

# NDF04N60Z, NDP04N60Z, NDD04N60Z

## N-Channel Power MOSFET 1.8 $\Omega$ , 600 Volts

### Features

- Low ON Resistance
- Low Gate Charge
- 100% Avalanche Tested
- These Devices are Pb-Free and are RoHS Compliant

### Applications

- Adapter (Notebook, Printer, Gaming)
- LCD Panel Power
- Lighting Ballasts

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

| Rating                                                                                                     | Symbol             | NDF          | NDD/NDP | Unit             |
|------------------------------------------------------------------------------------------------------------|--------------------|--------------|---------|------------------|
| Drain-to-Source Voltage                                                                                    | $V_{DS}$           | 600 (Note 1) |         | V                |
| Continuous Drain Current                                                                                   | $I_D$              | 4.0 (Note 2) |         | A                |
| Continuous Drain Current<br>$T_A = 100^\circ\text{C}$                                                      | $I_D$              | 2.7 (Note 2) |         | A                |
| Pulsed Drain Current, $V_{GS} @ 10\text{V}$                                                                | $I_{DM}$           | 14 (Note 2)  |         | A                |
| Power Dissipation (Note 1)                                                                                 | $P_D$              | 28           | 95      | W                |
| Gate-to-Source Voltage                                                                                     | $V_{GS}$           | $\pm 30$     |         | V                |
| Single Pulse Avalanche Energy,<br>$L = 6.4\text{ mH}$ , $I_D = 4.0\text{ A}$                               | $E_{AS}$           | 51           |         | mJ               |
| ESD (HBM) (JESD 22-114-B)                                                                                  | $V_{ESD}$          | 2500         |         | V                |
| RMS Isolation Voltage ( $t = 0.3$<br>sec., R.H. $\leq 30\%$ , $T_A = 25^\circ\text{C}$ )<br>(Figure 13)    | $V_{ISO}$          | 4500         | –       | V                |
| Peak Diode Recovery                                                                                        | $dv/dt$            | 4.5 (Note 3) |         | V/ns             |
| Continuous Source Current<br>(Body Diode)                                                                  | $I_S$              | 4.0          |         | A                |
| Maximum Temperature for<br>Soldering Leads, 0.063"<br>(1.6 mm) from Case for 10 s<br>Package Body for 10 s | $T_L$<br>$T_{PKG}$ | 300<br>260   |         | $^\circ\text{C}$ |
| Operating Junction and<br>Storage Temperature Range                                                        | $T_J$ , $T_{stg}$  | –55 to 150   |         | $^\circ\text{C}$ |

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.

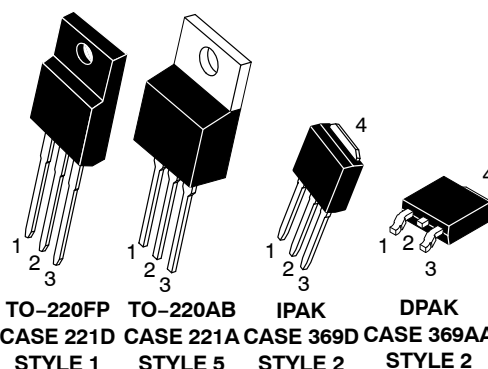
1. Surface mounted on FR4 board using 1" sq. pad size, 1 oz cu
2. Limited by maximum junction temperature
3.  $I_{SD} = 4.0\text{ A}$ ,  $di/dt \leq 100\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq BV_{DS}$ ,  $T_J = +150^\circ\text{C}$



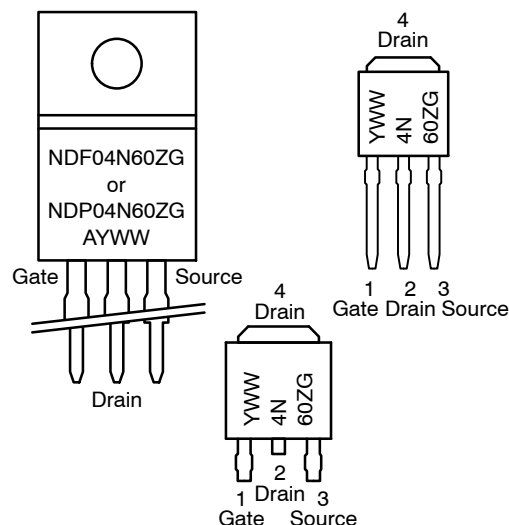
ON Semiconductor®

<http://onsemi.com>

| $V_{DS}$ | $R_{DS(ON)}$ (TYP) @ 2 A |
|----------|--------------------------|
| 600 V    | 1.8 $\Omega$             |



