# NDF04N60Z, NDD04N60Z

# Power MOSFET, N-Channel, 600 V, 2.0 Ω

**Features**
- Low ON Resistance
- Low Gate Charge
- ESD Diode−Protected Gate
- 100% Avalanche Tested
- These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

**ON Semiconductor®**

www.onsemi.com

| $V_{DSS}$ (@ $T_{Jmax}$) | $R_{DS(on)}$ (MAX) @ 2 A |
|---|---|
| 650 V | 2.0 Ω |

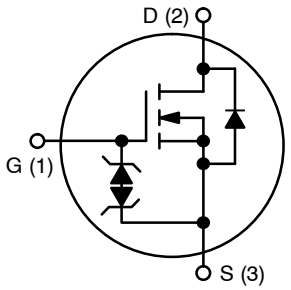
**ABSOLUTE MAXIMUM RATINGS** ($T_C$ = 25°C unless otherwise noted)

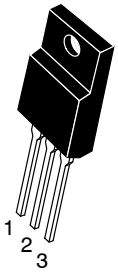
| Parameter | Symbol | NDF | NDD | Unit |
|---|---|---|---|---|
| Drain−to−Source Voltage | $V_{DSS}$ | 600 | | V |
| Continuous Drain Current $R_{\theta JC}$ (Note 1) | $I_D$ | 4.8 | 4.1 | A |
| Continuous Drain Current $R_{\theta JC}$, $T_A$ = 100°C (Note 1) | $I_D$ | 3.0 | 2.6 | A |
| Pulsed Drain Current, $V_{GS}$ @ 10V | $I_{DM}$ | 20 | 20 | A |
| Power Dissipation $R_{\theta JC}$ | $P_D$ | 30 | 83 | W |
| Gate−to−Source Voltage | $V_{GS}$ | ±30 | | V |
| Single Pulse Avalanche Energy, $I_D$ = 4.0 A | $E_{AS}$ | 120 | | mJ |
| ESD (HBM) (JESD22−A114) | $V_{esd}$ | 3000 | | V |
| RMS Isolation Voltage (t = 0.3 sec., R.H. ≤ 30%, $T_A$ = 25°C) (Figure 15) | $V_{ISO}$ | 4500 | – | V |
| Peak Diode Recovery (Note 2) | dV/dt | 4.5 | | V/ns |
| MOSFET dV/dt | dV/dt | 60 | | V/ns |
| Continuous Source Current (Body Diode) | $I_S$ | 4.0 | | A |
| Maximum Temperature for Soldering Leads | $T_L$ | 260 | | °C |
| Operating Junction and Storage Temperature Range | $T_J$, $T_{stg}$ | −55 to 150 | | °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.

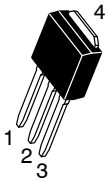
1. Limited by maximum junction temperature
2. $I_{SD}$ = 4.0 A, di/dt ≤ 100 A/μs, $V_{DD}$ ≤ $BV_{DSS}$, $T_J$ = +150°C

**N−Channel**

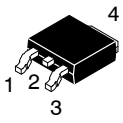



**NDF04N60ZG,**
**NDF04N60ZH**
**TO−220FP**
**CASE 221AH**




**NDD04N60Z−1G**
**IPAK**
**CASE 369D**




**NDD04N60ZT4G**
**DPAK**
**CASE 369AA**

## ORDERING AND MARKING INFORMATION

See detailed ordering, marking and shipping information on page 6 of this data sheet.

## THERMAL RESISTANCE

| Parameter | | Symbol | Value | Unit |
|---|---|---|---|---|
| Junction−to−Case (Drain) | NDF04N60Z<br>NDD04N60Z | $R_{\theta JC}$ | 4.2<br>1.5 | °C/W |
| Junction−to−Ambient Steady State | (Note 3) NDF04N60Z<br>(Note 4) NDD04N60Z<br>(Note 3) NDD04N60Z−1 | $R_{\theta JA}$ | 50<br>38<br>80 | |

3. Insertion mounted
4. Surface mounted on FR4 board using 1″ sq. pad size (Cu area = 1.127 in sq [2 oz] including traces).

