

# Self-Protected Low Side Driver with Temperature and Current Limit

65 V, 7.0 A, Single N-Channel

## NCV8406A, NCV8406B

NCV8406A/B is a three terminal protected Low-Side Smart Discrete device. The protection features include overcurrent, overtemperature, ESD and integrated Drain-to-Gate clamping for overvoltage protection. This device offers protection and is suitable for harsh automotive environments.

### Features

- Short Circuit Protection
- Thermal Shutdown with Automatic Restart
- Over Voltage Protection
- Integrated Clamp for Inductive Switching
- ESD Protection
- dV/dt Robustness
- Analog Drive Capability (Logic Level Input)
- These Devices are Faster than the Rest of the NCV Devices
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Qualified and PPAP Capable
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Typical Applications

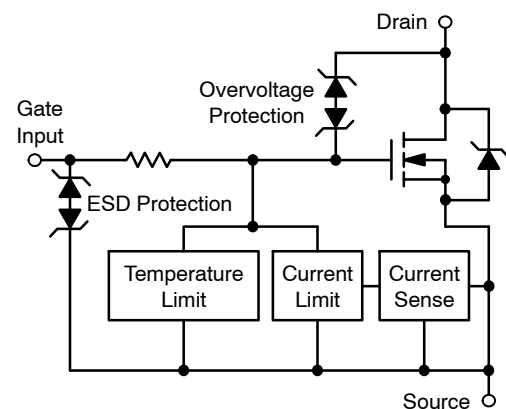
- Switch a Variety of Resistive, Inductive and Capacitive Loads
- Can Replace Electromechanical Relays and Discrete Circuits
- Automotive / Industrial



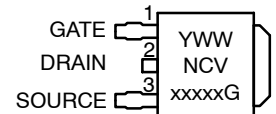
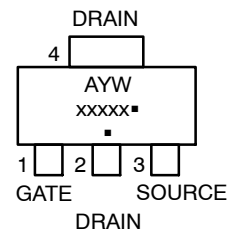
ON Semiconductor®

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| V <sub>DSS</sub><br>(Clamped) | R <sub>DS(on)</sub> TYP | I <sub>D</sub> TYP<br>(Limited) |
|-------------------------------|-------------------------|---------------------------------|
| 65 V                          | 210 mΩ                  | 7.0 A                           |



### MARKING DIAGRAM



A = Assembly Location

Y = Year

W, WW = Work Week

xxxxx = 8406A or 8406B

G or ■ = Pb-Free Package

(Note: Microdot may be in either location)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

# NCV8406A, NCV8406B

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

| Rating                                                                                                                                                                                                            | Symbol                                                | Value              | Unit               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|--------------------|--------------------|
| Drain-to-Source Voltage Internally Clamped                                                                                                                                                                        | $V_{DSS}$                                             | 60                 | Vdc                |
| Gate-to-Source Voltage                                                                                                                                                                                            | $V_{GS}$                                              | $\pm 14$           | Vdc                |
| Drain Current Continuous                                                                                                                                                                                          | $I_D$                                                 | Internally Limited |                    |
| Total Power Dissipation – SOT-223 Version<br>@ $T_A = 25^\circ\text{C}$ (Note 1)<br>@ $T_A = 25^\circ\text{C}$ (Note 2)                                                                                           | $P_D$                                                 | 1.25<br>1.81       | W                  |
| Total Power Dissipation – DPAK Version<br>@ $T_A = 25^\circ\text{C}$ (Note 1)<br>@ $T_A = 25^\circ\text{C}$ (Note 2)                                                                                              | $P_D$                                                 | 1.31<br>2.31       | W                  |
| Thermal Resistance – SOT-223 Version<br>Junction-to-Soldering Point<br>Junction-to-Ambient (Note 1)<br>Junction-to-Ambient (Note 2)                                                                               | $R_{\theta JS}$<br>$R_{\theta JA}$<br>$R_{\theta JA}$ | 7.0<br>100<br>69   | $^\circ\text{C/W}$ |
| Thermal Resistance – DPAK Version<br>Junction-to-Soldering Point<br>Junction-to-Ambient (Note 1)<br>Junction-to-Ambient (Note 2)                                                                                  | $R_{\theta JS}$<br>$R_{\theta JA}$<br>$R_{\theta JA}$ | 1.0<br>95<br>54    | $^\circ\text{C/W}$ |
| Single Pulse Inductive Load Switching Energy<br>(Starting $T_J = 25^\circ\text{C}$ , $V_{DD} = 50\text{ Vdc}$ , $V_{GS} = 5.0\text{ Vdc}$ ,<br>$I_L = 2.1\text{ Apk}$ , $L = 50\text{ mH}$ , $R_G = 25\ \Omega$ ) | $E_{AS}$                                              | 110                | mJ                 |
| Load Dump Voltage ( $V_{GS} = 0$ and $10\text{ V}$ , $R_I = 2\ \Omega$ , $R_L = 7\ \Omega$ , $t_d = 400\text{ ms}$ )                                                                                              | $V_{LD}$                                              | 75                 | V                  |
| Operating Junction Temperature Range                                                                                                                                                                              | $T_J$                                                 | $-40$ to $150$     | $^\circ\text{C}$   |
| Storage Temperature Range                                                                                                                                                                                         | $T_{stg}$                                             | $-55$ to $150$     | $^\circ\text{C}$   |

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. Surface mounted onto minimum pad size (100 sq/mm) FR4 PCB, 1 oz cu.
2. Mounted onto 1" square pad size (700 sq/mm) FR4 PCB, 1 oz cu.

