

# NCV8403, NCV8403A

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

42 V, 14 A, Single N-Channel, SOT-223

NCV8403/A 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)
- AEC-Q101 Qualified and PPAP Capable
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements
- These Devices are Pb-Free and are RoHS Compliant

### Typical Applications

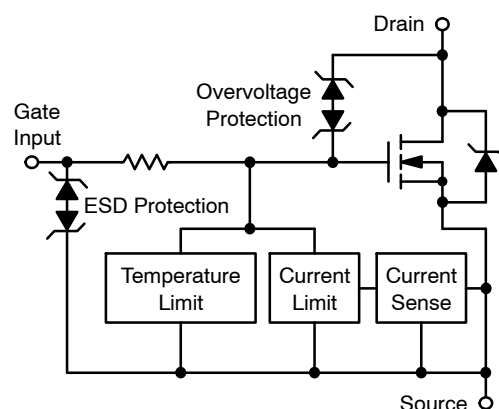
- Switch a Variety of Resistive, Inductive and Capacitive Loads
- Can Replace Electromechanical Relays and Discrete Circuits
- Automotive / Industrial



ON Semiconductor®

<http://onsemi.com>

| $V_{DS}$<br>(Clamped) | $R_{DS(on)}$ TYP | $I_D$ MAX<br>(Limited) |
|-----------------------|------------------|------------------------|
| 42 V                  | 53 mΩ @ 10 V     | 15 A                   |



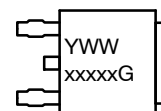
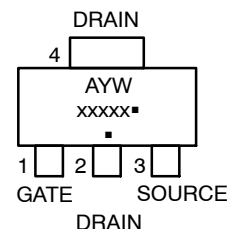
### MARKING DIAGRAM



SOT-223  
CASE 318E  
STYLE 3



DPAK  
CASE 369C



A = Assembly Location  
Y = Year  
W, WW = Work Week  
xxxxx = V8403 or 8403A  
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.

# NCV8403, NCV8403A

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

| Rating                                                                                                                                                                                                                                            | Symbol                                                                                                                                                 | Value                                  | Unit               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------|
| Drain-to-Source Voltage Internally Clamped                                                                                                                                                                                                        | $V_{\text{DSS}}$                                                                                                                                       | 42                                     | Vdc                |
| Gate-to-Source Voltage                                                                                                                                                                                                                            | $V_{\text{GS}}$                                                                                                                                        | $\pm 14$                               | Vdc                |
| Drain Current      Continuous                                                                                                                                                                                                                     | $I_{\text{D}}$                                                                                                                                         | Internally Limited                     |                    |
| Total Power Dissipation<br>@ $T_A = 25^\circ\text{C}$ (Note 1)<br>@ $T_A = 25^\circ\text{C}$ (Note 2)                                                                                                                                             | $P_{\text{D}}$                                                                                                                                         | 1.13<br>1.56                           | W                  |
| Thermal Resistance – SOT-223 Version<br>Junction-to-Case<br>Junction-to-Ambient (Note 1)<br>Junction-to-Ambient (Note 2)<br>Thermal Resistance – DPAK Version<br>Junction-to-Case<br>Junction-to-Ambient (Note 1)<br>Junction-to-Ambient (Note 2) | $R_{\theta\text{JC}}$<br>$R_{\theta\text{JA}}$<br>$R_{\theta\text{JA}}$<br><br>$R_{\theta\text{JC}}$<br>$R_{\theta\text{JA}}$<br>$R_{\theta\text{JA}}$ | 12<br>110<br>80<br><br>2.5<br>95<br>50 | $^\circ\text{C/W}$ |
| Single Pulse Inductive Load Switching Energy<br>( $V_{\text{DD}} = 25\text{ Vdc}$ , $V_{\text{GS}} = 5.0\text{ V}$ , $I_{\text{L}} = 2.8\text{ A}$ , $L = 120\text{ mH}$ , $R_{\text{G}} = 25\ \Omega$ )                                          | $E_{\text{AS}}$                                                                                                                                        | 470                                    | mJ                 |
| Load Dump Voltage ( $V_{\text{GS}} = 0$ and $10\text{ V}$ , $R_{\text{I}} = 2.0\ \Omega$ , $R_{\text{L}} = 4.5\ \Omega$ , $t_{\text{d}} = 400\text{ ms}$ )                                                                                        | $V_{\text{LD}}$                                                                                                                                        | 55                                     | V                  |
| Operating Junction Temperature                                                                                                                                                                                                                    | $T_{\text{J}}$                                                                                                                                         | $-40$ to $150$                         | $^\circ\text{C}$   |
| Storage Temperature                                                                                                                                                                                                                               | $T_{\text{stg}}$                                                                                                                                       | $-55$ 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 onto minimum pad size (0.412" square) FR4 PCB, 1 oz cu.
2. Mounted onto 1" square pad size (1.127" square) FR4 PCB, 1 oz cu.