## ELECTRICAL CHARACTERISTICS ($T_J$ = 25°C unless otherwise noted)

| Characteristic | Test Conditions | | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | | | |
| Drain−to−Source Breakdown Voltage | $V_{GS}$ = 0 V, $I_D$ = 1 mA | | $BV_{DSS}$ | 600 | | | V |
| Breakdown Voltage Temperature Coefficient | Reference to 25°C, $I_D$ = 1 mA | | $\Delta BV_{DSS}/\Delta T_J$ | | 0.6 | | V/°C |
| Drain−to−Source Leakage Current | $V_{DS}$ = 600 V, $V_{GS}$ = 0 V | 25°C | $I_{DSS}$ | | | 1 | μA |
| | | 150°C | | | | 50 | |
| Gate−to−Source Forward Leakage | $V_{GS}$ = ±20 V | | $I_{GSS}$ | | | ±10 | μA |
| **ON CHARACTERISTICS** (Note 5) | | | | | | | |
| Static Drain−to−Source On−Resistance | $V_{GS}$ = 10 V, $I_D$ = 2.0 A | | $R_{DS(on)}$ | | 1.8 | 2.0 | Ω |
| Gate Threshold Voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 50 μA | | $V_{GS(th)}$ | 3.0 | 3.9 | 4.5 | V |
| Forward Transconductance | $V_{DS}$ = 15 V, $I_D$ = 2.0 A | | $g_{FS}$ | | 3.3 | | S |
| **DYNAMIC CHARACTERISTICS** | | | | | | | |
| Input Capacitance (Note 6) | $V_{DS}$ = 25 V, $V_{GS}$ = 0 V, f = 1.0 MHz | | $C_{iss}$ | 427 | 535 | 640 | pF |
| Output Capacitance (Note 6) | | | $C_{oss}$ | 50 | 62 | 75 | |
| Reverse Transfer Capacitance (Note 6) | | | $C_{rss}$ | 8 | 14 | 20 | |
| Total Gate Charge (Note 6) | $V_{DD}$ = 300 V, $I_D$ = 4.0 A, $V_{GS}$ = 10 V | | $Q_g$ | 10 | 19 | 29 | nC |
| Gate−to−Source Charge (Note 6) | | | $Q_{gs}$ | 2 | 3.9 | 6 | |
| Gate−to−Drain (“Miller”) Charge | | | $Q_{gd}$ | 5 | 10 | 15 | nC |
| Plateau Voltage | | | $V_{GP}$ | | 6.5 | | V |
| Gate Resistance | | | $R_g$ | | 4.7 | | Ω |
| **RESISTIVE SWITCHING CHARACTERISTICS** | | | | | | | |
| Turn−On Delay Time | $V_{DD}$ = 300 V, $I_D$ = 4.0 A, $V_{GS}$ = 10 V, $R_G$ = 5 Ω | | $t_{d(on)}$ | | 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°C unless otherwise noted)

| | | | | | | |
|---|---|---|---|---|---|---|
| Diode Forward Voltage | $I_S$ = 4.0 A, $V_{GS}$ = 0 V | $V_{SD}$ | | | 1.6 | V |
| Reverse Recovery Time | $V_{GS}$ = 0 V, $V_{DD}$ = 30 V, $I_S$ = 4.0 A, di/dt = 100 A/μs | $t_{rr}$ | | 285 | | ns |
| Reverse Recovery Charge | | $Q_{rr}$ | | 1.3 | | 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.

