |
| Turn-Off Delay Time |                                                                                                           | t <sub>d(off)</sub> | - | 28  | - |    |
| Fall Time           |                                                                                                           | t <sub>f</sub>      | - | 60  | - |    |
| Gate Charge         | (V <sub>DS</sub> = 20 Vdc, I <sub>D</sub> = 20 Adc,<br>V <sub>GS</sub> = 4.5 Vdc) (Note 3)                | Q <sub>T</sub>      | - | 29  | - | nC |
|                     |                                                                                                           | Q <sub>1</sub>      | - | 8.0 | - |    |
|                     |                                                                                                           | Q <sub>2</sub>      | - | 20  | - |    |

### SOURCE-DRAIN DIODE CHARACTERISTICS

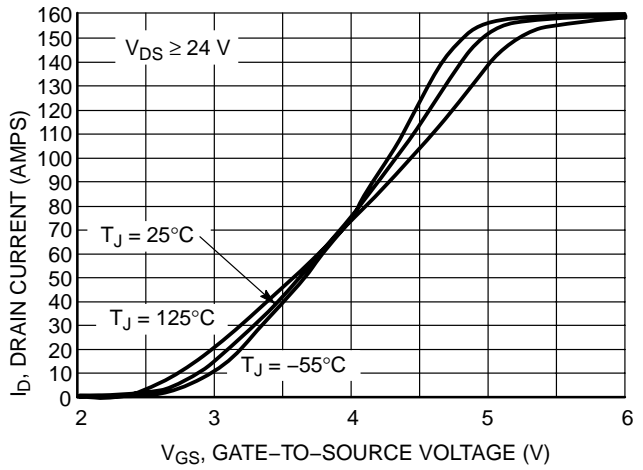
|                                |                                                                                                                                                                                                   |                 |    |                     |          |     |    |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----|---------------------|----------|-----|----|
| Forward On-Voltage             | (I <sub>S</sub> = 2.3 Adc, V <sub>GS</sub> = 0 Vdc)<br>(I <sub>S</sub> = 40 Adc, V <sub>GS</sub> = 0 Vdc) (Note 3)<br>(I <sub>S</sub> = 2.3 Adc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 150°C) | V <sub>SD</sub> | -  | 0.75<br>1.2<br>0.65 | 1.0<br>- | Vdc |    |
| Reverse Recovery Time          |                                                                                                                                                                                                   | t <sub>rr</sub> | -  | 40                  | -        |     | ns |
|                                |                                                                                                                                                                                                   | t <sub>a</sub>  | -  | 21                  | -        |     |    |
|                                | t <sub>b</sub>                                                                                                                                                                                    | -               | 18 | -                   |          |     |    |
| Reverse Recovery Stored Charge |                                                                                                                                                                                                   | Q <sub>RR</sub> | -  | 0.036               | -        | μC  |    |

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
4. Switching characteristics are independent of operating junction temperatures.