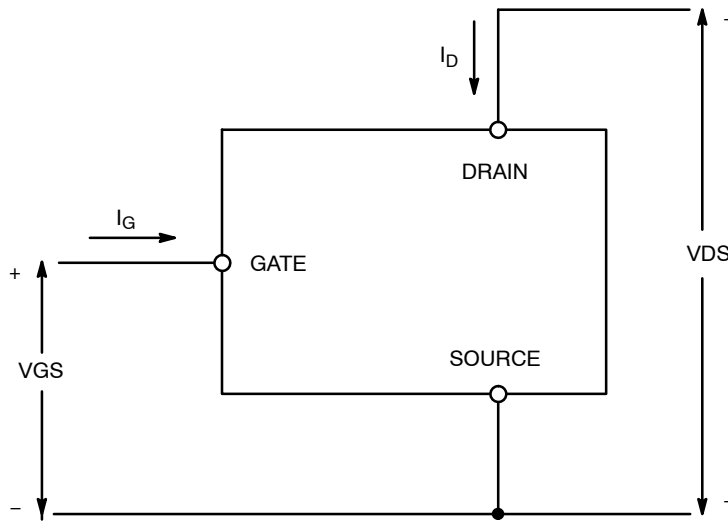


Figure 1. Voltage and Current Convention

# NCV8406A, NCV8406B

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

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

### OFF CHARACTERISTICS

|                                                                                             |                      |    |    |     |    |
|---------------------------------------------------------------------------------------------|----------------------|----|----|-----|----|
| Drain-to-Source Clamped Breakdown Voltage<br>(V <sub>GS</sub> = 0 V, I <sub>D</sub> = 2 mA) | V <sub>(BR)DSS</sub> | 60 | 65 | 70  | V  |
| Zero Gate Voltage Drain Current<br>(V <sub>DS</sub> = 52 V, V <sub>GS</sub> = 0 V)          | I <sub>DSS</sub>     | –  | 22 | 100 | μA |
| Gate Input Current<br>(V <sub>GS</sub> = 5.0 V, V <sub>DS</sub> = 0 V)                      | I <sub>GSS</sub>     | –  | 30 | 100 | μA |

### ON CHARACTERISTICS

|                                                                                                                                                                                                        |                     |          |             |            |             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------|-------------|------------|-------------|
| Gate Threshold Voltage<br>(V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 150 μA)<br>Threshold Temperature Coefficient                                                                           | V <sub>GS(th)</sub> | 1.2<br>– | 1.66<br>4.0 | 2.0<br>–   | V<br>–mV/°C |
| Static Drain-to-Source On-Resistance (Note 3)<br>(V <sub>GS</sub> = 10 V, I <sub>D</sub> = 2.0 A, T <sub>J</sub> @ 25°C)                                                                               | R <sub>DS(on)</sub> | –        | 185         | 210        | mΩ          |
| Static Drain-to-Source On-Resistance (Note 3)<br>(V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 2.0 A, T <sub>J</sub> @ 25°C)<br>(V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 2.0 A, T <sub>J</sub> @ 150°C) | R <sub>DS(on)</sub> | –<br>–   | 210<br>445  | 240<br>520 | mΩ          |
| Source-Drain Forward On Voltage<br>(I <sub>S</sub> = 7.0 A, V <sub>GS</sub> = 0 V)                                                                                                                     | V <sub>SD</sub>     | –        | 0.9         | 1.1        | V           |

### SWITCHING CHARACTERISTICS (Note 6)

|                     |                                                                                                                                                     |                                     |   |      |   |      |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|---|------|---|------|
| Turn-on Delay Time  | R <sub>L</sub> = 6.6 Ω, V <sub>in</sub> = 0 to 10 V,<br>V <sub>DD</sub> = 13.8 V, I <sub>D</sub> = 2.0 A, 10% V <sub>in</sub> to 10% I <sub>D</sub> | t <sub>d(on)</sub>                  | – | 127  | – | ns   |
| Turn-on Rise Time   | R <sub>L</sub> = 6.6 Ω, V <sub>in</sub> = 0 to 10 V,<br>V <sub>DD</sub> = 13.8 V, I <sub>D</sub> = 2.0 A, 10% I <sub>D</sub> to 90% I <sub>D</sub>  | t <sub>rise</sub>                   | – | 486  | – | ns   |
| Turn-off Delay Time | R <sub>L</sub> = 6.6 Ω, V <sub>in</sub> = 0 to 10 V,<br>V <sub>DD</sub> = 13.8 V, I <sub>D</sub> = 2.0 A, 90% V <sub>in</sub> to 90% I <sub>D</sub> | t <sub>d(off)</sub>                 | – | 1600 | – | ns   |
| Turn-off Fall Time  | R <sub>L</sub> = 6.6 Ω, V <sub>in</sub> = 0 to 10 V,<br>V <sub>DD</sub> = 13.8 V, I <sub>D</sub> = 2.0 A, 90% I <sub>D</sub> to 10% I <sub>D</sub>  | t <sub>fall</sub>                   | – | 692  | – | ns   |
| Slew Rate ON        | R <sub>L</sub> = 6.6 Ω, V <sub>in</sub> = 0 to 10 V,<br>V <sub>DD</sub> = 13.8 V, I <sub>D</sub> = 2.0 A, 70% to 50% V <sub>DD</sub>                | dV <sub>DS</sub> /dT <sub>on</sub>  | – | 79   | – | V/μs |
| Slew Rate OFF       | R <sub>L</sub> = 6.6 Ω, V <sub>in</sub> = 0 to 10 V,<br>V <sub>DD</sub> = 13.8 V, I <sub>D</sub> = 2.0 A, 50% to 70% V <sub>DD</sub>                | dV <sub>DS</sub> /dT <sub>off</sub> | – | 27   | – | V/μs |

### SELF PROTECTION CHARACTERISTICS (Note 4)

|                                    |                                                                                                                                                                                                                                                            |                       |                   |                   |                    |    |
|------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------|-------------------|--------------------|----|
| Current Limit                      | V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = 25°C (Note 5)<br>V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = 150°C (Notes 5, 6)<br>V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 10 V, T <sub>J</sub> = 25°C (Notes 5) | I <sub>LIM</sub>      | 5.0<br>3.5<br>6.5 | 7.0<br>4.5<br>8.5 | 9.5<br>6.0<br>10.5 | A  |
| Temperature Limit (Turn-off)       | V <sub>GS</sub> = 5.0 V (Note 6)                                                                                                                                                                                                                           | T <sub>LIM(off)</sub> | 150               | 180               | 200                | °C |
| Thermal Hysteresis                 | V <sub>GS</sub> = 5.0 V                                                                                                                                                                                                                                    | ΔT <sub>LIM(on)</sub> | –                 | 10                | –                  | °C |
| Temperature Limit (Turn-off)       | V <sub>GS</sub> = 10 V (Note 6)                                                                                                                                                                                                                            | T <sub>LIM(off)</sub> | 150               | 180               | 200                | °C |
| Thermal Hysteresis                 | V <sub>GS</sub> = 10 V                                                                                                                                                                                                                                     | ΔT <sub>LIM(on)</sub> | –                 | 20                | –                  | °C |
| Input Current during Thermal Fault | V <sub>DS</sub> = 0 V, V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = T <sub>J</sub> > T <sub>(fault)</sub> (Note 6)<br>V <sub>DS</sub> = 0 V, V <sub>GS</sub> = 10 V, T <sub>J</sub> = T <sub>J</sub> > T <sub>(fault)</sub> (Note 6)                          | I <sub>g(fault)</sub> | –<br>–            | 5.9<br>12.3       | –                  | mA |