5. Pulse Width ≤ 380 μs, Duty Cycle ≤ 2%.
6. Guaranteed by design.

## TYPICAL CHARACTERISTICS

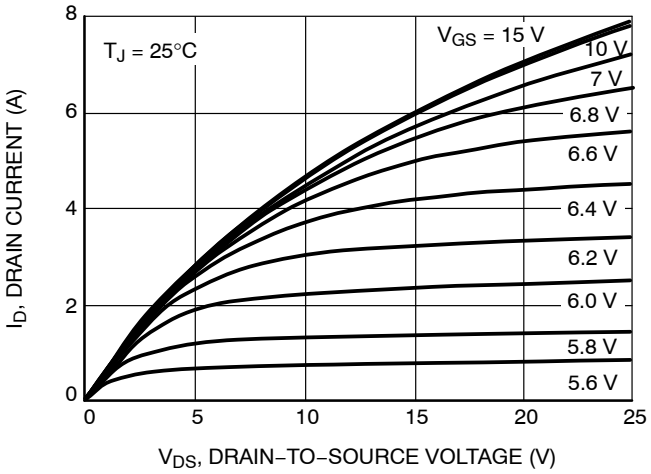



**Figure 1. On−Region Characteristics**

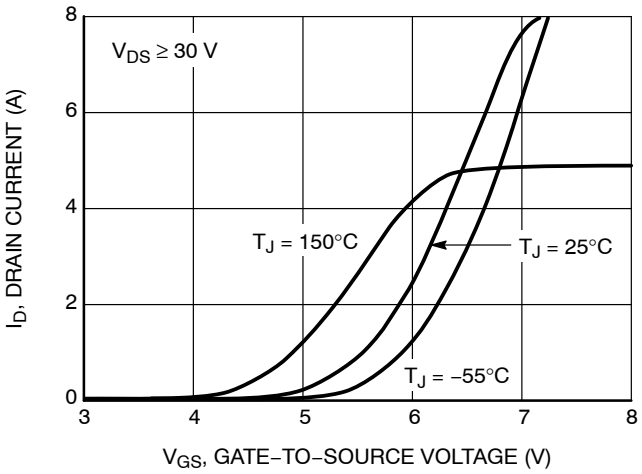



**Figure 2. Transfer Characteristics**

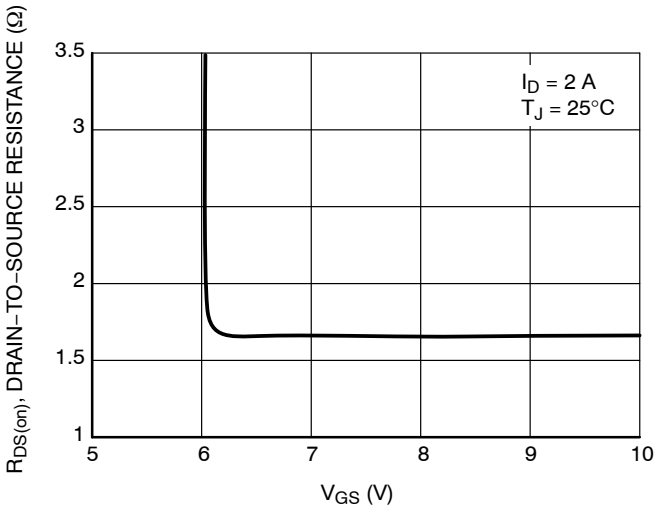



**Figure 3. On−Resistance vs. Gate Voltage**

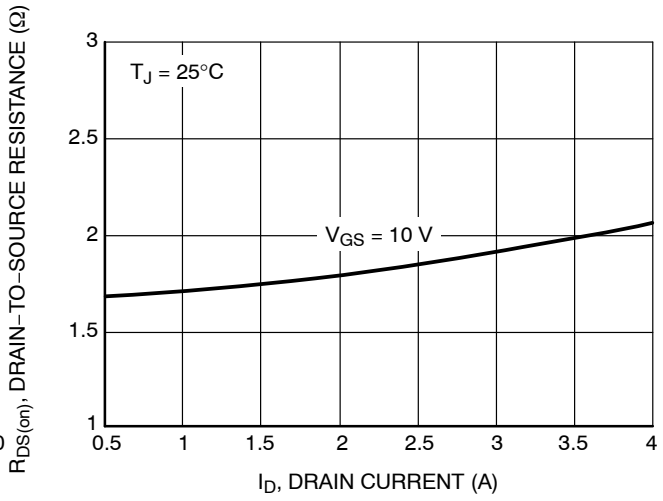



**Figure 4. On−Resistance vs. Drain Current and Gate Voltage**

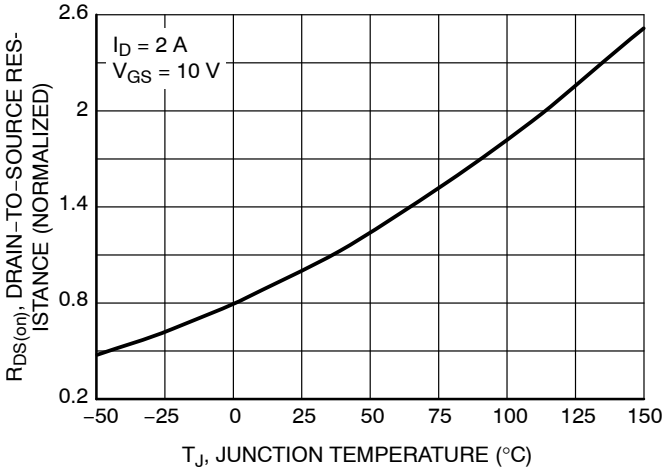



**Figure 5. On−Resistance Variation with Temperature**

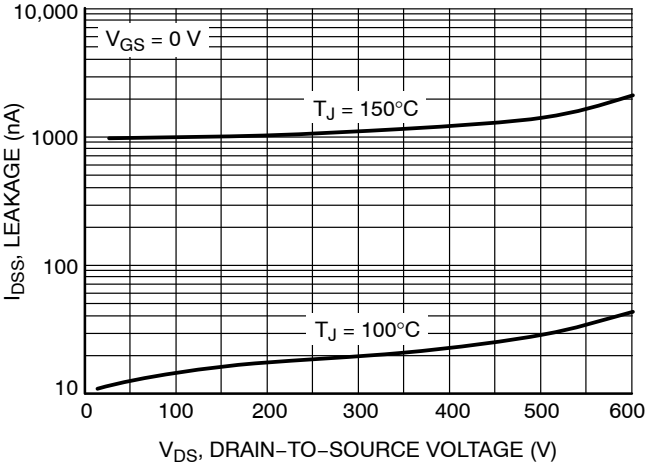



**Figure 6. Drain−to−Source Leakage Current vs. Voltage**

## TYPICAL CHARACTERISTICS

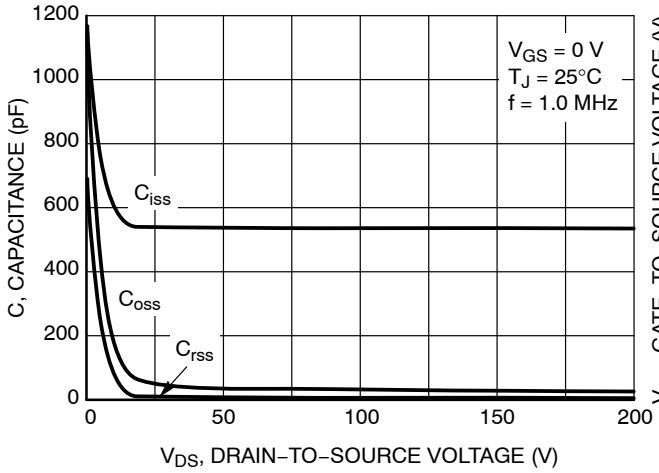