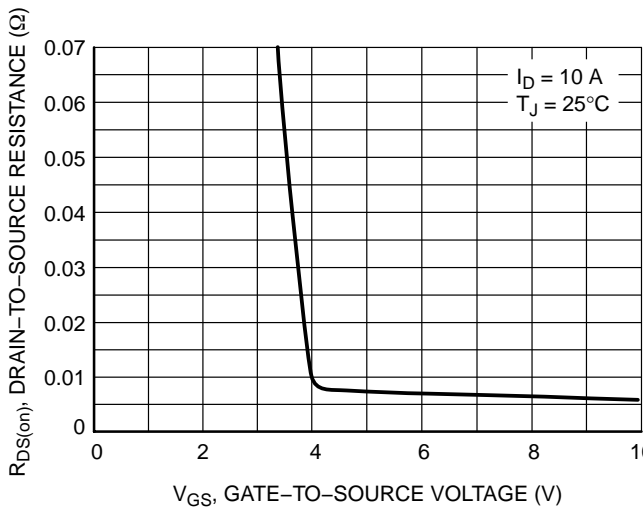
# NTB90N02, NTP90N02



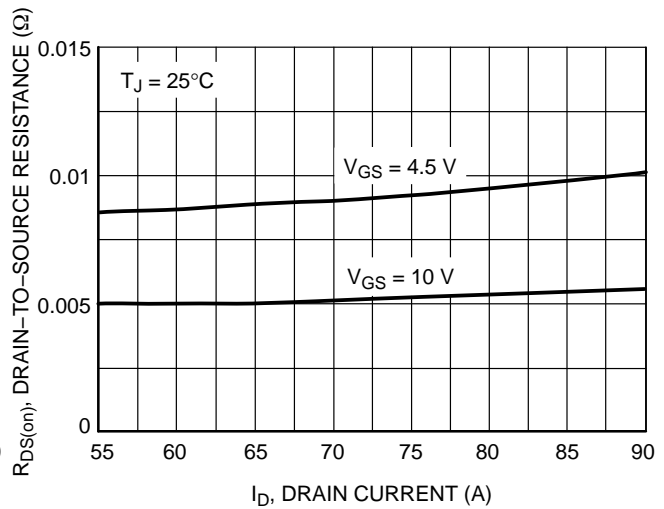
**Figure 1. On-Region Characteristics**



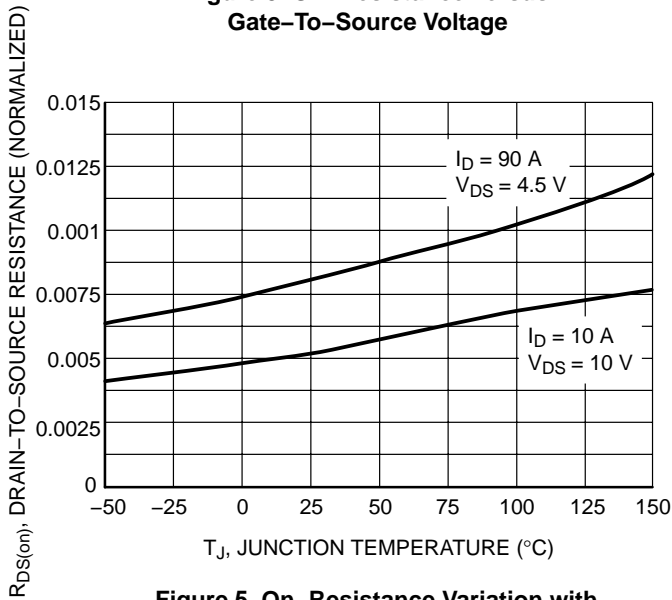
**Figure 2. Transfer Characteristics**



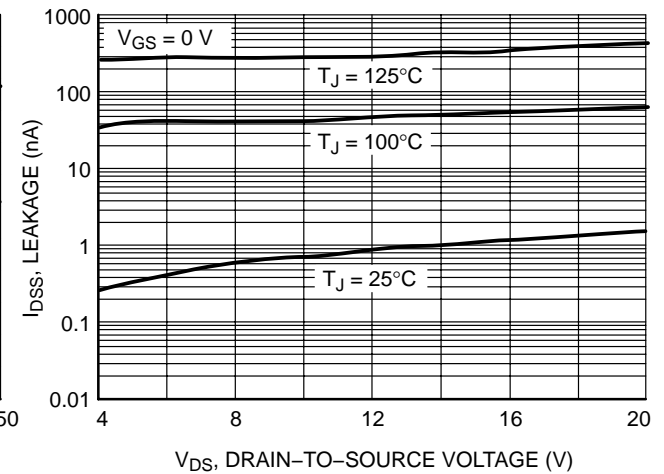
**Figure 3. On-Resistance versus Gate-to-Source Voltage**



