

# MOSFET – N-Channel, Field Effect Transistor, Enhancement Mode

## NDP6060L / NDB6060L

### General Description

These logic level N-Channel enhancement mode power field effect transistors are produced using onsemi's proprietary, high cell density, DMOS technology. This very high density process has been especially tailored to minimize on-state resistance, provide superior switching performance, and withstand high energy pulses in the avalanche and commutation modes. These devices are particularly suited for low voltage applications such as automotive, DC/DC converters, PWM motor controls, and other battery powered circuits where fast switching, low in-line power loss, and resistance to transients are needed.

### Features

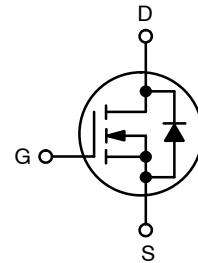
- 48 A, 60 V
  - $R_{DS(ON)} = 0.025 \text{ m}\Omega @ V_{GS} = 5 \text{ V}$
- Low Drive Requirements Allowing Operation Directly from Logic Drivers.  $V_{GS(TH)} < 2.0 \text{ V}$
- Critical DC Electrical Parameters Specified at Elevated Temperature
- Rugged Internal Source-Drain Diode Can Eliminate the Need for an External Zener Diode Transient Suppressor
- 175°C Maximum Junction Temperature Rating
- High Density Cell Design for Extremely Low  $R_{DS(ON)}$
- TO-220 and TO-263 (D<sup>2</sup>PAK) Package for Both Through Hole and Surface Mount Applications
- These Devices are Pb-Free and are RoHS Compliant

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

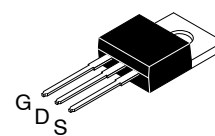
| Symbol         | Rating                                                                                  | NDP6060L / NDB6060L  | Unit      |
|----------------|-----------------------------------------------------------------------------------------|----------------------|-----------|
| $V_{DSS}$      | Drain-Source Voltage                                                                    | 60                   | V         |
| $V_{DGR}$      | Drain-Gate Voltage ( $R_{GS} \leq 1 \text{ M}\Omega$ )                                  | 60                   | V         |
| $V_{GSS}$      | Drain-Source Voltage<br>– Continuous<br>– Nonrepetitive ( $t_p < 50 \mu\text{s}$ )      | $\pm 16$<br>$\pm 25$ | V         |
| $I_D$          | Drain Current<br>– Continuous<br>– Pulsed                                               | 48<br>144            | A         |
| $P_D$          | Total Power Dissipation @ $T_C = 25^\circ\text{C}$<br>– Derate above $25^\circ\text{C}$ | 100<br>0.67          | W<br>W/°C |
| $T_J, T_{STG}$ | Operating and Storage Temperature Range                                                 | –65 to 175           | °C        |
| $T_L$          | Maximum lead temperature for soldering purposes, 1/8" from case for 5 seconds           | 275                  | °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.

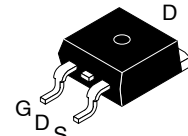
| $V_{DSS}$ | $R_{DS(ON)} \text{ MAX}$ | $I_D \text{ MAX}$ |
|-----------|--------------------------|-------------------|
| 60 V      | 0.025 m $\Omega$ @ 5 V   | 48 A              |



N-CHANNEL MOSFET



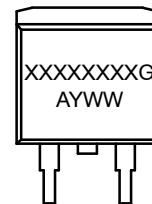
TO-220-3LD  
CASE 340AT



D2PAK-3  
(TO-263, 3-LEAD)  
CASE 418AJ

### MARKING DIAGRAM

XXXXX  
XXXXX  
AYWWZZ



XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Assembly Lot Code  
G = Pb-Free Package

### ORDERING INFORMATION

| Device   | Package                                  | Shipping†             |
|----------|------------------------------------------|-----------------------|
| NDP6060L | TO-220-3LD<br>(Pb-Free / Halide Free)    | 800 /<br>Units / Tube |
| NDB6060L | D2PAK-3<br>(TO-263, 3-LEAD)<br>(Pb-Free) | 800 /<br>Units / Tube |

†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](#).

# NDP6060L / NDB6060L

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

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------|-----------|-----------|-----|-----|-----|------|
|--------|-----------|-----------|-----|-----|-----|------|

### DRAIN-SOURCE AVALANCHE RATINGS (Note 1)

|                  |                                            |                                               |   |   |     |    |
|------------------|--------------------------------------------|-----------------------------------------------|---|---|-----|----|
| W <sub>DSS</sub> | Single Pulse Drain-Source Avalanche Energy | V <sub>DD</sub> = 25 V, I <sub>D</sub> = 48 A | – | – | 200 | mJ |
| I <sub>AR</sub>  | Maximum Drain-Source Avalanche Current     |                                               | – | – | 48  | A  |