**Figure 7. Capacitance Variation**

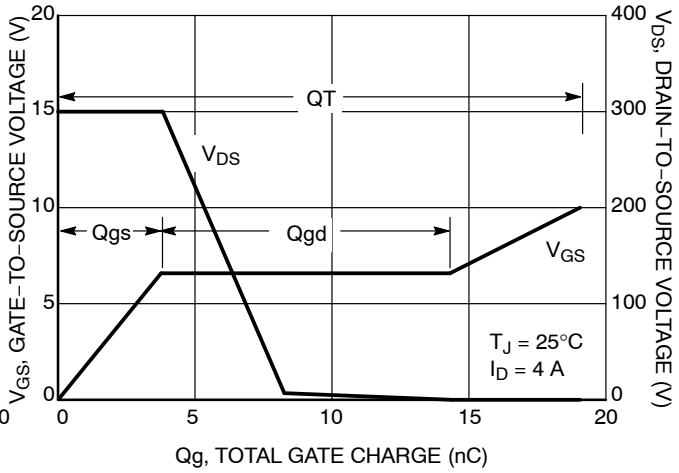



**Figure 8. Gate−to−Source and Drain−to−Source Voltage vs. Total Charge**

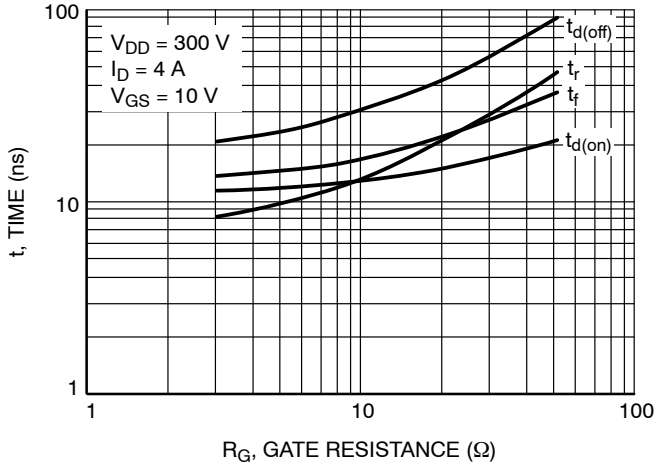



**Figure 9. Resistive Switching Time Variation vs. Gate Resistance**

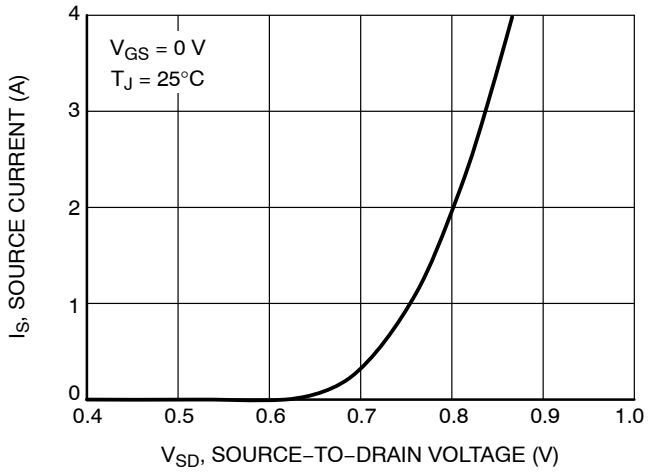



**Figure 10. Diode Forward Voltage vs. Current**

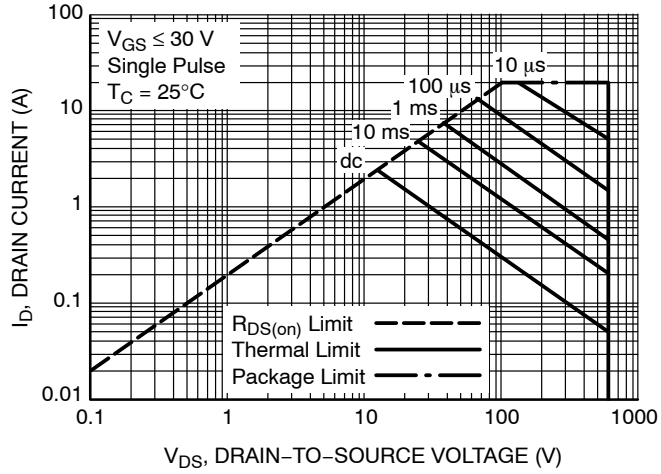



**Figure 11. Maximum Rated Forward Biased Safe Operating Area for NDF04N60Z**

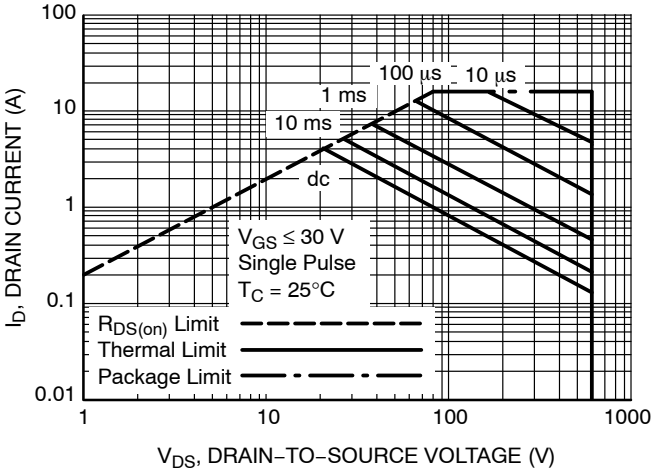



**Figure 12. Maximum Rated Forward Biased Safe Operating Area for NDD04N60Z**

## TYPICAL CHARACTERISTICS

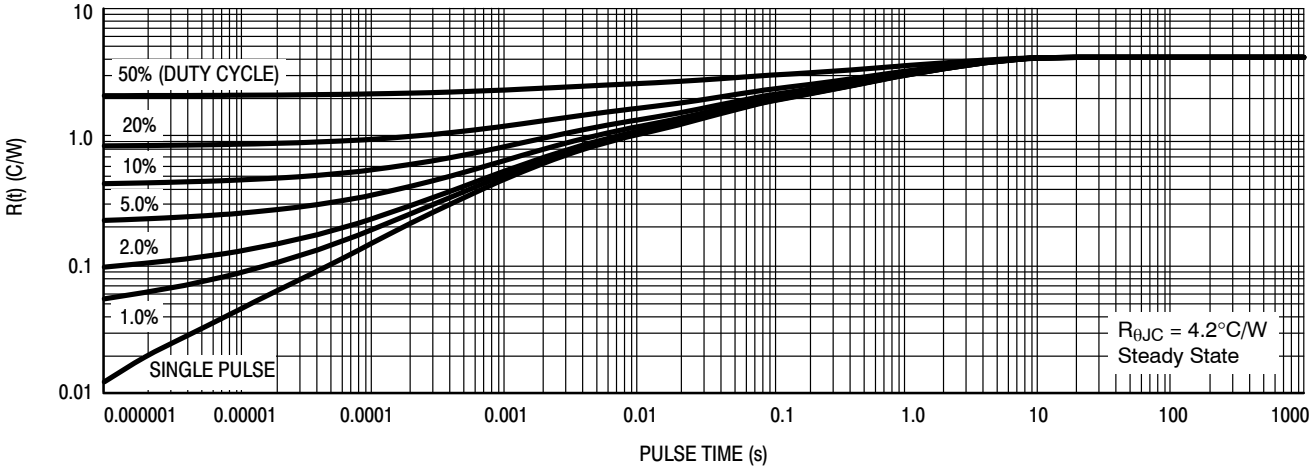