**Figure 4. On-Resistance versus Drain Current and Gate Voltage**

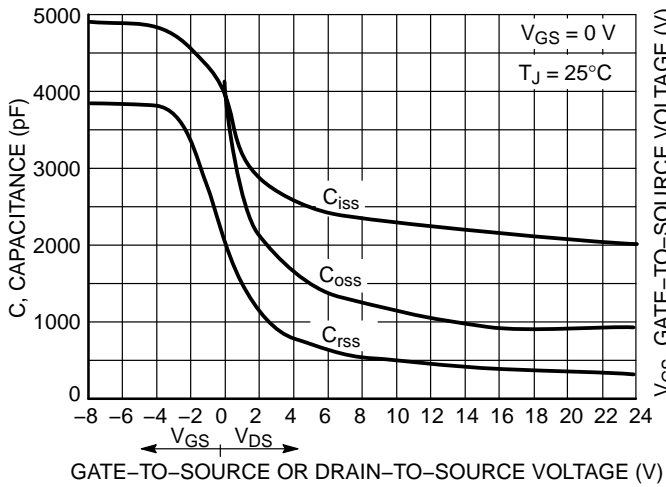


**Figure 5. On-Resistance Variation with Temperature**

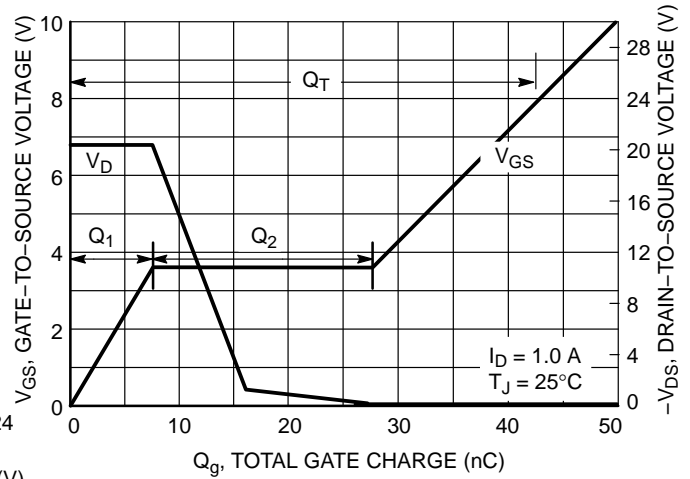


**Figure 6. Drain-to-Source Leakage Current versus Voltage**

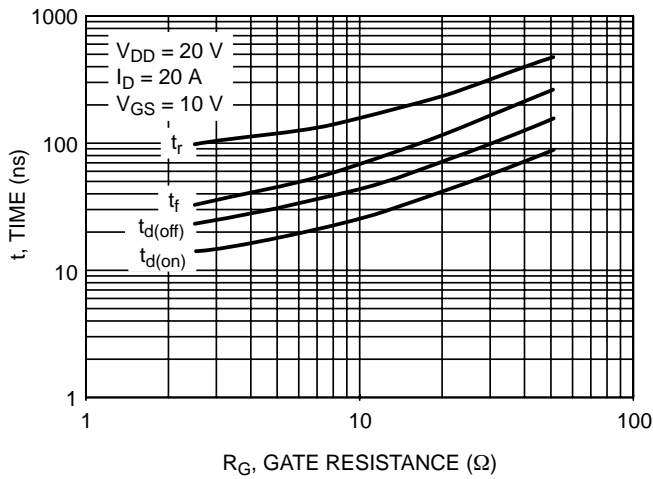
# NTB90N02, NTP90N02



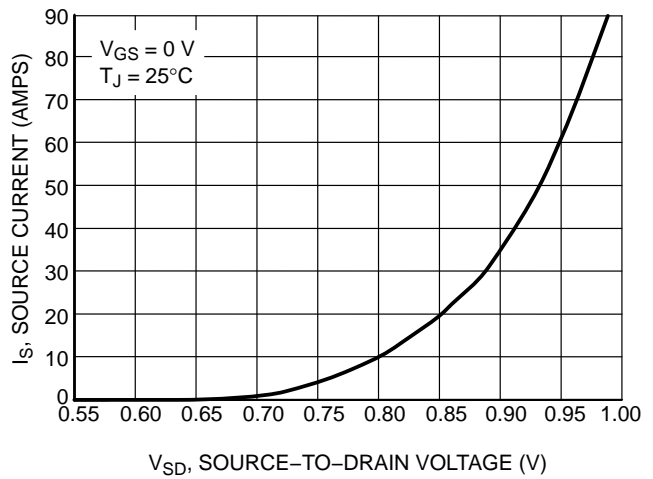
**Figure 7. Capacitance Variation**



**Figure 8. Gate-to-Source and Drain-to-Source Voltage versus Total Charge**



**Figure 9. Resistive Switching Time Variation versus Gate Resistance**



**Figure 10. Diode Forward Voltage versus Current**

## ORDERING INFORMATION

| Device      | Package                         | Shipping†       |
|-------------|---------------------------------|-----------------|
| NTP90N02    | TO-220AB                        | 50 Units / Rail |
| NTP90N02G   | TO-220AB<br>(Pb-Free)           | 50 Units / Rail |
| NTB90N02    | D <sup>2</sup> PAK              | 50 Units / Rail |
| NTB90N02G   | D <sup>2</sup> PAK<br>(Pb-Free) | 50 Units / Rail |
| NTB90N02T4  | D <sup>2</sup> PAK              | 800 Tape & Reel |
| NTB90N02T4G | D <sup>2</sup> PAK<br>(Pb-Free) | 800 Tape & Reel |

†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.

POWER MOSFET SWITCHING

Switching behavior is most easily modeled and predicted by recognizing that the power MOSFET is charge controlled. The lengths of various switching intervals ( $\Delta t$ ) are determined by how fast the FET input capacitance can be charged by current from the generator.