### ESD ELECTRICAL CHARACTERISTICS

|                                                                                     |     |             |        |        |   |
|-------------------------------------------------------------------------------------|-----|-------------|--------|--------|---|
| Electro-Static Discharge Capability<br>Human Body Model (HBM)<br>Machine Model (MM) | ESD | 6000<br>500 | –<br>– | –<br>– | V |
|-------------------------------------------------------------------------------------|-----|-------------|--------|--------|---|

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.

- Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
- Fault conditions are viewed as beyond the normal operating range of the part.
- Current limit measured at 380 μs after gate pulse.
- Not subject to production test.

TYPICAL PERFORMANCE CURVES

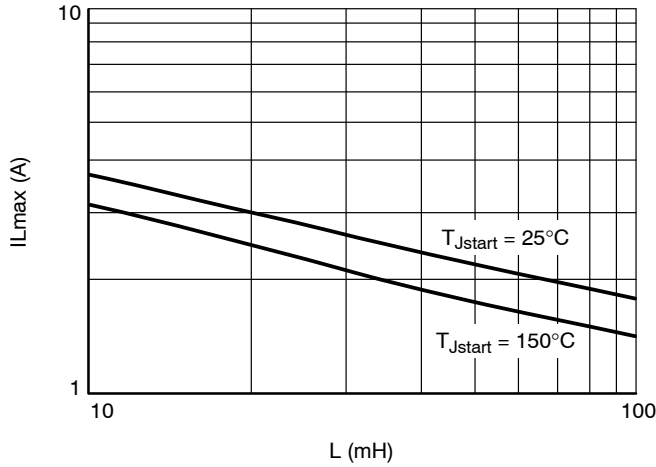


Figure 2. Single Pulse Maximum Switch-off Current vs. Load Inductance

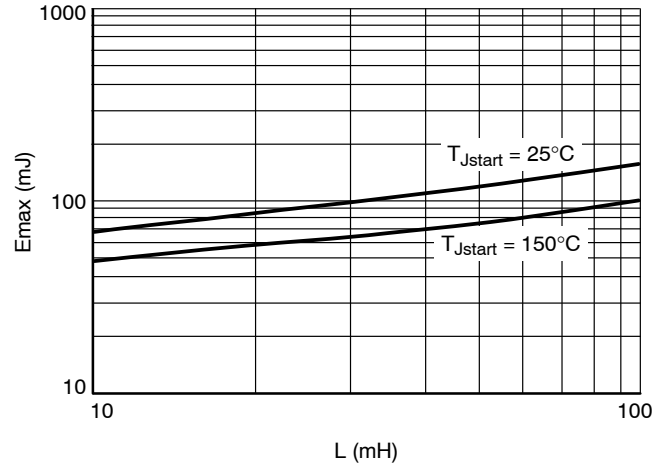


Figure 3. Single-Pulse Maximum Switching Energy vs. Load Inductance

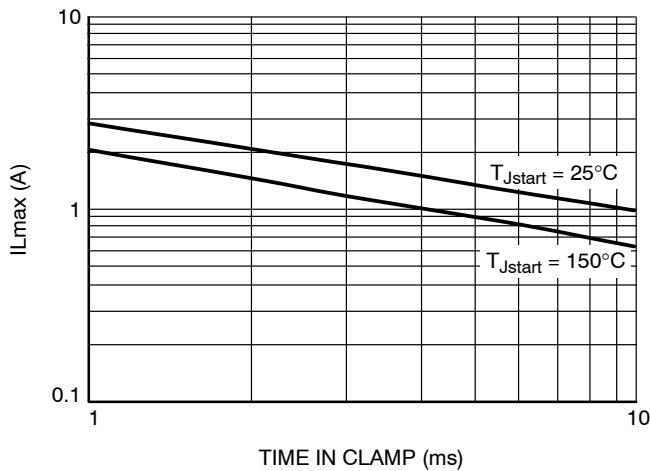


Figure 4. Single Pulse Maximum Inductive Switch-off Current vs. Time in Clamp

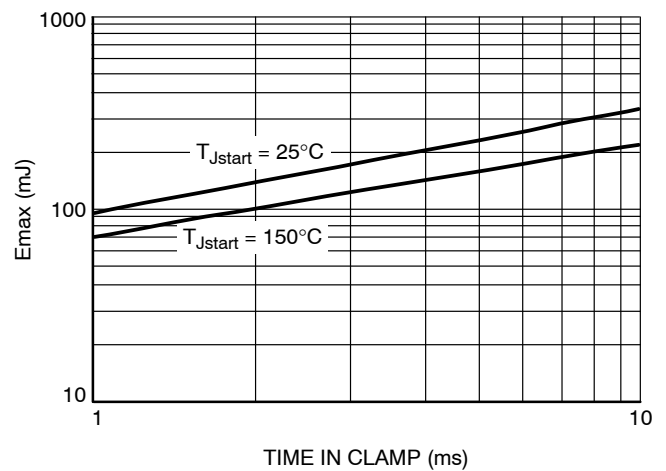


Figure 5. Single-Pulse Maximum Inductive Switching Energy vs. Time in Clamp

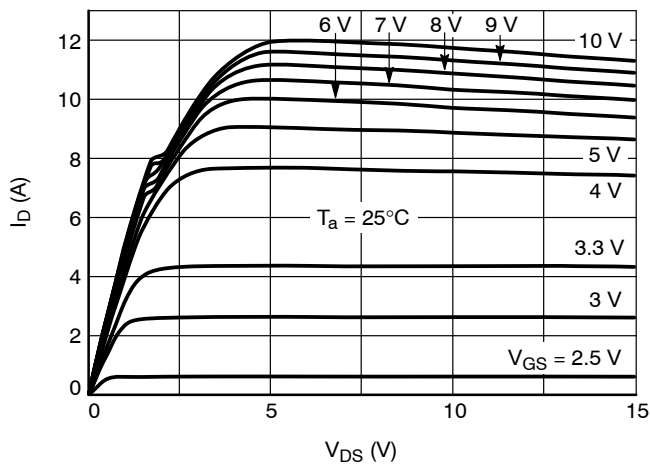


Figure 6. On-state Output Characteristics

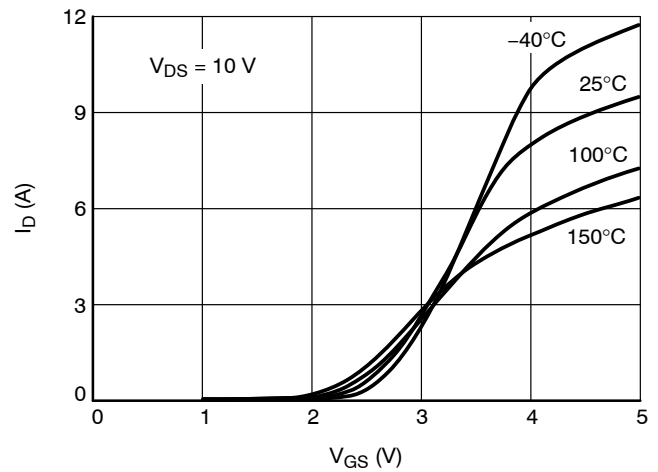


Figure 7. Transfer Characteristics

TYPICAL PERFORMANCE CURVES

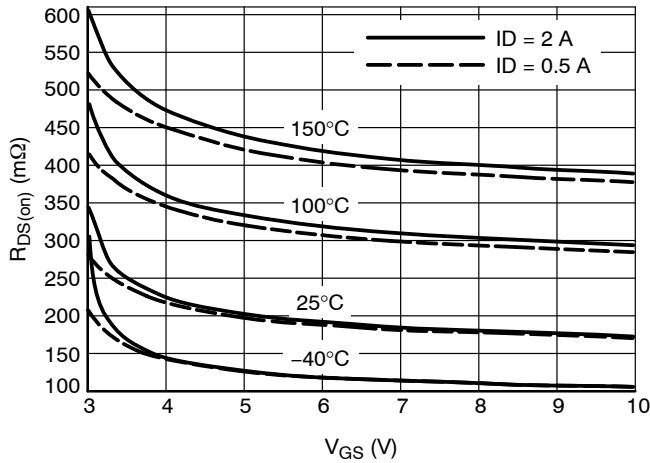


Figure 8.  $R_{DS(on)}$  vs. Gate-Source Voltage

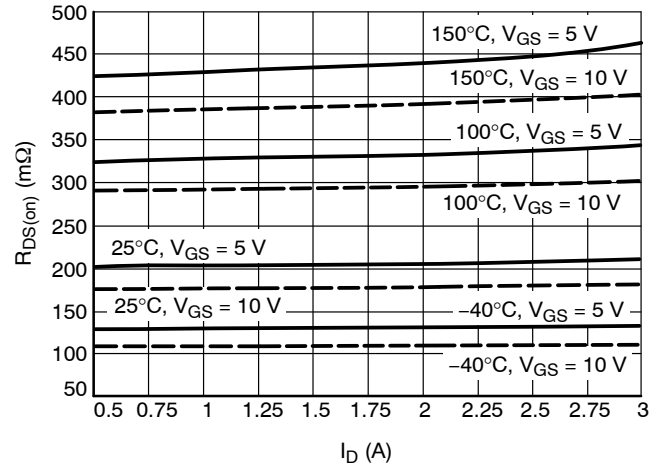


Figure 9.  $R_{DS(on)}$  vs. Drain Current

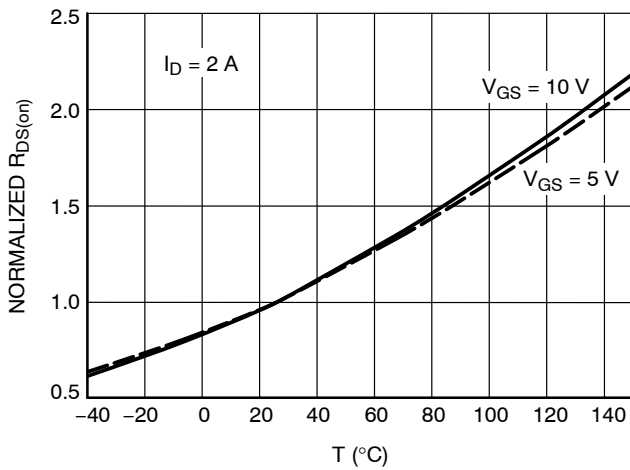