**Figure 13. Thermal Impedance for NDF04N60Z**

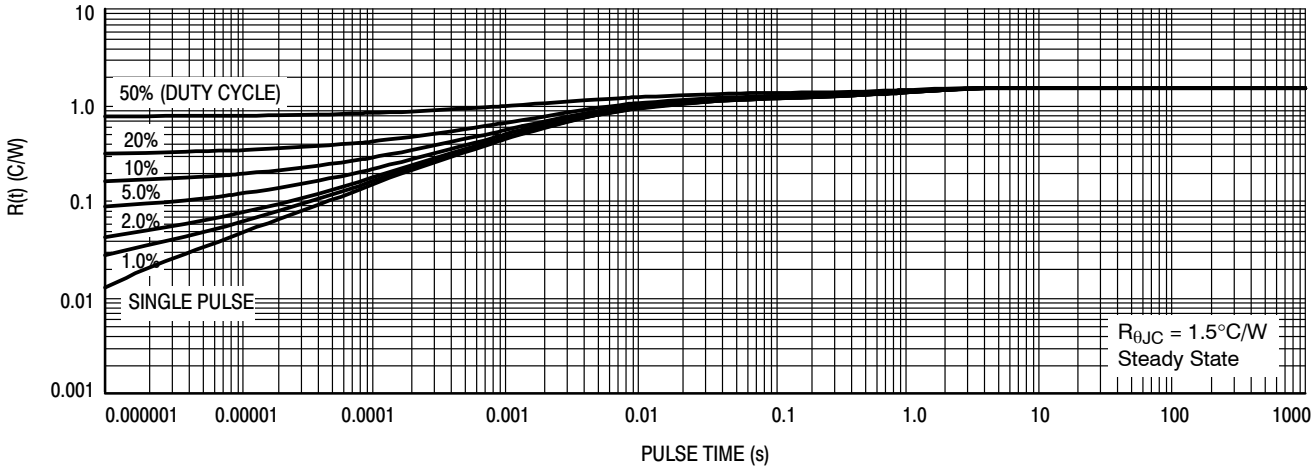



**Figure 14. Thermal Impedance for NDD04N60Z**

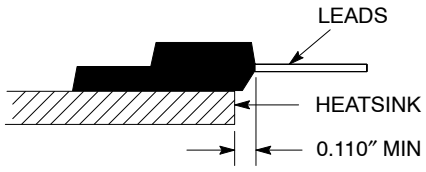



**Figure 15. Mounting Position for Isolation Test**

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

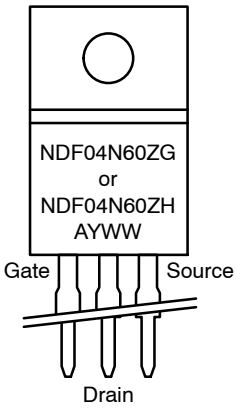
*For additional mounting information, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

## ORDERING INFORMATION

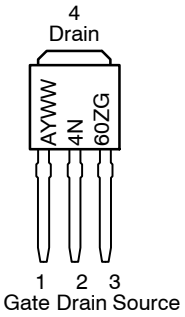
| Order Number | Package | Shipping† |
|---|---|---|
| NDF04N60ZG | TO−220FP<br>(Pb−Free, Halogen−Free) | 50 Units / Rail |
| NDF04N60ZH | TO−220FP<br>(Pb−Free, Halogen−Free) | 50 Units / Rail |
| NDD04N60Z−1G | IPAK<br>(Pb−Free, Halogen−Free) | 75 Units / Rail |
| NDD04N60ZT4G | DPAK<br>(Pb−Free, Halogen−Free) | 2500 / Tape and 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.

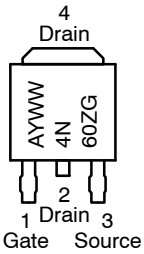
## MARKING DIAGRAMS




TO−220FP




IPAK




DPAK

A = Location Code*
Y = Year
WW = Work Week
G, H = Pb−Free, Halogen−Free Package

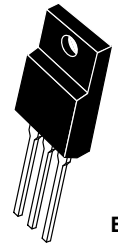
* The Assembly Location Code (A) is front side optional. In cases where the Assembly Location is stamped in the package bottom (molding ejecter pin), the front side assembly code may be blank.

# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS

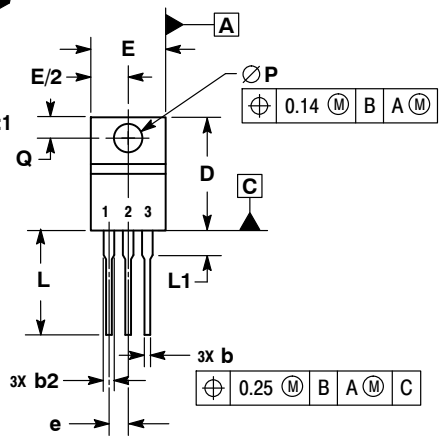
ON Semiconductor®

**TO−220 FULLPACK, 3−LEAD**
CASE 221AH
ISSUE F

DATE 30 SEP 2014

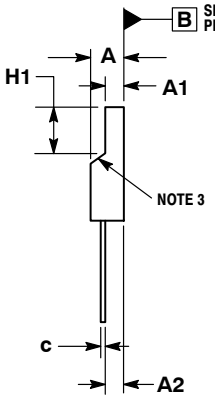


SCALE 1:1




FRONT VIEW

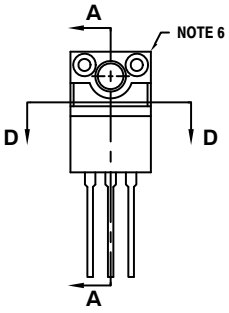
SECTION D−D



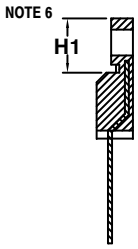

SIDE VIEW

NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. CONTOUR UNCONTROLLED IN THIS AREA.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH AND GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.13 PER SIDE. THESE DIMENSIONS ARE TO BE MEASURED AT OUTERMOST EXTREME OF THE PLASTIC BODY.
5. DIMENSION b2 DOES NOT INCLUDE DAMBAR PROTRUSION. LEAD WIDTH INCLUDING PROTRUSION SHALL NOT EXCEED 2.00.
6. CONTOURS AND FEATURES OF THE MOLDED PACKAGE BODY MAY VARY WITHIN THE ENVELOP DEFINED BY DIMENSIONS A1 AND H1 FOR MANUFACTURING PURPOSES.

| | MILLIMETERS | |
|---|---|---|
| DIM | MIN | MAX |
| A | 4.30 | 4.70 |
| A1 | 2.50 | 2.90 |
| A2 | 2.50 | 2.90 |
| b | 0.54 | 0.84 |
| b2 | 1.10 | 1.40 |
| c | 0.49 | 0.79 |
| D | 14.70 | 15.30 |
| E | 9.70 | 10.30 |
| e | 2.54 BSC | |
| H1 | 6.60 | 7.10 |
| L | 12.50 | 14.73 |
| L1 | --- | 2.80 |
| P | 3.00 | 3.40 |
| Q | 2.80 | 3.20 |

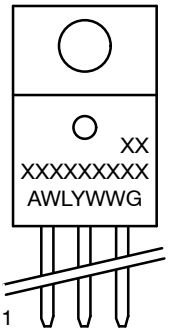



ALTERNATE CONSTRUCTION




SECTION A−A

### GENERIC MARKING DIAGRAM*




A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Package

*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.

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

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

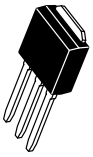
| | | |
|---|---|---|
| DOCUMENT NUMBER: | 98AON52577E | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red. |
| DESCRIPTION: | TO−220 FULLPACK, 3−LEAD | PAGE 1 OF 1 |

# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS

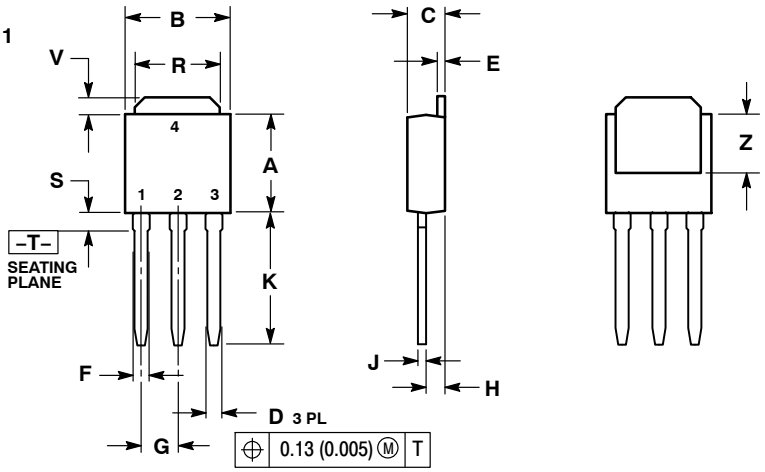
ON Semiconductor®

**IPAK**
CASE 369D−01
ISSUE C

DATE 15 DEC 2010



SCALE 1:1




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

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | 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 1:
PIN 1. BASE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