### MARKING DIAGRAMS



A = Location Code  
Y = Year  
WW = Work Week  
G = Pb-Free Package

### ORDERING INFORMATION

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

# NDF04N60Z, NDP04N60Z, NDD04N60Z

## THERMAL RESISTANCE

| Parameter                                 | Symbol          | NDF04N60Z | NDD/NDP | Unit                 |
|-------------------------------------------|-----------------|-----------|---------|----------------------|
| Junction-to-Case (Drain)                  | $R_{\theta JC}$ | 4.4       | 1.3     | $^{\circ}\text{C/W}$ |
| Junction-to-Ambient Steady State (Note 4) | $R_{\theta JA}$ | 50        | 50      |                      |

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

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

### OFF CHARACTERISTICS

|                                           |                                                            |                              |     |     |          |                             |
|-------------------------------------------|------------------------------------------------------------|------------------------------|-----|-----|----------|-----------------------------|
| Drain-to-Source Breakdown Voltage         | $V_{GS} = 0\text{ V}, I_D = 1\text{ mA}$                   | $BV_{DSS}$                   | 600 |     |          | V                           |
| Breakdown Voltage Temperature Coefficient | Reference to $25^{\circ}\text{C}$ ,<br>$I_D = 1\text{ mA}$ | $\Delta BV_{DSS}/\Delta T_J$ |     | 0.6 |          | $\text{V}/^{\circ}\text{C}$ |
| Drain-to-Source Leakage Current           | $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$               | $I_{DSS}$                    |     |     | 1        | $\mu\text{A}$               |
|                                           |                                                            |                              |     |     | 50       |                             |
| Gate-to-Source Forward Leakage            | $V_{GS} = \pm 20\text{ V}$                                 | $I_{GSS}$                    |     |     | $\pm 10$ | $\mu\text{A}$               |

### ON CHARACTERISTICS (Note 5)

|                                      |                                                 |              |     |     |     |          |
|--------------------------------------|-------------------------------------------------|--------------|-----|-----|-----|----------|
| Static Drain-to-Source On-Resistance | $V_{GS} = 10\text{ V}, I_D = 2.0\text{ A}$      | $R_{DS(on)}$ |     | 1.8 | 2.0 | $\Omega$ |
| Gate Threshold Voltage               | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ | $V_{GS(th)}$ | 3.0 |     | 4.5 | V        |
| Forward Transconductance             | $V_{DS} = 15\text{ V}, I_D = 2.0\text{ A}$      | $g_{FS}$     |     | 3.3 |     | S        |

### DYNAMIC CHARACTERISTICS

|                                 |                                                                        |           |  |     |  |          |
|---------------------------------|------------------------------------------------------------------------|-----------|--|-----|--|----------|
| Input Capacitance               | $V_{DS} = 25\text{ V}, V_{GS} = 0\text{ V},$<br>$f = 1.0\text{ MHz}$   | $C_{iss}$ |  | 535 |  | pF       |
| Output Capacitance              |                                                                        | $C_{oss}$ |  | 62  |  |          |
| Reverse Transfer Capacitance    |                                                                        | $C_{rss}$ |  | 14  |  |          |
| Total Gate Charge               | $V_{DD} = 300\text{ V}, I_D = 4.0\text{ A},$<br>$V_{GS} = 10\text{ V}$ | $Q_g$     |  | 19  |  | nC       |
| Gate-to-Source Charge           |                                                                        | $Q_{gs}$  |  | 3.9 |  |          |
| Gate-to-Drain ("Miller") Charge |                                                                        | $Q_{gd}$  |  | 10  |  |          |
| Gate Resistance                 |                                                                        | $R_g$     |  | 4.7 |  | $\Omega$ |