Figure 10. Normalized  $R_{DS(on)}$  vs. Temperature

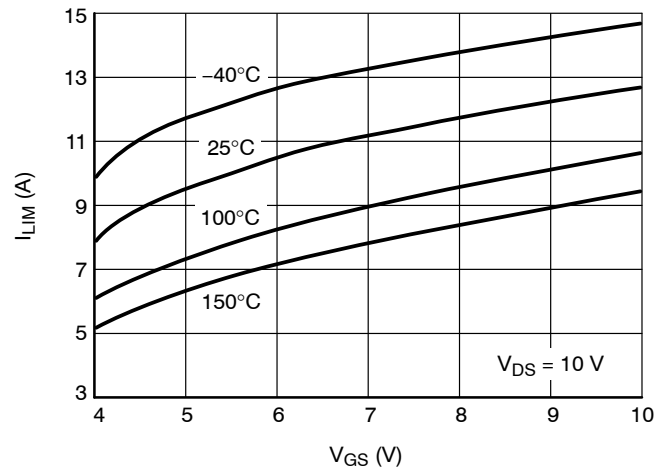


Figure 11. Current Limit vs. Gate-Source Voltage

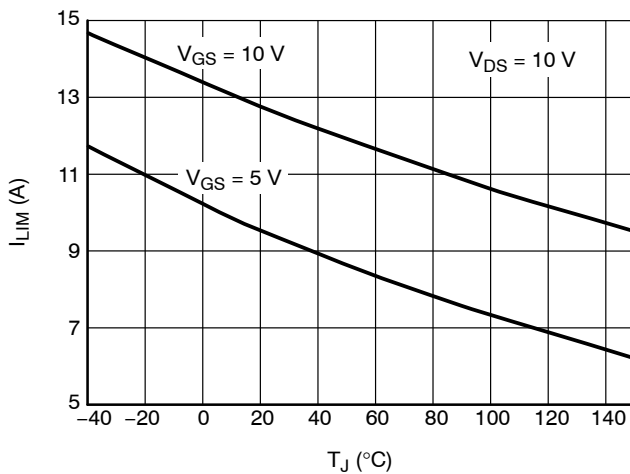


Figure 12. Current Limit vs. Junction Temperature

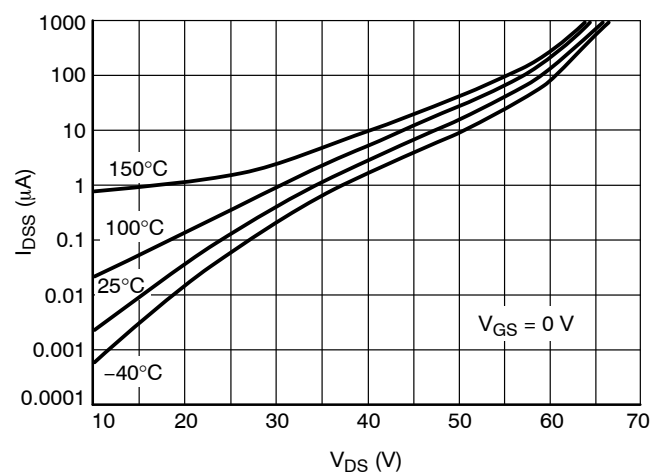


Figure 13. Drain-to-Source Leakage Current

TYPICAL PERFORMANCE CURVES

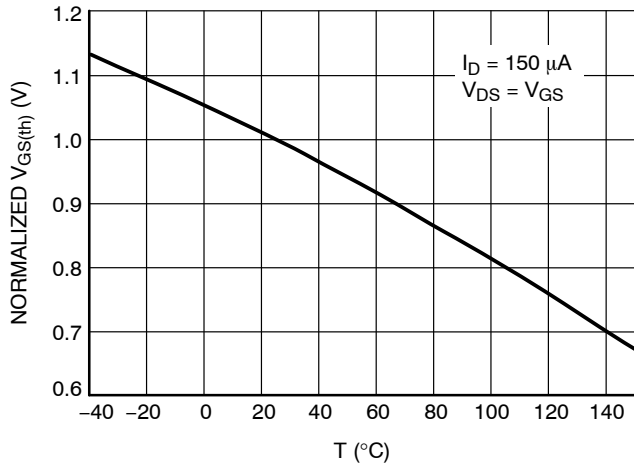


Figure 14. Normalized Threshold Voltage vs. Temperature

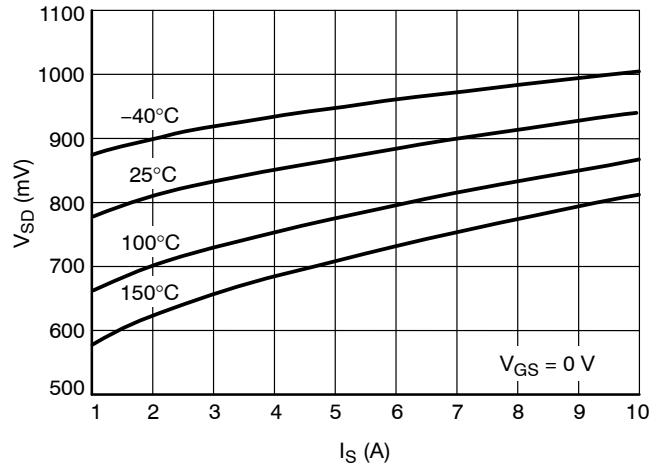


Figure 15. Source-Drain Diode Forward Characteristics

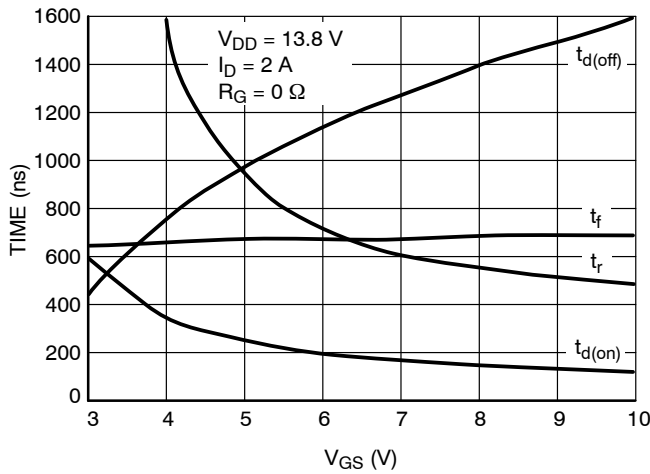


Figure 16. Resistive Load Switching Time vs. Gate-Source Voltage

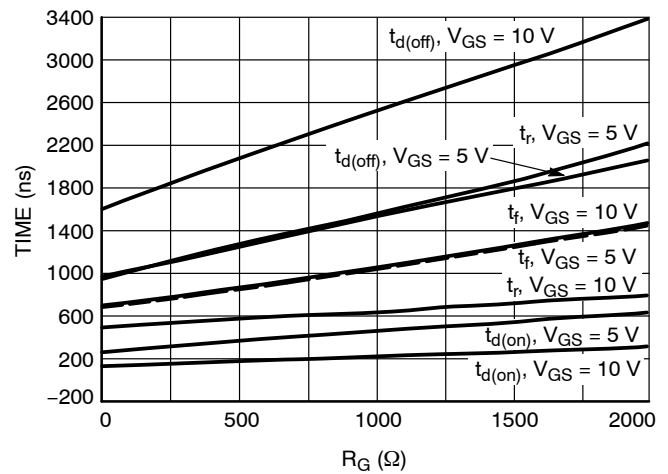


Figure 17. Resistive Load Switching Time vs. Gate Resistance

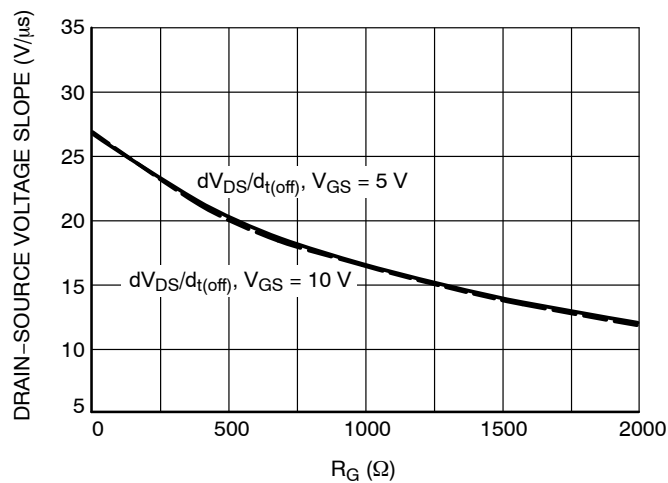


Figure 18. Drain-Source Voltage Slope during Turn On and Turn Off vs. Gate Resistance