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

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

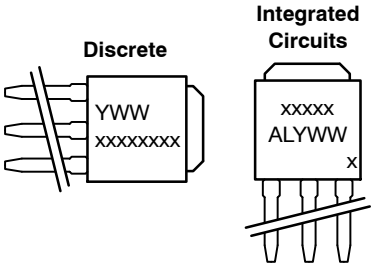
STYLE 4:
PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

STYLE 5:
PIN 1. GATE
2. ANODE
3. CATHODE
4. ANODE

STYLE 6:
PIN 1. MT1
2. MT2
3. GATE
4. MT2

STYLE 7:
PIN 1. GATE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

## MARKING DIAGRAMS

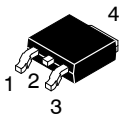



xxxxxxxxx = Device Code
A = Assembly Location
IL = Wafer Lot
Y = Year
WW = Work Week

| | | |
|---|---|---|
| **DOCUMENT NUMBER:** | **98AON10528D** | Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red. |
| **DESCRIPTION:** | **IPAK (DPAK INSERTION MOUNT)** | **PAGE 1 OF 1** |

# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS

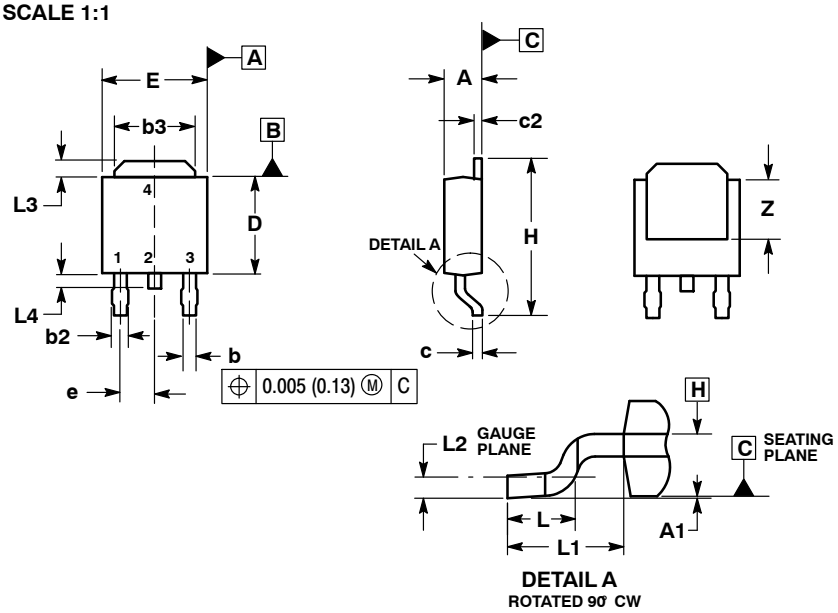
ON Semiconductor®




SCALE 1:1

**DPAK (SINGLE GUAGE)**
CASE 369AA−01
ISSUE B

DATE 03 JUN 2010




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.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | 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 | 0.030 | 0.045 | 0.76 | 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 | 0.108 REF | | 2.74 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 | −−− |

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

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

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

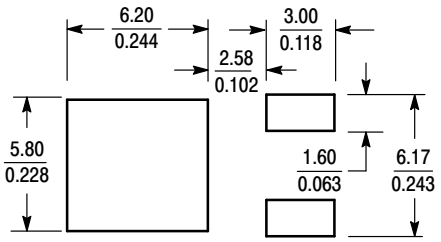
STYLE 4:
PIN 1. CATHODE
2. ANODE
3. GATE
4. ANODE

STYLE 5:
PIN 1. GATE
2. ANODE
3. CATHODE
4. ANODE

STYLE 6:
PIN 1. MT1
2. MT2
3. GATE
4. MT2

STYLE 7:
PIN 1. GATE
2. COLLECTOR
3. EMITTER
4. COLLECTOR

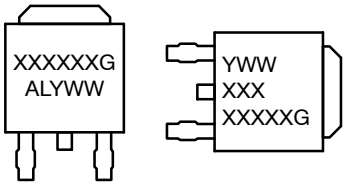
### SOLDERING FOOTPRINT*




SCALE 3:1 (mm / inches)

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

### GENERIC MARKING DIAGRAM*




IC Discrete

XXXXXX = Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking.

| | | |
|---|---|---|
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| DESCRIPTION: | DPAK (SINGLE GAUGE) | PAGE 1 OF 1 |

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