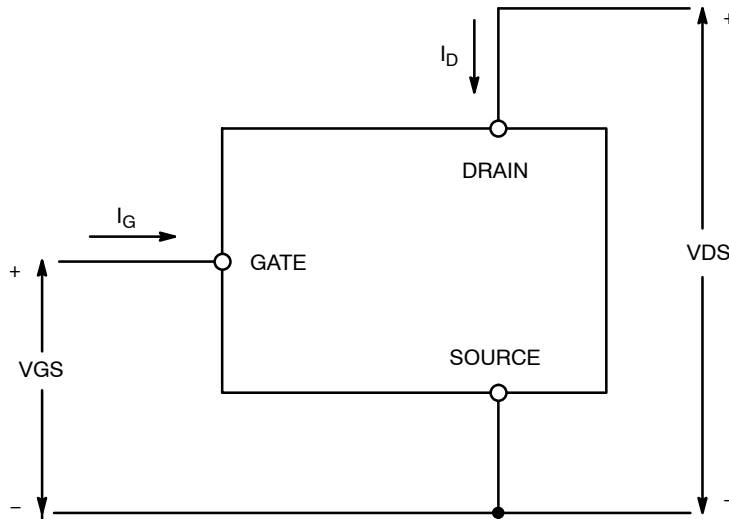


Figure 1. Voltage and Current Convention

# NCV8403, NCV8403A

## 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 Vdc, I <sub>D</sub> = 250 μAdc)<br>(V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 250 μAdc, T <sub>J</sub> = -40°C to 150°C) (Note 3) | V <sub>(BR)DSS</sub> | 42<br>40 | 46<br>45   | 51<br>51 | Vdc<br>Vdc |
| Zero Gate Voltage Drain Current<br>(V <sub>DS</sub> = 32 Vdc, V <sub>GS</sub> = 0 Vdc)<br>(V <sub>DS</sub> = 32 Vdc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 150°C) (Note 3)                      | I <sub>DSS</sub>     | –<br>–   | 0.6<br>2.5 | 5.0<br>– | μAdc       |
| Gate Input Current<br>(V <sub>GS</sub> = 5.0 Vdc, V <sub>DS</sub> = 0 Vdc)                                                                                                                          | I <sub>GSS</sub>     | –        | 50         | 125      | μAdc       |

### ON CHARACTERISTICS

|                                                                                                                                                                                                                         |                     |          |            |           |              |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------|------------|-----------|--------------|
| Gate Threshold Voltage<br>(V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.2 mAdc)<br>Threshold Temperature Coefficient (Negative)                                                                               | V <sub>GS(th)</sub> | 1.0<br>– | 1.7<br>5.0 | 2.2<br>–  | Vdc<br>mV/°C |
| Static Drain-to-Source On-Resistance (Note 4)<br>(V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 3.0 Adc, T <sub>J</sub> @ 25°C)<br>(V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 3.0 Adc, T <sub>J</sub> @ 150°C) (Note 3)   | R <sub>DS(on)</sub> | –<br>–   | 53<br>95   | 68<br>123 | mΩ           |
| Static Drain-to-Source On-Resistance (Note 4)<br>(V <sub>GS</sub> = 5.0 Vdc, I <sub>D</sub> = 3.0 Adc, T <sub>J</sub> @ 25°C)<br>(V <sub>GS</sub> = 5.0 Vdc, I <sub>D</sub> = 3.0 Adc, T <sub>J</sub> @ 150°C) (Note 3) | R <sub>DS(on)</sub> | –<br>–   | 63<br>105  | 76<br>135 | mΩ           |
| Source-Drain Forward On Voltage<br>(I <sub>S</sub> = 7.0 A, V <sub>GS</sub> = 0 V)                                                                                                                                      | V <sub>SD</sub>     | –        | 0.95       | 1.1       | V            |