TYPICAL PERFORMANCE CURVES

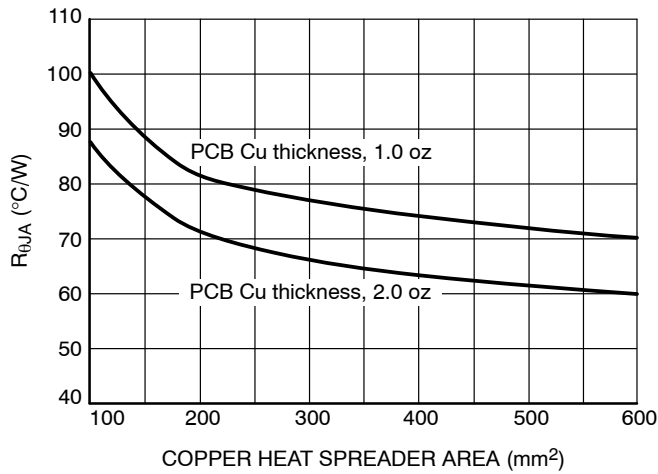


Figure 19.  $R_{\theta JA}$  vs. Copper Area – SOT-223

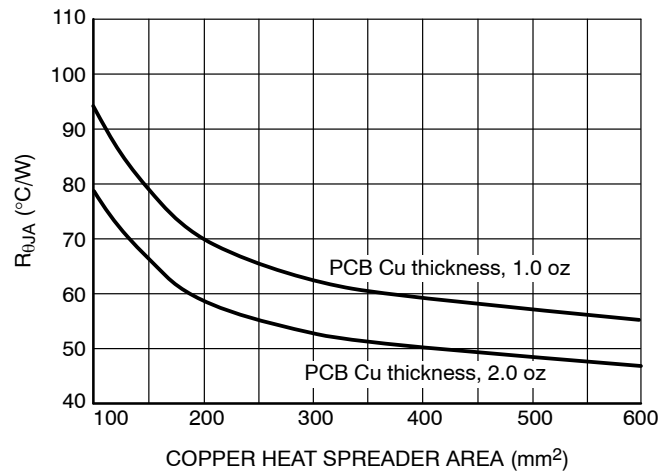


Figure 20.  $R_{\theta JA}$  vs. Copper Area – DPAK

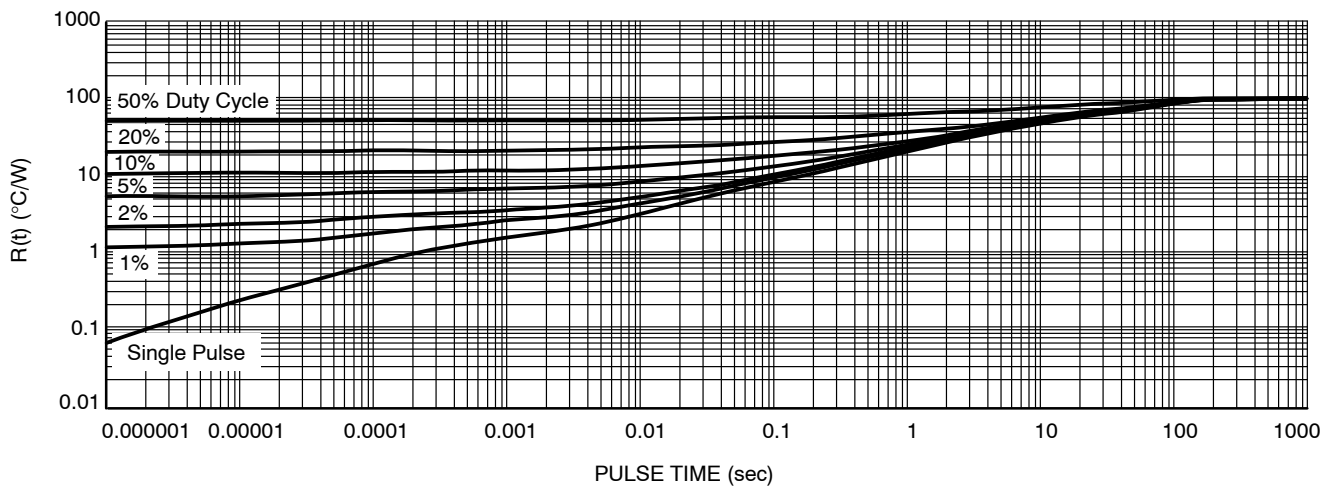