### OFF CHARACTERISTICS

|                   |                                 |                                                |    |   |      |    |
|-------------------|---------------------------------|------------------------------------------------|----|---|------|----|
| BV <sub>DSS</sub> | Drain-Source Breakdown Voltage  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA | 60 | – | –    | V  |
| I <sub>DSS</sub>  | Zero Gate Voltage Drain Current | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V  | –  | – | 250  | μA |
|                   |                                 | T <sub>J</sub> = 125°C                         | –  | – | 1    | mA |
| I <sub>GSSF</sub> | Gate-Body Leakage, Forward      | V <sub>GS</sub> = 16 V, V <sub>DS</sub> = 0 V  | –  | – | 100  | nA |
| I <sub>GSSR</sub> | Gate-Body Leakage, Reverse      | V <sub>GS</sub> = –16 V, V <sub>DS</sub> = 0 V | –  | – | –100 | nA |

### ON CHARACTERISTICS (Note 1)

|                     |                                   |                                                             |      |   |       |   |
|---------------------|-----------------------------------|-------------------------------------------------------------|------|---|-------|---|
| V <sub>GS(th)</sub> | Gate Threshold Voltage            | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA | 1    | – | 2     | V |
|                     |                                   | T <sub>J</sub> = 125°C                                      | 0.65 | – | 1.5   |   |
| R <sub>DS(on)</sub> | Static Drain-Source On-Resistance | V <sub>GS</sub> = 5 V, I <sub>D</sub> = 24 A                | –    | – | 0.025 | W |
|                     |                                   | T <sub>J</sub> = 125°C                                      | –    | – | 0.04  |   |
|                     |                                   | V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 24 A              | –    | – | 0.02  | W |
| I <sub>D(on)</sub>  | On-State Drain Current            | V <sub>GS</sub> = 5 V, V <sub>DS</sub> = 10 V               | 48   | – | –     | A |
| g <sub>FS</sub>     | Forward Transconductance          | V <sub>DS</sub> = 10 V, I <sub>D</sub> = 24 A               | 10   | – | –     | S |

### DYNAMIC CHARACTERISTICS

|                  |                              |                                                               |   |      |      |    |
|------------------|------------------------------|---------------------------------------------------------------|---|------|------|----|
| C <sub>iss</sub> | Input Capacitance            | V <sub>DS</sub> = 25 V, V <sub>GS</sub> = 0 V,<br>f = 1.0 MHz | – | 1630 | 2000 | pF |
| C <sub>oss</sub> | Output Capacitance           |                                                               | – | 460  | 800  | pF |
| C <sub>rss</sub> | Reverse Transfer Capacitance |                                                               | – | 150  | 400  | pF |

### SWITCHING CHARACTERISTICS (Note 1)

|                     |                       |                                                                                                                             |   |     |     |    |
|---------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------|---|-----|-----|----|
| t <sub>D(on)</sub>  | Turn – On Delay Time  | V <sub>DD</sub> = 30 V, I <sub>D</sub> = 48 A,<br>V <sub>GS</sub> = 5 V, R <sub>GEN</sub> = 15 Ω,<br>R <sub>GS</sub> = 15 Ω | – | 15  | 30  | nS |
| t <sub>r</sub>      | Turn – On Rise Time   |                                                                                                                             | – | 320 | 500 | nS |
| t <sub>D(off)</sub> | Turn – Off Delay Time |                                                                                                                             | – | 49  | 100 | nS |
| t <sub>f</sub>      | Turn – Off Fall Time  |                                                                                                                             | – | 161 | 300 | nS |
| Q <sub>g</sub>      | Total Gate Charge     | V <sub>DS</sub> = 48 V,<br>I <sub>D</sub> = 48 A, V <sub>GS</sub> = 5 V                                                     | – | 36  | 60  | nC |
| Q <sub>gs</sub>     | Gate-Source Charge    |                                                                                                                             | – | 8.2 | –   | nC |
| Q <sub>gd</sub>     | Gate-Drain Charge     |                                                                                                                             | – | 21  | –   | nC |

### DRAIN-SOURCE DIODE CHARACTERISTICS

|                 |                                                       |                                                       |    |     |     |    |
|-----------------|-------------------------------------------------------|-------------------------------------------------------|----|-----|-----|----|
| I <sub>S</sub>  | Maximum Continuous Drain-Source Diode Forward Current |                                                       | –  | –   | 48  | A  |
| I <sub>SM</sub> | Maximum Pulsed Drain-Source Diode Forward Current     |                                                       | –  | –   | 144 | A  |
| V <sub>SD</sub> | Drain-Source Diode Forward Voltage                    | V <sub>GS</sub> = 0 V, I <sub>S</sub> = 24 A (Note 1) | –  | –   | 1.3 | V  |
|                 |                                                       | T <sub>J</sub> = 125°C                                | –  | –   | 1.2 |    |
| t <sub>rr</sub> | Reverse Recovery Time                                 | V <sub>GS</sub> = 0 V, I <sub>F</sub> = 48 A,         | 35 | 75  | 140 | ns |
| I <sub>rr</sub> | Reverse Recovery Current                              | dI <sub>F</sub> /dt = 100 A/μs                        | 2  | 3.6 | 8   | A  |

### THERMAL CHARACTERISTICS

|                  |                                         |   |   |      |      |
|------------------|-----------------------------------------|---|---|------|------|
| R <sub>θJC</sub> | Thermal Resistance, Junction-to-Case    | – | – | 1.5  | °C/W |
| R <sub>θJA</sub> | Thermal Resistance, Junction-to-Ambient | – | – | 62.5 | °C/W |

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.

1. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

TYPICAL CHARACTERISTICS

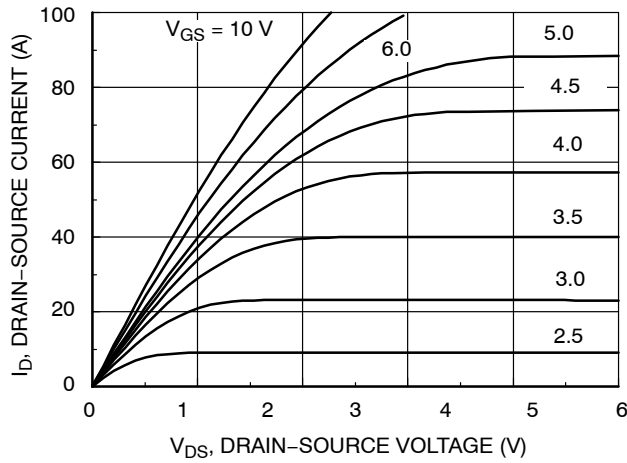


Figure 1. On-Region Characteristics

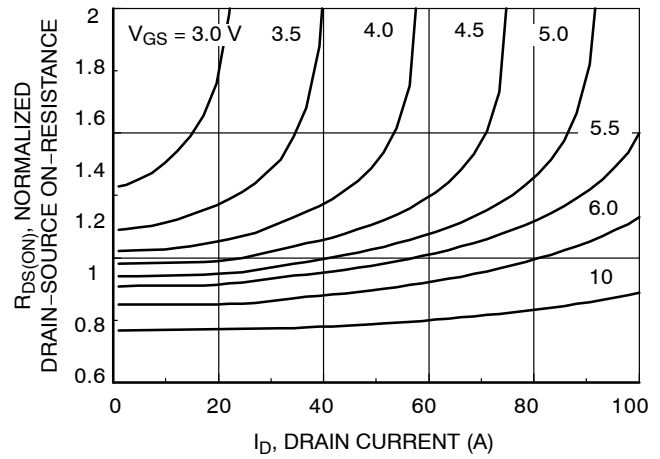


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current

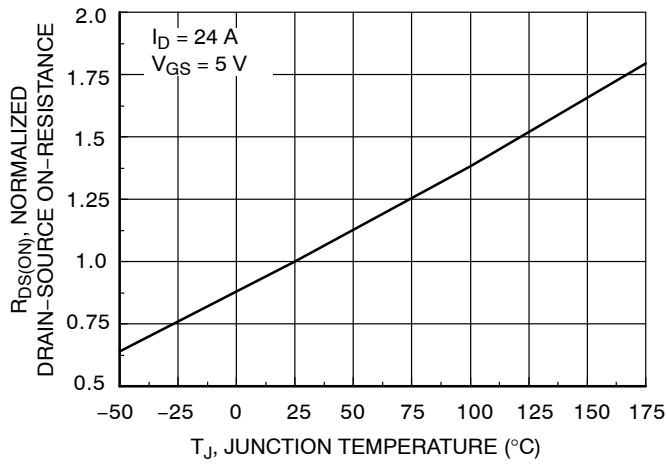


Figure 3. On-Resistance Variation with Temperature

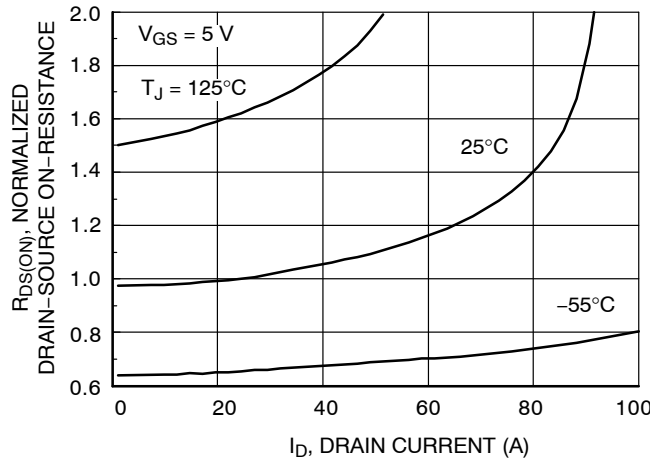


Figure 4. On-Resistance Variation with Drain Current and Temperature

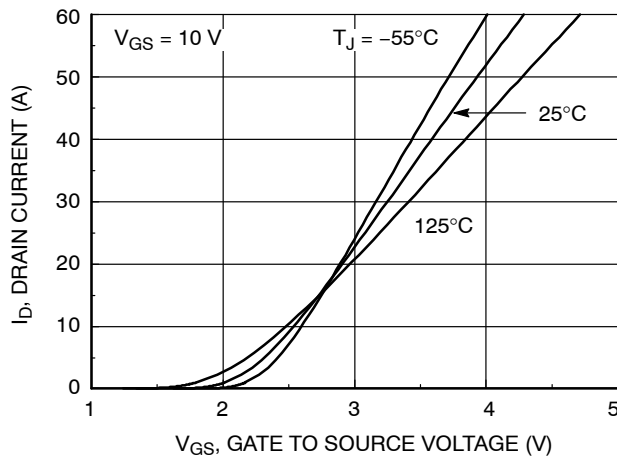


Figure 5. Transfer Characteristics

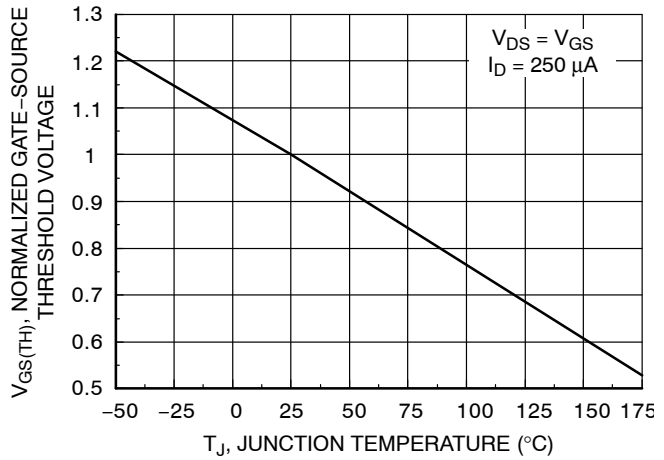


Figure 6. Gate Threshold Variation with Temperature

TYPICAL CHARACTERISTICS (continued)