### RESISTIVE SWITCHING CHARACTERISTICS

|                     |                                                                                               |              |  |     |  |    |
|---------------------|-----------------------------------------------------------------------------------------------|--------------|--|-----|--|----|
| Turn-On Delay Time  | $V_{DD} = 300\text{ V}, I_D = 4.0\text{ A},$<br>$V_{GS} = 10\text{ V}, R_G = 5\text{ }\Omega$ | $t_{d(on)}$  |  | 13  |  | ns |
| Rise Time           |                                                                                               | $t_r$        |  | 9.0 |  |    |
| Turn-Off Delay Time |                                                                                               | $t_{d(off)}$ |  | 24  |  |    |
| Fall Time           |                                                                                               | $t_f$        |  | 15  |  |    |

### SOURCE-DRAIN DIODE CHARACTERISTICS ( $T_C = 25^{\circ}\text{C}$ unless otherwise noted)

|                         |                                                                                                       |          |  |     |     |               |
|-------------------------|-------------------------------------------------------------------------------------------------------|----------|--|-----|-----|---------------|
| Diode Forward Voltage   | $I_S = 4.0\text{ A}, V_{GS} = 0\text{ V}$                                                             | $V_{SD}$ |  |     | 1.6 | V             |
| Reverse Recovery Time   | $V_{GS} = 0\text{ V}, V_{DD} = 30\text{ V}$<br>$I_S = 4.0\text{ A}, di/dt = 100\text{ A}/\mu\text{s}$ | $t_{rr}$ |  | 285 |     | ns            |
| Reverse Recovery Charge |                                                                                                       | $Q_{rr}$ |  | 1.3 |     | $\mu\text{C}$ |