The published capacitance data is difficult to use for calculating rise and fall because drain-gate capacitance varies greatly with applied voltage. Accordingly, gate charge data is used. In most cases, a satisfactory estimate of average input current ( $I_{G(AV)}$ ) can be made from a rudimentary analysis of the drive circuit so that

$$t = Q/I_{G(AV)}$$

During the rise and fall time interval when switching a resistive load,  $V_{GS}$  remains virtually constant at a level known as the plateau voltage,  $V_{SGP}$ . Therefore, rise and fall times may be approximated by the following:

$$t_r = Q_2 \times R_2/10(V_{GG} - V_{GSP})$$

$$t_f = Q_2 \times R_2/V_{GSP}$$

where:

$V_{GG}$  = the gate drive voltage, which varies from zero to  $V_{GG}$

$R_G$  = the gate drive resistance and  $Q_2$  and  $V_{GSP}$  are read from the gate charge curve.

During the turn-on and turn-off delay times, gate current is not constant. The simplest calculation uses appropriate values from the capacitance curves in a standard equation for voltage change in an RC network.

The equations are:

$$t_{d(on)} = R_G C_{iss} \ln [V_{GG}/(V_{GG} - V_{GSP})]$$

$$t_{d(off)} = R_G C_{iss} \ln (V_{GG}/V_{GSP})$$

The capacitance ( $C_{iss}$ ) is read from the capacitance curve at a voltage corresponding to the off-state condition when calculating  $t_{d(on)}$  and is read at a voltage corresponding to the on-state when calculating  $t_{d(off)}$ .

At high switching speeds, parasitic circuit elements complicate the analysis. The inductance of the MOSFET source lead, inside the package and in the circuit wiring which is common to both the drain and gate current paths, produces a voltage at the source which reduces the gate drive current. The voltage is determined by  $L di/dt$ , but since  $di/dt$  is a function of drain current, the mathematical solution is complex. The MOSFET output capacitance also complicates the mathematics. And finally, MOSFETs have finite internal gate resistance which effectively adds to the resistance of the driving source, but the internal resistance is difficult to measure and, consequently, is not specified.

The resistive switching time variation versus gate resistance (Figure 9) shows how typical switching performance is affected by the parasitic circuit elements. If the parasitics were not present, the slope of the curves would maintain a value of unity regardless of the switching speed. The circuit used to obtain the data is constructed to minimize common inductance in the drain and gate circuit loops and is believed readily achievable with board mounted components. Most power electronic loads are inductive; the data in the figure is taken with a resistive load, which approximates an optimally snubbed inductive load. Power MOSFETs may be safely operated into an inductive load; however, snubbing reduces switching losses.

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



## TO-220 CASE 221A ISSUE AK

DATE 13 JAN 2022



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 2009.
2. CONTROLLING DIMENSION: INCHES
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
4. MAX WIDTH FOR F102 DEVICE = 1.35MM

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN.   | MAX.  | MIN.        | MAX.  |
| A   | 0.570  | 0.620 | 14.48       | 15.75 |
| B   | 0.380  | 0.415 | 9.66        | 10.53 |
| C   | 0.160  | 0.190 | 4.07        | 4.83  |
| D   | 0.025  | 0.038 | 0.64        | 0.96  |
| F   | 0.142  | 0.161 | 3.60        | 4.09  |
| G   | 0.095  | 0.105 | 2.42        | 2.66  |
| H   | 0.110  | 0.161 | 2.80        | 4.10  |
| J   | 0.014  | 0.024 | 0.36        | 0.61  |
| K   | 0.500  | 0.562 | 12.70       | 14.27 |
| L   | 0.045  | 0.060 | 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        | 1.41  |
| 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 1:  
PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

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

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

STYLE 4:  
PIN 1. MAIN TERMINAL 1  
2. MAIN TERMINAL 2  
3. GATE  
4. MAIN TERMINAL 2

STYLE 5:  
PIN 1. GATE  
2. DRAIN  
3. SOURCE  
4. DRAIN

STYLE 6:  
PIN 1. ANODE  
2. CATHODE  
3. ANODE  
4. CATHODE

STYLE 7:  
PIN 1. CATHODE  
2. ANODE  
3. CATHODE  
4. ANODE

STYLE 8:  
PIN 1. CATHODE  
2. ANODE  
3. EXTERNAL TRIP/DELAY  
4. ANODE

STYLE 9:  
PIN 1. GATE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR

STYLE 10:  
PIN 1. GATE  
2. SOURCE  
3. DRAIN  
4. SOURCE

STYLE 11:  
PIN 1. DRAIN  
2. SOURCE  
3. GATE  
4. SOURCE

STYLE 12:  
PIN 1. MAIN TERMINAL 1  
2. MAIN TERMINAL 2  
3. GATE  
4. NOT CONNECTED

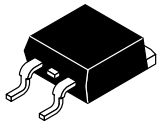
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| DESCRIPTION:     | TO-220      | PAGE 1 OF 1                                                                                                                                                                      |