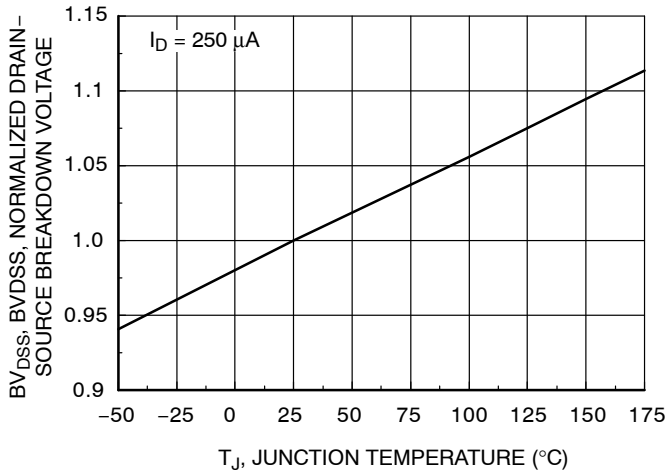


Figure 7. Breakdown Voltage Variation with Temperature

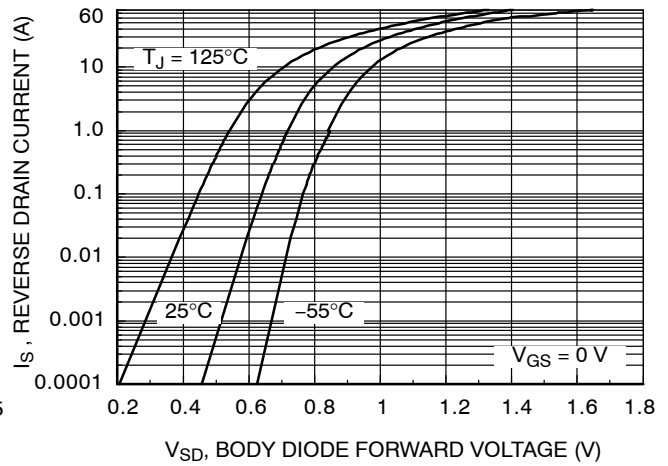


Figure 8. Body Diode Forward Voltage Variation with Current and Temperature

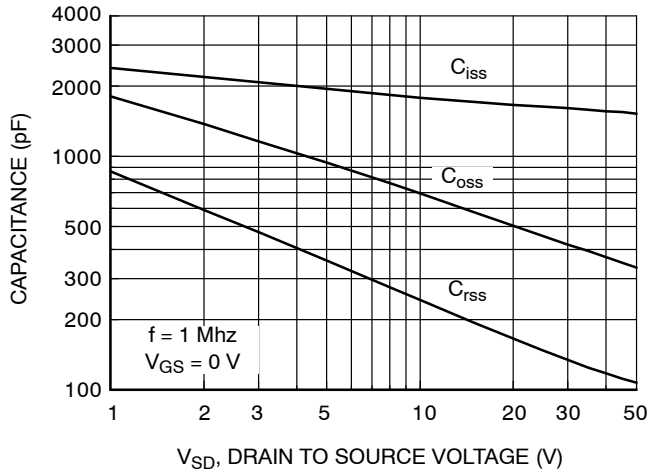


Figure 9. Capacitance Characteristics

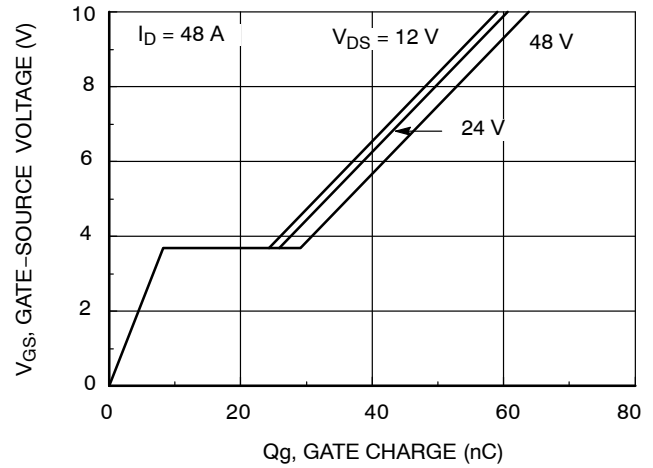


Figure 10. Gate Charge Characteristics

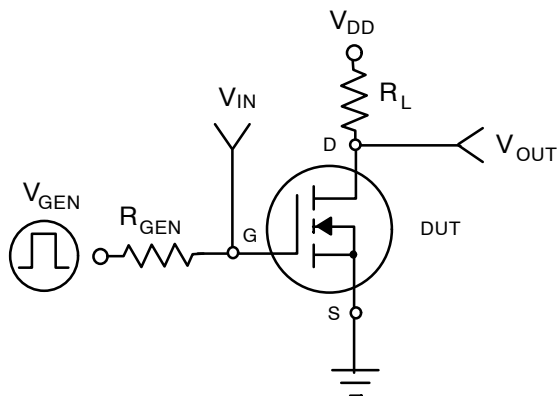


Figure 11. Switching Test Circuit

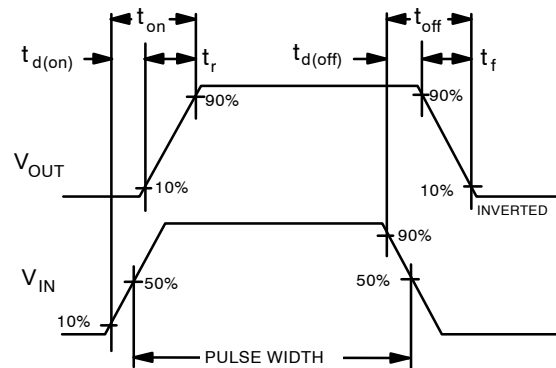


Figure 12. Switching Waveforms

## TYPICAL CHARACTERISTICS

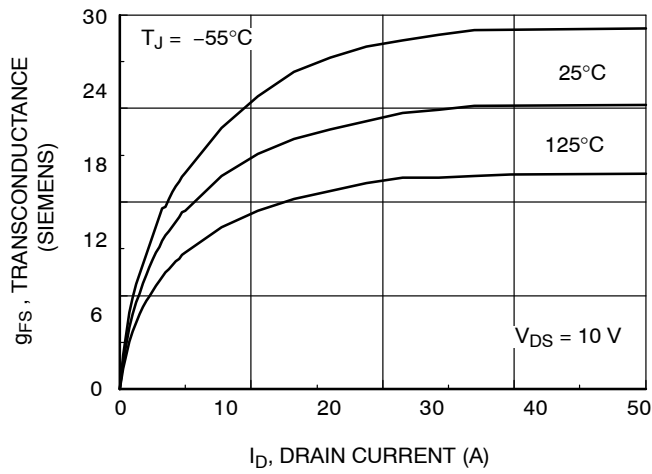


Figure 13. Transconductance Variation with Drain Current and Temperature