4. Insertion mounted

5. Pulse Width  $\leq 380\text{ }\mu\text{s}$ , Duty Cycle  $\leq 2\%$ .

TYPICAL CHARACTERISTICS

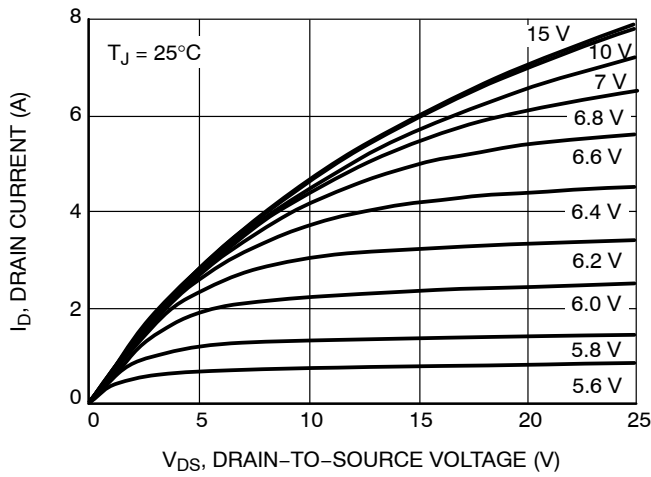


Figure 1. On-Region Characteristics

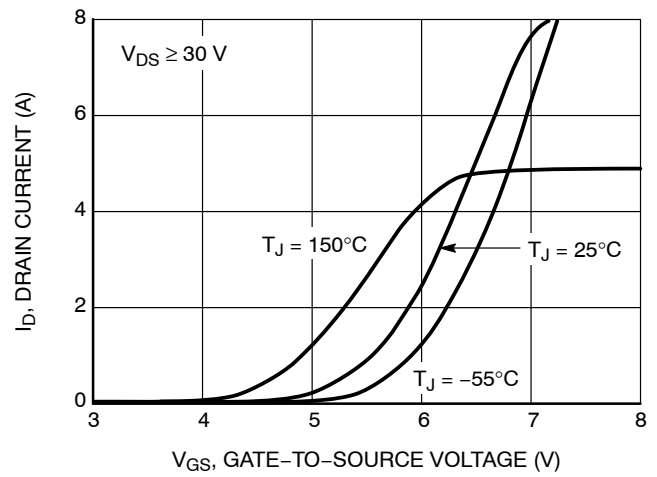


Figure 2. Transfer Characteristics

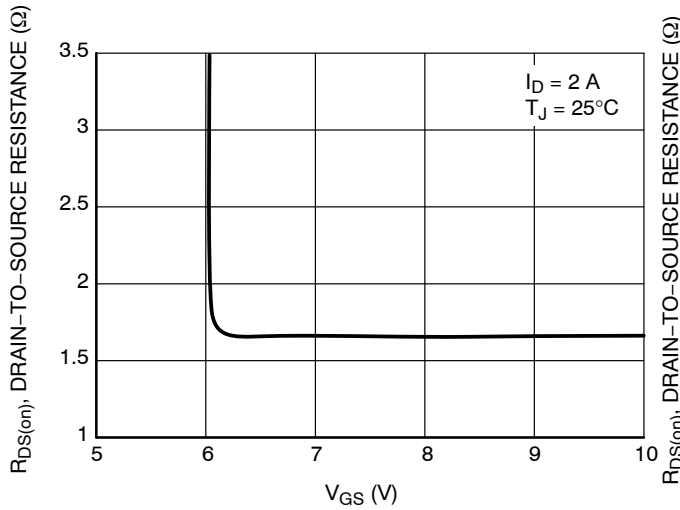


Figure 3. On-Resistance vs. Gate Voltage

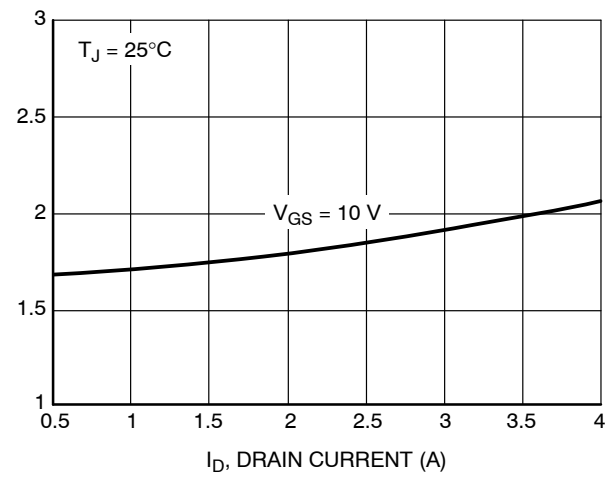


Figure 4. On-Resistance vs. Drain Current and Gate Voltage

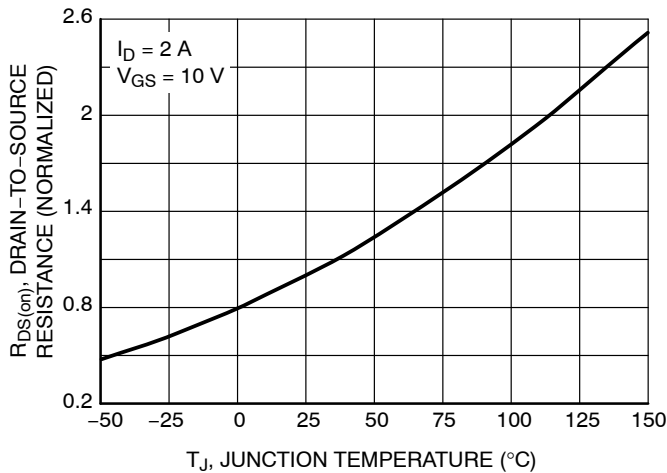


Figure 5. On-Resistance Variation with Temperature

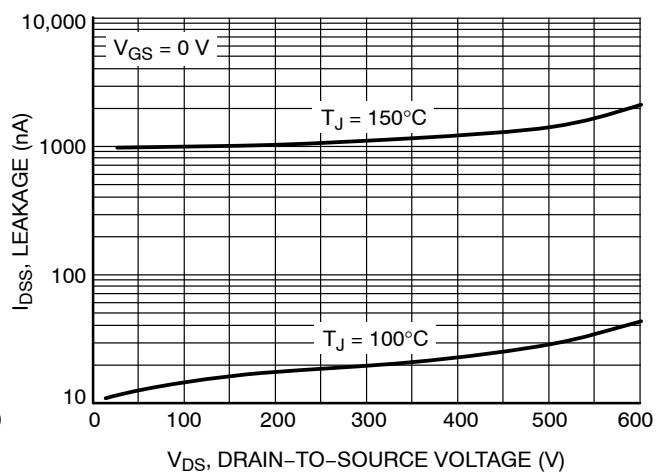