### SWITCHING CHARACTERISTICS (Note 3)

|                                                             |                                                                                                              |                                     |      |  |      |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-------------------------------------|------|--|------|
| Turn-ON Time (10% V <sub>IN</sub> to 90% I <sub>D</sub> )   | V <sub>IN</sub> = 0 V to 5 V, V <sub>DD</sub> = 25 V<br>I <sub>D</sub> = 1.0 A, Ext R <sub>G</sub> = 2.5 Ω   | t <sub>ON</sub>                     | 44   |  | μs   |
| Turn-OFF Time (90% V <sub>IN</sub> to 10% I <sub>D</sub> )  |                                                                                                              | t <sub>OFF</sub>                    | 84   |  |      |
| Turn-ON Time (10% V <sub>IN</sub> to 90% I <sub>D</sub> )   | V <sub>IN</sub> = 0 V to 10 V, V <sub>DD</sub> = 25 V,<br>I <sub>D</sub> = 1.0 A, Ext R <sub>G</sub> = 2.5 Ω | t <sub>ON</sub>                     | 15   |  |      |
| Turn-OFF Time (90% V <sub>IN</sub> to 10% I <sub>D</sub> )  |                                                                                                              | t <sub>OFF</sub>                    | 116  |  |      |
| Slew-Rate ON (20% V <sub>DS</sub> to 50% V <sub>DS</sub> )  | V <sub>in</sub> = 0 to 10 V, V <sub>DD</sub> = 12 V,<br>R <sub>L</sub> = 4.7 Ω                               | -dV <sub>DS</sub> /dt <sub>ON</sub> | 2.43 |  | V/μs |
| Slew-Rate OFF (80% V <sub>DS</sub> to 50% V <sub>DS</sub> ) |                                                                                                              | dV <sub>DS</sub> /dt <sub>OFF</sub> | 0.83 |  |      |

### SELF PROTECTION CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted) (Note 5)

|                              |                                                                                                             |                       |           |          |          |     |
|------------------------------|-------------------------------------------------------------------------------------------------------------|-----------------------|-----------|----------|----------|-----|
| Current Limit                | V <sub>GS</sub> = 5.0 V, V <sub>DS</sub> = 10 V<br>V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = 150°C (Note 3) | I <sub>LIM</sub>      | 10<br>5.0 | 15<br>10 | 20<br>15 | Adc |
| Current Limit                | V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V<br>V <sub>GS</sub> = 10 V, T <sub>J</sub> = 150°C (Note 3)   | I <sub>LIM</sub>      | 12<br>8.0 | 17<br>13 | 22<br>18 | Adc |
| Temperature Limit (Turn-off) | V <sub>GS</sub> = 5.0 Vdc (Note 3)                                                                          | T <sub>LIM(off)</sub> | 150       | 175      | 200      | °C  |
| Thermal Hysteresis           | V <sub>GS</sub> = 5.0 Vdc                                                                                   | ΔT <sub>LIM(on)</sub> | –         | 15       | –        | °C  |
| Temperature Limit (Turn-off) | V <sub>GS</sub> = 10 Vdc (Note 3)                                                                           | T <sub>LIM(off)</sub> | 150       | 165      | 185      | °C  |
| Thermal Hysteresis           | V <sub>GS</sub> = 10 Vdc                                                                                    | ΔT <sub>LIM(on)</sub> | –         | 15       | –        | °C  |

### GATE INPUT CHARACTERISTICS (Note 3)

|                                        |                                                |                  |  |      |  |    |
|----------------------------------------|------------------------------------------------|------------------|--|------|--|----|
| Device ON Gate Input Current           | V <sub>GS</sub> = 5 V I <sub>D</sub> = 1.0 A   | I <sub>GON</sub> |  | 50   |  | μA |
|                                        | V <sub>GS</sub> = 10 V I <sub>D</sub> = 1.0 A  |                  |  | 400  |  |    |
| Current Limit Gate Input Current       | V <sub>GS</sub> = 5 V, V <sub>DS</sub> = 10 V  | I <sub>GCL</sub> |  | 0.1  |  | mA |
|                                        | V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V |                  |  | 0.6  |  |    |
| Thermal Limit Fault Gate Input Current | V <sub>GS</sub> = 5 V, V <sub>DS</sub> = 10 V  | I <sub>GTL</sub> |  | 0.45 |  | mA |
|                                        | V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V |                  |  | 1.5  |  |    |