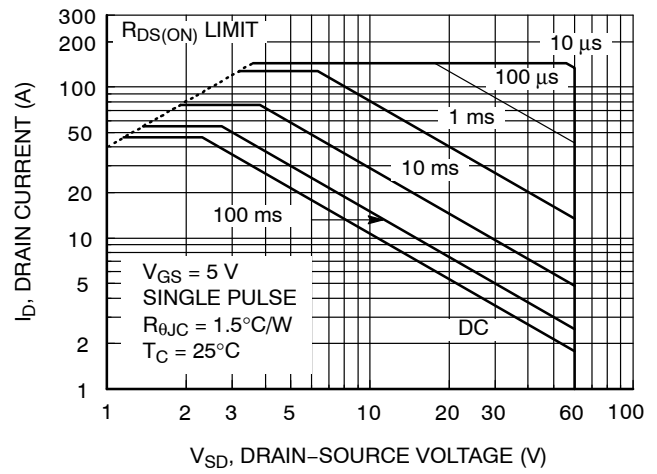


Figure 14. Maximum Safe Operating Area

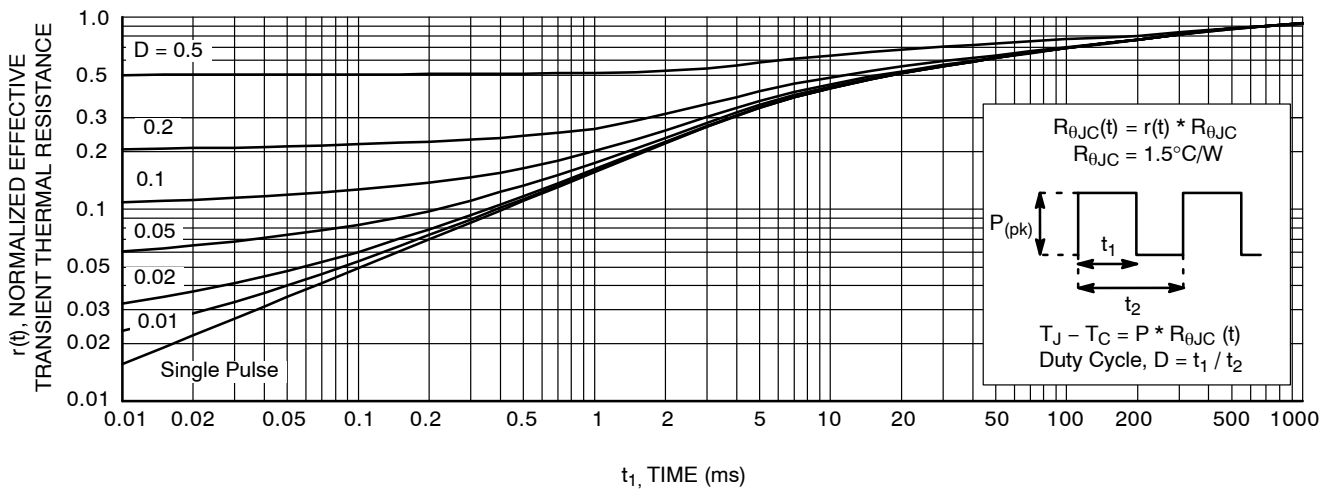
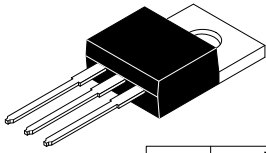


Figure 15. Transient Thermal Response Curve



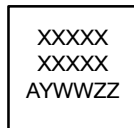
TO-220-3LD  
CASE 340AT  
ISSUE B

DATE 08 AUG 2022

| DIM | MILLIMETERS  |      |       |
|-----|--------------|------|-------|
|     | MIN.         | NOM. | MAX.  |
| A   | 4.00         | --   | 4.70  |
| A1  | SEE NOTE "F" |      |       |
| A2  | 2.10         | --   | 2.85  |
| b   | 0.55         | --   | 1.00  |
| b2  | 1.10         | --   | 1.62  |
| b4  | 1.42         | --   | 1.62  |
| c   | 0.36         | --   | 0.60  |
| D   | 13.90        | --   | 16.30 |
| D1  | 8.13         | --   | 9.40  |
| D2  | 11.50        | --   | 14.30 |
| D3  | 15.42        | --   | 16.51 |
| E   | 9.65         | --   | 10.67 |
| E1  | 7.59         | --   | 8.65  |
| e   | 2.40         | --   | 2.67  |
| H1  | 6.06         | --   | 6.69  |
| L   | 12.70        | --   | 14.04 |
| L1  | 2.70         | --   | 4.10  |
| P   | 3.50         | --   | 4.00  |
| Q   | 2.50         | --   | 3.40  |
| z   | 2.13 REF     |      |       |
| z1  | 2.06 REF     |      |       |
| θ   | 3°           | --   | 5°    |