Figure 6. Drain-to-Source Leakage Current vs. Voltage

TYPICAL CHARACTERISTICS

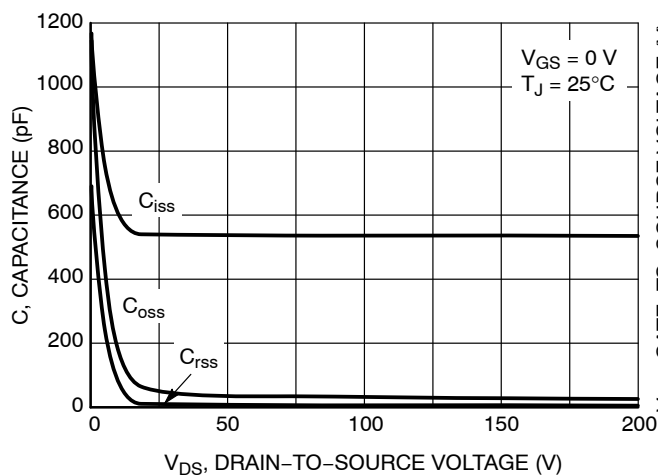


Figure 7. Capacitance Variation

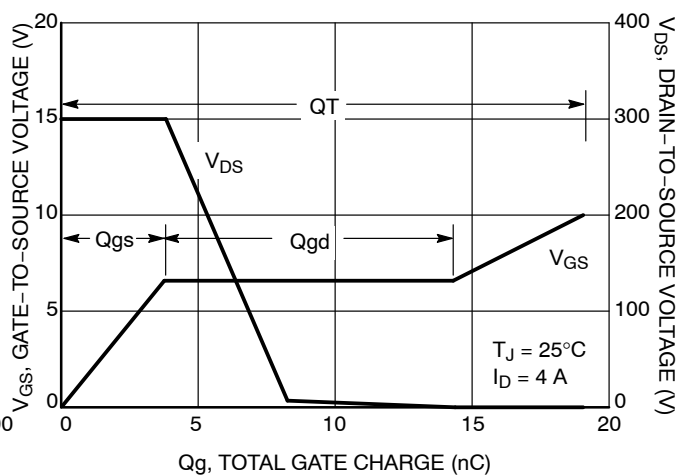


Figure 8. Gate-to-Source and Drain-to-Source Voltage vs. Total Charge

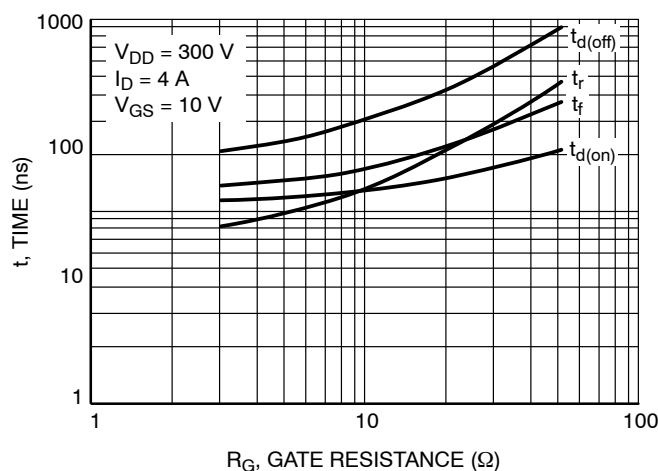


Figure 9. Resistive Switching Time Variation vs. Gate Resistance

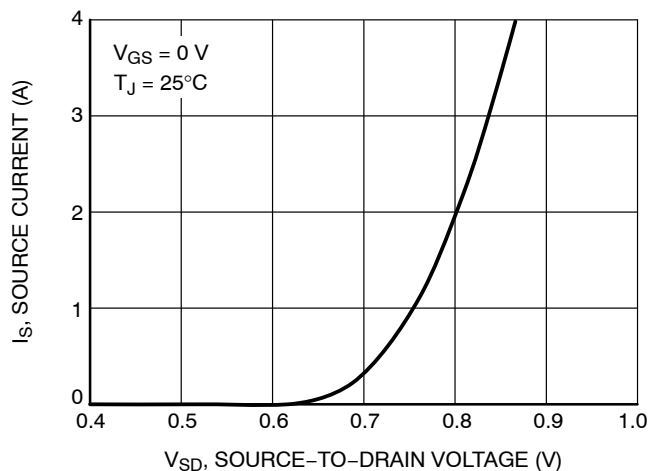


Figure 10. Diode Forward Voltage vs. Current

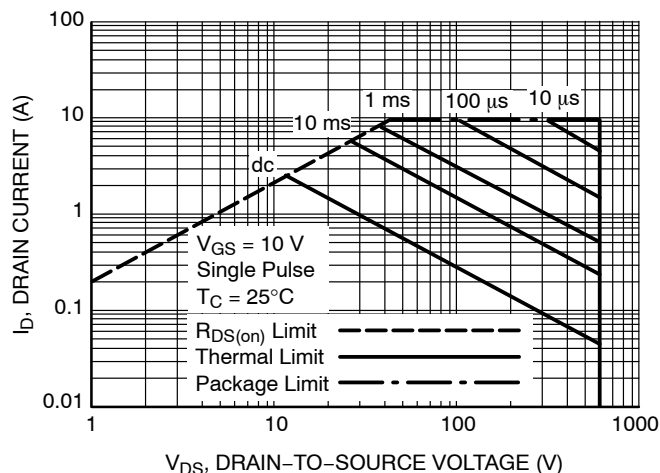


Figure 11. Maximum Rated Forward Biased Safe Operating Area for NDF04N60Z