Figure 21. Transient Thermal Resistance – SOT-223 Version

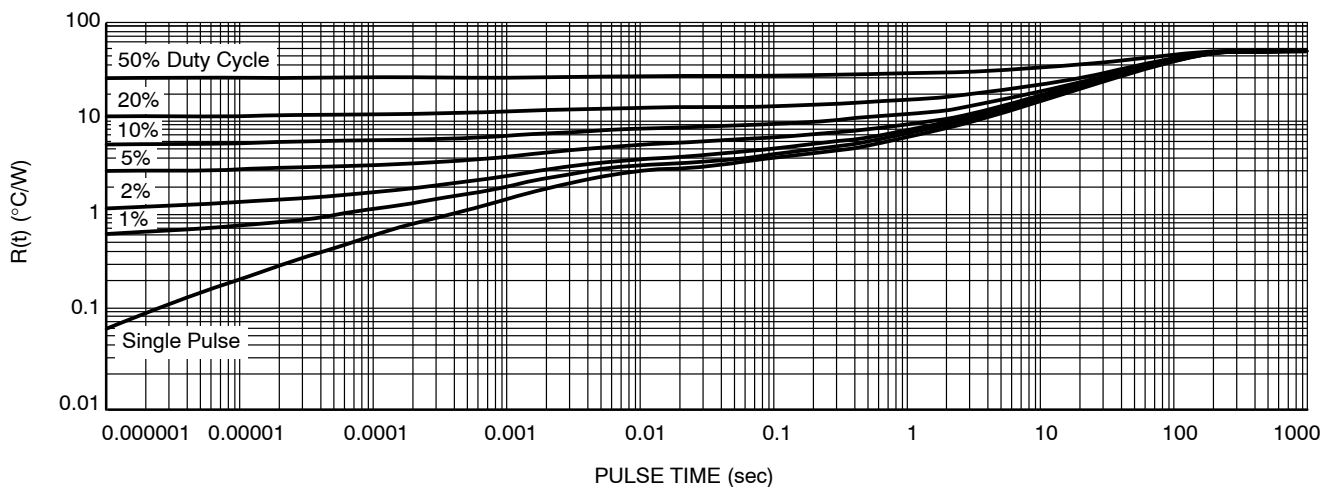
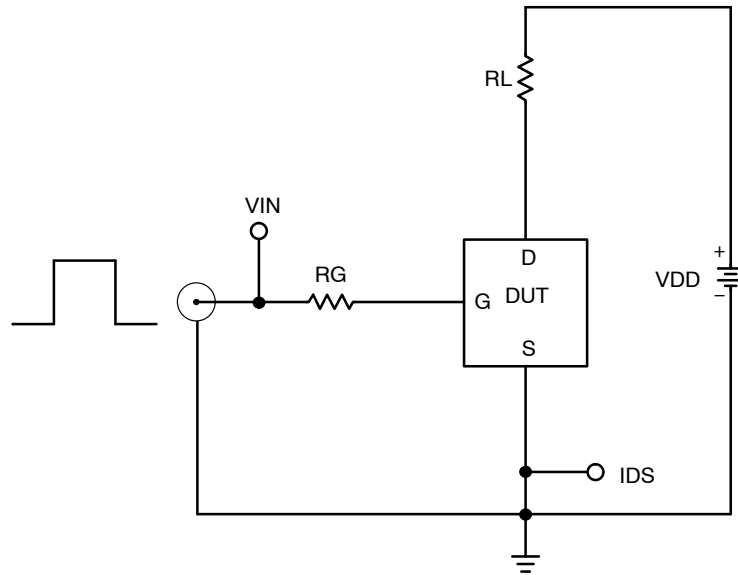


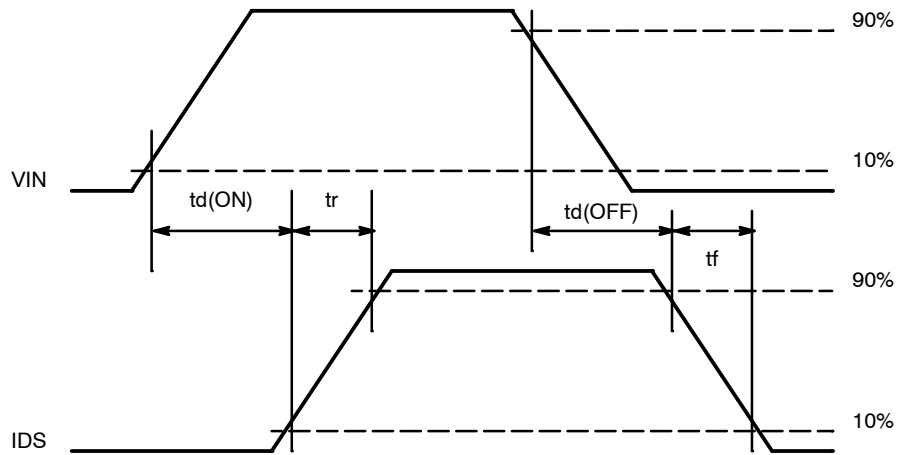
Figure 22. Transient Thermal Resistance – DPAK Version