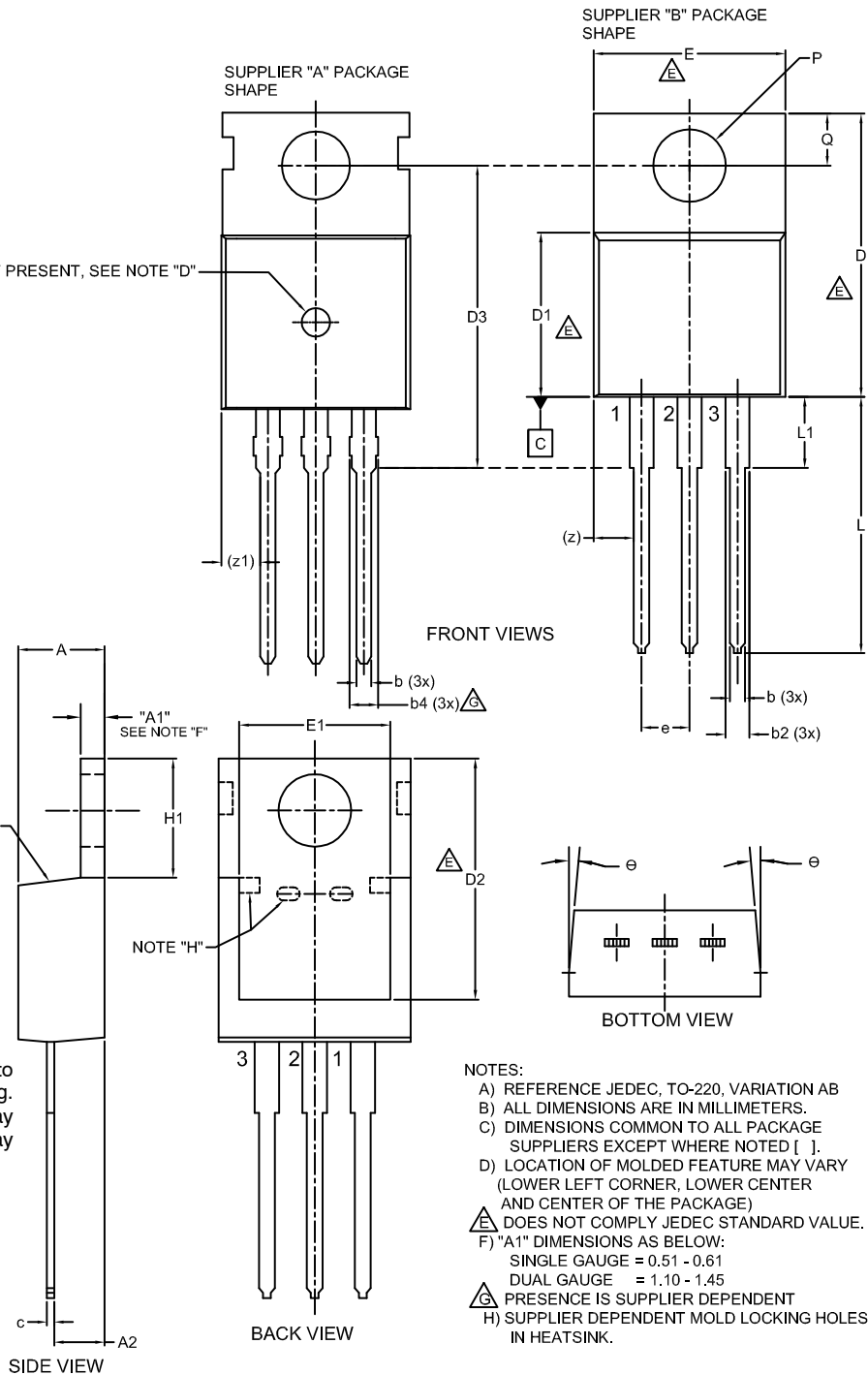
IF PRESENT, SEE NOTE "D"

GENERIC  
MARKING DIAGRAM\*



XXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
ZZ = Assembly Lot Code

\*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. Some products may not follow the Generic Marking.

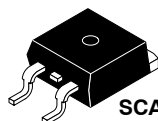


NOTES:

- A) REFERENCE JEDEC, TO-220, VARIATION AB
- B) ALL DIMENSIONS ARE IN MILLIMETERS.
- C) DIMENSIONS COMMON TO ALL PACKAGE SUPPLIERS EXCEPT WHERE NOTED [ ].
- D) LOCATION OF MOLDED FEATURE MAY VARY (LOWER LEFT CORNER, LOWER CENTER AND CENTER OF THE PACKAGE)
- E) DOES NOT COMPLY JEDEC STANDARD VALUE.
- F) "A1" DIMENSIONS AS BELOW:  
SINGLE GAUGE = 0.51 - 0.61  
DUAL GAUGE = 1.10 - 1.45
- G) PRESENCE IS SUPPLIER DEPENDENT
- H) SUPPLIER DEPENDENT MOLD LOCKING HOLES IN HEATSINK.

|                  |             |                                                                                                                                                                                     |
|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| DESCRIPTION:     | TO-220-3LD  | PAGE 1 OF 1                                                                                                                                                                         |