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# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

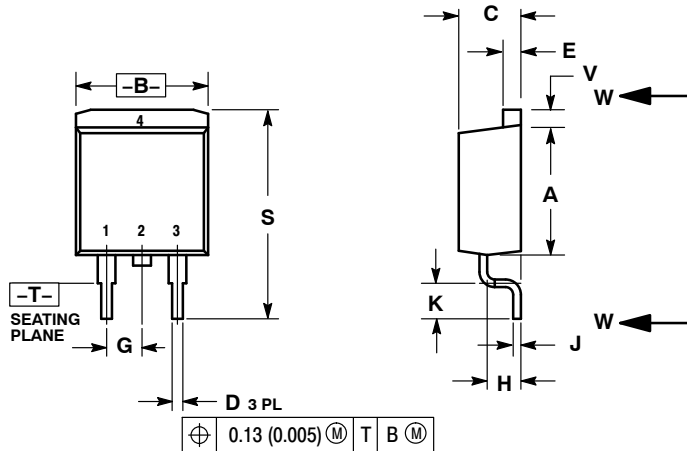
ON Semiconductor®



**D<sup>2</sup>PAK 3**  
CASE 418B-04  
ISSUE L

DATE 17 FEB 2015

SCALE 1:1

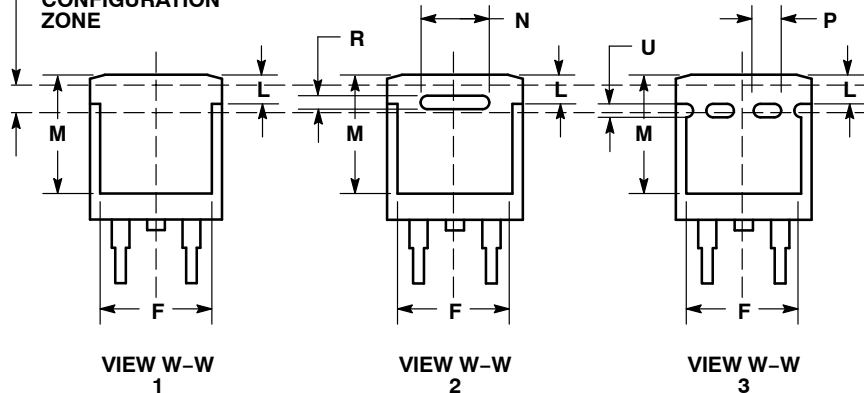


**NOTES:**

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  |

**VARIABLE CONFIGURATION ZONE**



- |                                                                              |                                                                     |                                                                         |                                                                              |                                                                         |                                                                              |
|------------------------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------|
| <b>STYLE 1:</b><br>PIN 1. BASE<br>2. COLLECTOR<br>3. EMITTER<br>4. COLLECTOR | <b>STYLE 2:</b><br>PIN 1. GATE<br>2. DRAIN<br>3. SOURCE<br>4. DRAIN | <b>STYLE 3:</b><br>PIN 1. ANODE<br>2. CATHODE<br>3. ANODE<br>4. CATHODE | <b>STYLE 4:</b><br>PIN 1. GATE<br>2. COLLECTOR<br>3. EMITTER<br>4. COLLECTOR | <b>STYLE 5:</b><br>PIN 1. CATHODE<br>2. ANODE<br>3. CATHODE<br>4. ANODE | <b>STYLE 6:</b><br>PIN 1. NO CONNECT<br>2. CATHODE<br>3. ANODE<br>4. CATHODE |
|------------------------------------------------------------------------------|---------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------|

**MARKING INFORMATION AND FOOTPRINT ON PAGE 2**

|                         |                           |                                                                                                                                                                                  |
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| <b>DESCRIPTION:</b>     | <b>D<sup>2</sup>PAK 3</b> | <b>PAGE 1 OF 2</b>                                                                                                                                                               |

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**D<sup>2</sup>PAK 3**  
CASE 418B-04  
ISSUE L

DATE 17 FEB 2015

**GENERIC  
MARKING DIAGRAM\***



- xx = Specific Device Code
- A = Assembly Location
- WL = Wafer Lot
- Y = Year
- WW = Work Week
- G = Pb-Free Package
- AKA = Polarity Indicator

\*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.

**SOLDERING FOOTPRINT\***



\*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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