# NCV8406A, NCV8406B

## TEST CIRCUITS AND WAVEFORMS



**Figure 23. Resistive Load Switching Test Circuit**



**Figure 24. Resistive Load Switching Waveforms**

TEST CIRCUITS AND WAVEFORMS

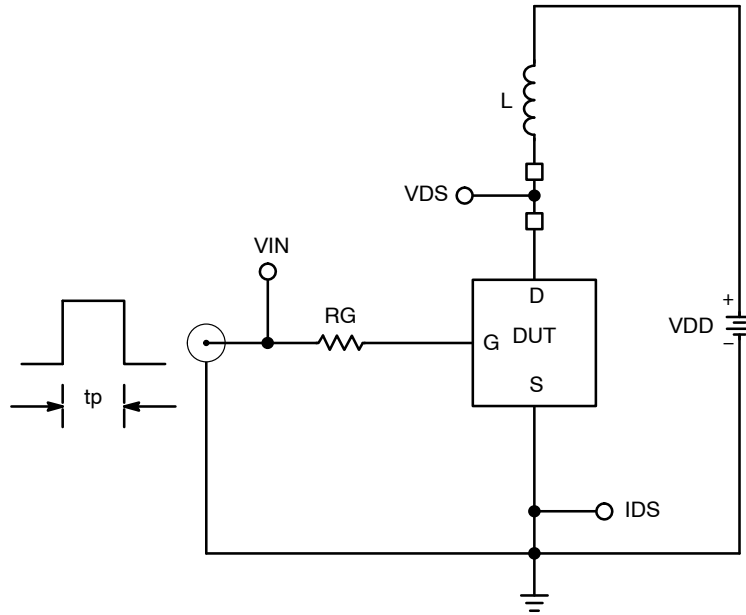


Figure 25. Inductive Load Switching Test Circuit

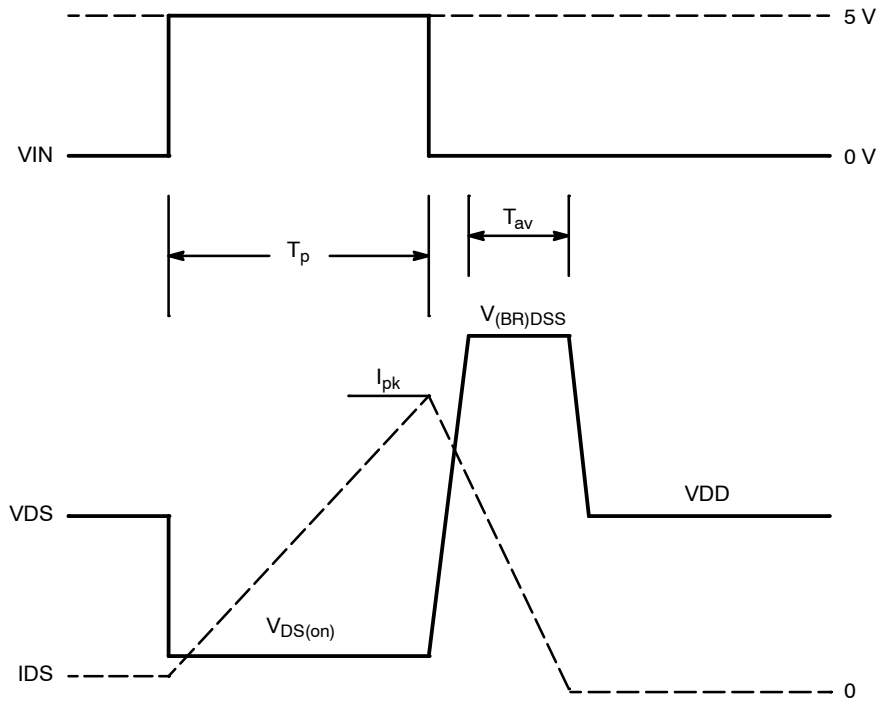


Figure 26. Inductive Load Switching Waveforms

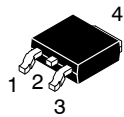
## NCV8406A, NCV8406B

### ORDERING INFORMATION

| Device        | Package              | Shipping†          |
|---------------|----------------------|--------------------|
| NCV8406ASTT1G | SOT-223<br>(Pb-Free) | 1000 / Tape & Reel |
| NCV8406ASTT3G | SOT-223<br>(Pb-Free) | 4000 / Tape & Reel |
| NCV8406ADTRKG | DPAK<br>(Pb-Free)    | 2500 / Tape & Reel |
| NCV8406BDTRKG | DPAK<br>(Pb-Free)    | 2500 / 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.

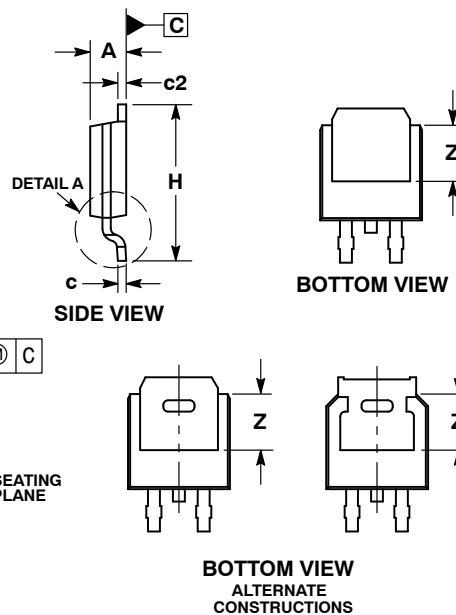
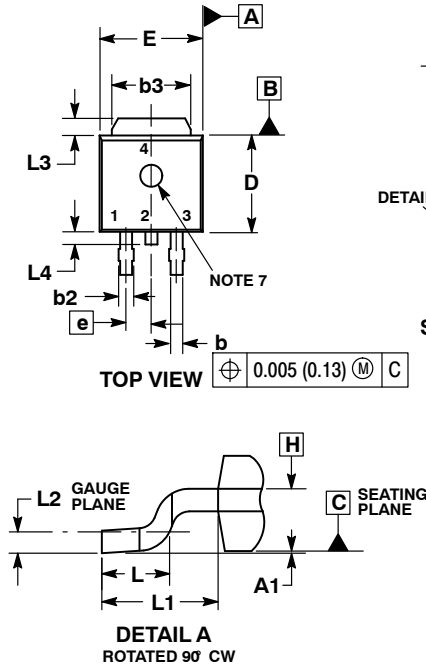
# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



SCALE 1:1

## DPAK (SINGLE GAUGE) CASE 369C ISSUE F

DATE 21 JUL 2015

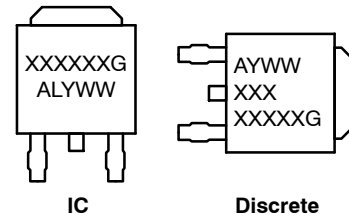


### NOTES:

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.
7. OPTIONAL MOLD FEATURE.

| DIM | INCHES |       | MILLIMETERS |       |
|-----|--------|-------|-------------|-------|
|     | 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  | 0.028  | 0.045 | 0.72        | 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  | 0.114  | REF   | 2.90        | 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        | ---   |

### GENERIC MARKING DIAGRAM\*

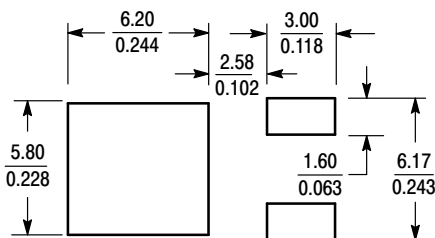


XXXXXX = Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present. Some products may not follow the Generic Marking.

- 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
- STYLE 8:  
PIN 1. N/C  
2. CATHODE  
3. ANODE  
4. CATHODE
- STYLE 9:  
PIN 1. ANODE  
2. CATHODE  
3. RESISTOR ADJUST  
4. CATHODE
- STYLE 10:  
PIN 1. CATHODE  
2. ANODE  
3. CATHODE  
4. ANODE

### 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.

|                         |                            |                                                                                                                                                                                  |
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| <b>DESCRIPTION:</b>     | <b>DPAK (SINGLE GAUGE)</b> | <b>PAGE 1 OF 1</b>                                                                                                                                                               |

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