# NDF04N60Z, NDP04N60Z, NDD04N60Z

## TYPICAL CHARACTERISTICS

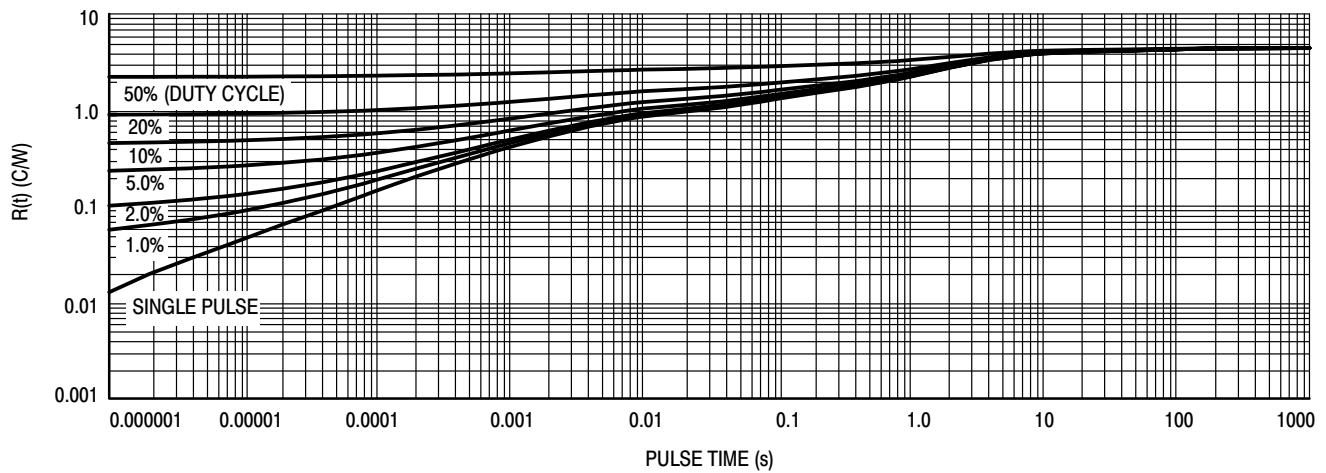


Figure 12. Thermal Impedance for NDF04N60Z

## ORDERING INFORMATION

| Order Number | Package               | Shipping <sup>†</sup> |
|--------------|-----------------------|-----------------------|
| NDF04N60ZG   | TO-220FP<br>(Pb-Free) | 50 Units / Rail       |
| NDP04N60ZG   | TO-220AB<br>(Pb-Free) | In Development        |
| NDD04N60Z-1G | IPAK<br>(Pb-Free)     | In Development        |
| NDD04N60ZG   | DPAK<br>(Pb-Free)     | In Development        |

<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.