### ESD ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted) (Note 3)

|                                     |                        |     |      |   |   |   |
|-------------------------------------|------------------------|-----|------|---|---|---|
| Electro-Static Discharge Capability | Human Body Model (HBM) | ESD | 4000 | – | – | V |
| Electro-Static Discharge Capability | Machine Model (MM)     | ESD | 400  | – | – | V |

3. Not subject to production testing.

4. Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%.

5. Fault conditions are viewed as beyond the normal operating range of the part.

TYPICAL PERFORMANCE CURVES

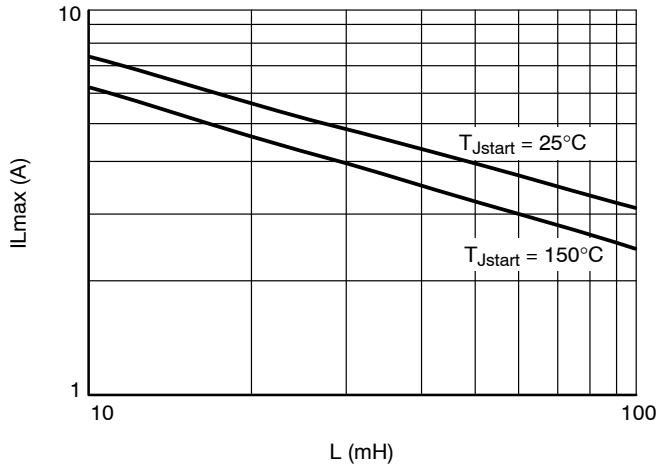