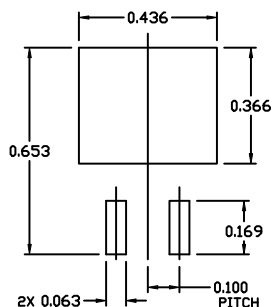
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SCALE 1:1

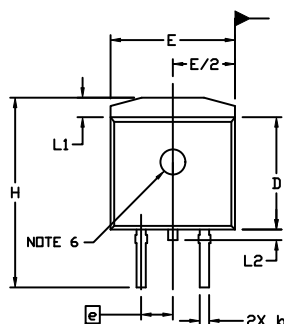
**D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)**  
CASE 418AJ  
ISSUE F

DATE 11 MAR 2021



**RECOMMENDED  
MOUNTING FOOTPRINT**

For additional information on our Pb-free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERM1.

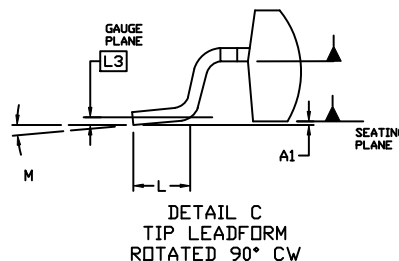
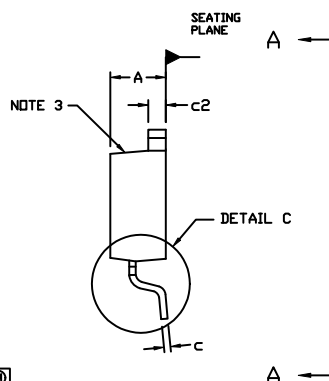


0.100 BSC 0.100 BSC

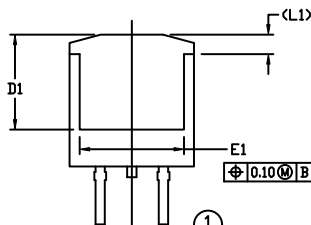
**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: INCHES
3. CHAMFER OPTIONAL.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005 PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
5. THERMAL PAD CONTOUR IS OPTIONAL WITHIN DIMENSIONS E, L1, D1, AND E1.
6. OPTIONAL MOLD FEATURE.
7. ①, ② ... OPTIONAL CONSTRUCTION FEATURE CALL OUTS.

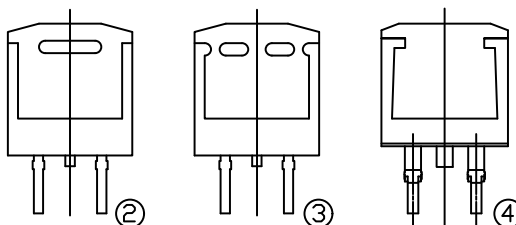
| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN.      | MAX.  | MIN.        | MAX.  |
| A   | 0.160     | 0.190 | 4.06        | 4.83  |
| A1  | 0.000     | 0.010 | 0.00        | 0.25  |
| b   | 0.020     | 0.039 | 0.51        | 0.99  |
| c   | 0.012     | 0.029 | 0.30        | 0.74  |
| c2  | 0.045     | 0.065 | 1.14        | 1.65  |
| D   | 0.330     | 0.380 | 8.38        | 9.65  |
| D1  | 0.260     | ---   | 6.60        | ---   |
| E   | 0.380     | 0.420 | 9.65        | 10.67 |
| E1  | 0.245     | ---   | 6.22        | ---   |
| e   | 0.100 BSC | ---   | 2.54 BSC    | ---   |
| H   | 0.575     | 0.625 | 14.60       | 15.88 |
| L   | 0.070     | 0.110 | 1.78        | 2.79  |
| L1  | ---       | 0.066 | ---         | 1.68  |
| L2  | ---       | 0.070 | ---         | 1.78  |
| L3  | 0.010 BSC | ---   | 0.25 BSC    | ---   |
| M   | 0°        | 8°    | 0°          | 8°    |



DETAIL C  
TIP LEADFORM  
ROTATED 90° CW

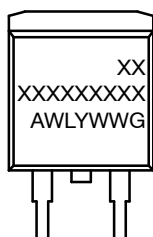


VIEW A-A

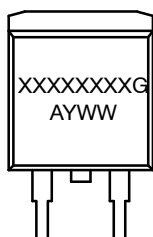


VIEW A-A  
OPTIONAL CONSTRUCTIONS

**GENERIC MARKING DIAGRAMS\***



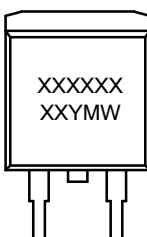
IC



Standard



Rectifier



SSG

XXXXXX = Specific Device Code  
A = Assembly Location  
WL = Wafer Lot  
Y = Year  
WW = Work Week  
W = Week Code (SSG)  
M = Month Code (SSG)  
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. Some products may not follow the Generic Marking.

|                         |                                            |                                                                                                                                                                                  |
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