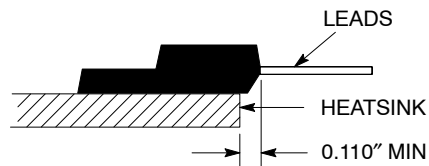


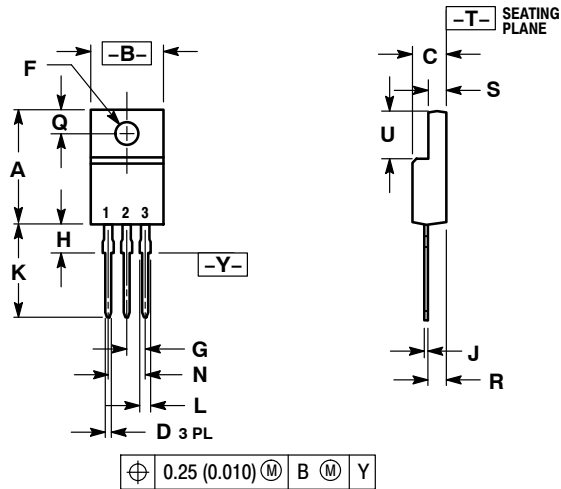
Figure 13. Mounting Position for Isolation Test

Measurement made between leads and heatsink with all leads shorted together.

# NDF04N60Z, NDP04N60Z, NDD04N60Z

## PACKAGE DIMENSIONS

### TO-220 FULLPAK CASE 221D-03 ISSUE J

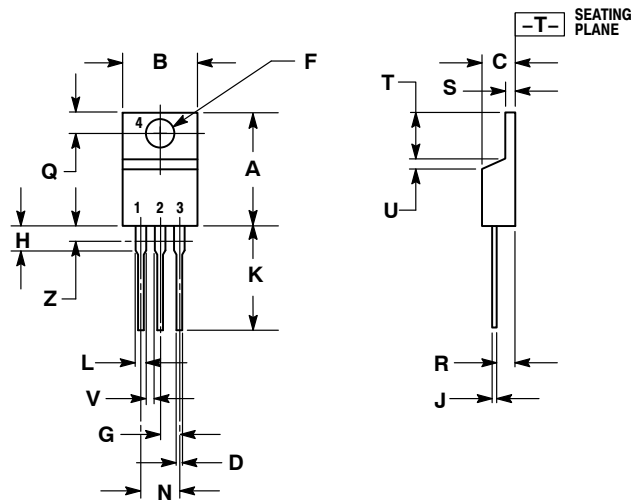


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH
  3. 221D-01 THRU 221D-02 OBSOLETE, NEW STANDARD 221D-03.

| 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  |

- STYLE 1:
- PIN 1. GATE
  - DRAIN
  - SOURCE

### TO-220AB CASE 221A-09 ISSUE AE



- 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.

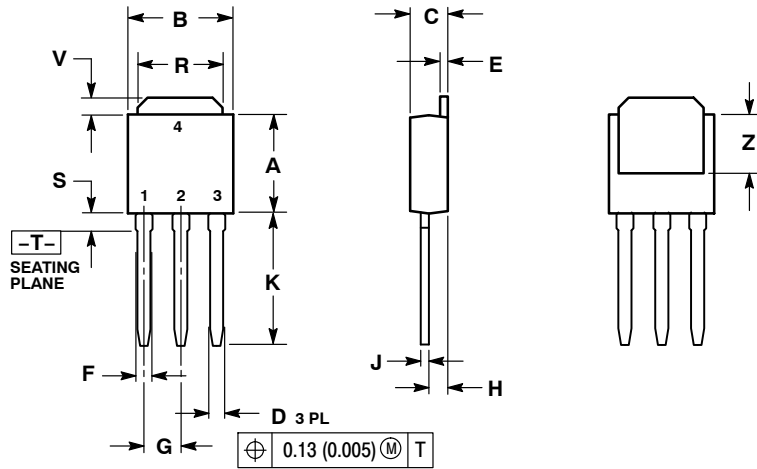
| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | MIN    | MAX   | MIN         | MAX   |
| A   | 0.570  | 0.620 | 14.48       | 15.75 |
| B   | 0.380  | 0.405 | 9.66        | 10.28 |
| C   | 0.160  | 0.190 | 4.07        | 4.82  |
| D   | 0.025  | 0.035 | 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  | 0.060 | 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        | 1.39  |
| 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:
- PIN 1. GATE
  - DRAIN
  - SOURCE
  - DRAIN

# NDF04N60Z, NDP04N60Z, NDD04N60Z

## PACKAGE DIMENSIONS

**IPAK**  
CASE 369D-01  
ISSUE B



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.

| DIM | INCHES    |       | MILLIMETERS |      |
|-----|-----------|-------|-------------|------|
|     | MIN       | MAX   | MIN         | MAX  |
| A   | 0.235     | 0.245 | 5.97        | 6.35 |
| B   | 0.250     | 0.265 | 6.35        | 6.73 |
| C   | 0.086     | 0.094 | 2.19        | 2.38 |
| D   | 0.027     | 0.035 | 0.69        | 0.88 |
| E   | 0.018     | 0.023 | 0.46        | 0.58 |
| F   | 0.037     | 0.045 | 0.94        | 1.14 |
| G   | 0.090 BSC |       | 2.29 BSC    |      |
| H   | 0.034     | 0.040 | 0.87        | 1.01 |
| J   | 0.018     | 0.023 | 0.46        | 0.58 |
| K   | 0.350     | 0.380 | 8.89        | 9.65 |
| R   | 0.180     | 0.215 | 4.45        | 5.45 |
| S   | 0.025     | 0.040 | 0.63        | 1.01 |
| V   | 0.035     | 0.050 | 0.89        | 1.27 |
| Z   | 0.155     | ---   | 3.93        | ---  |

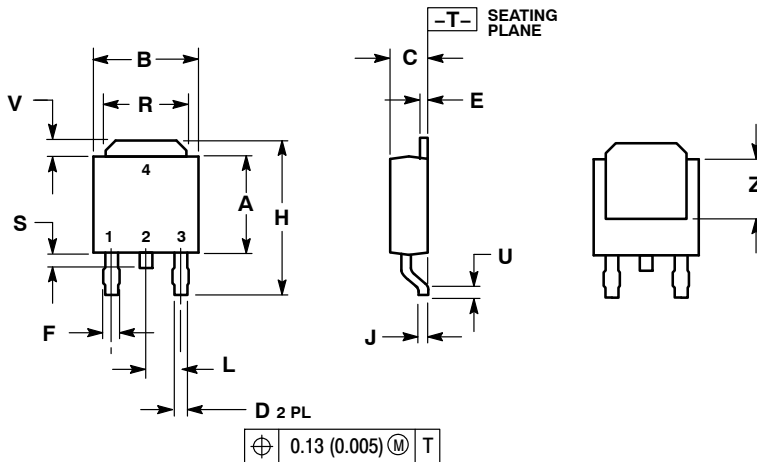
STYLE 2:

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

# NDF04N60Z, NDP04N60Z, NDD04N60Z

## PACKAGE DIMENSIONS

DPAK  
CASE 369AA-01  
ISSUE A

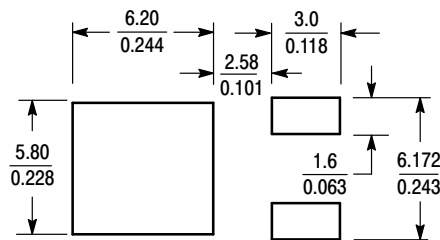


- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.235     | 0.245 | 5.97        | 6.22  |
| B   | 0.250     | 0.265 | 6.35        | 6.73  |
| C   | 0.086     | 0.094 | 2.19        | 2.38  |
| D   | 0.025     | 0.035 | 0.63        | 0.89  |
| E   | 0.018     | 0.024 | 0.46        | 0.61  |
| F   | 0.030     | 0.045 | 0.77        | 1.14  |
| H   | 0.386     | 0.410 | 9.80        | 10.40 |
| J   | 0.018     | 0.023 | 0.46        | 0.58  |
| L   | 0.090 BSC |       | 2.29 BSC    |       |
| R   | 0.180     | 0.215 | 4.57        | 5.45  |
| S   | 0.024     | 0.040 | 0.60        | 1.01  |
| U   | 0.020     | ---   | 0.51        | ---   |
| V   | 0.035     | 0.050 | 0.89        | 1.27  |
| Z   | 0.155     | ---   | 3.93        | ---   |

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

## 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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