Figure 2. Single Pulse Maximum Switch-off Current vs. Load Inductance

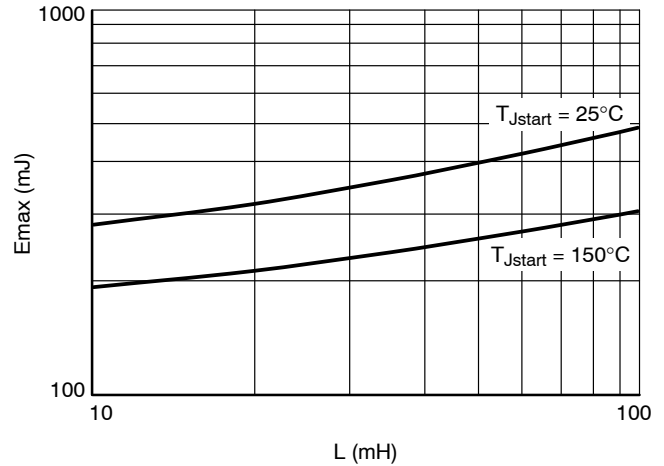


Figure 3. Single-Pulse Maximum Switching Energy vs. Load Inductance

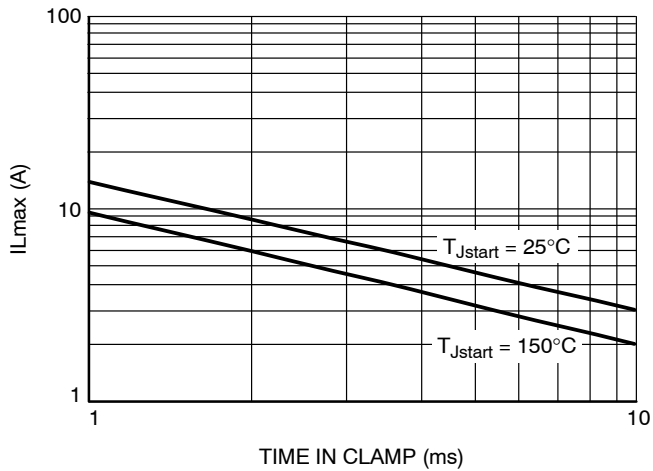


Figure 4. Single Pulse Maximum Inductive Switch-off Current vs. Time in Clamp

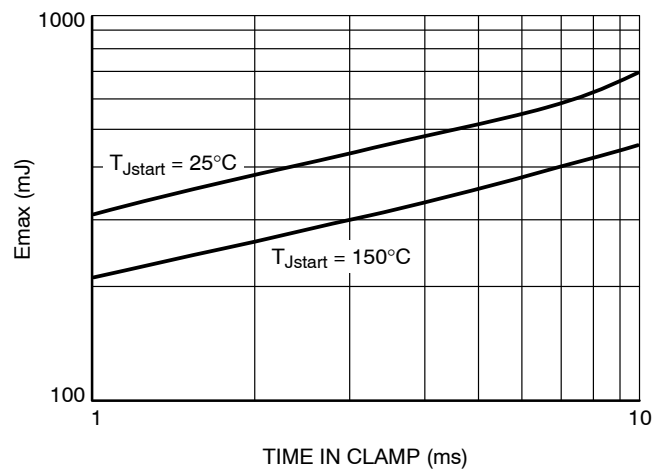


Figure 5. Single-Pulse Maximum Inductive Switching Energy vs. Time in Clamp

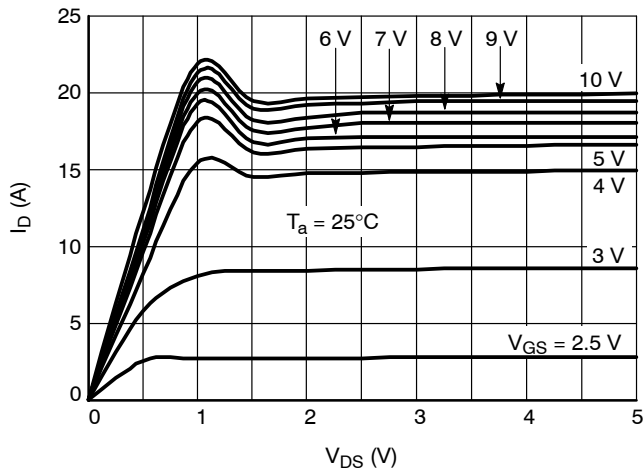


Figure 6. On-state Output Characteristics

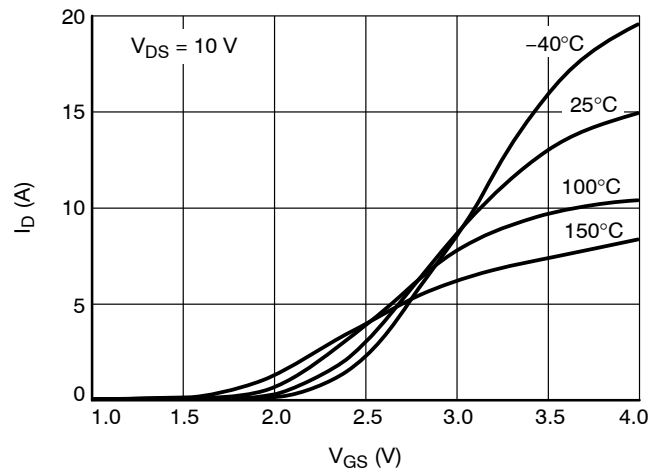


Figure 7. Transfer Characteristics

TYPICAL PERFORMANCE CURVES

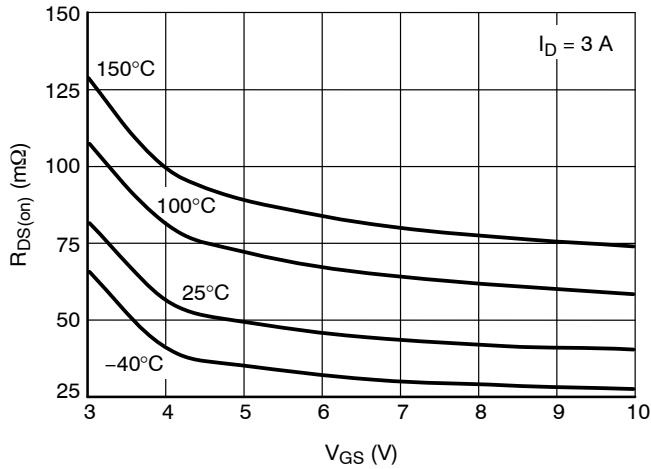


Figure 8.  $R_{DS(on)}$  vs. Gate-Source Voltage

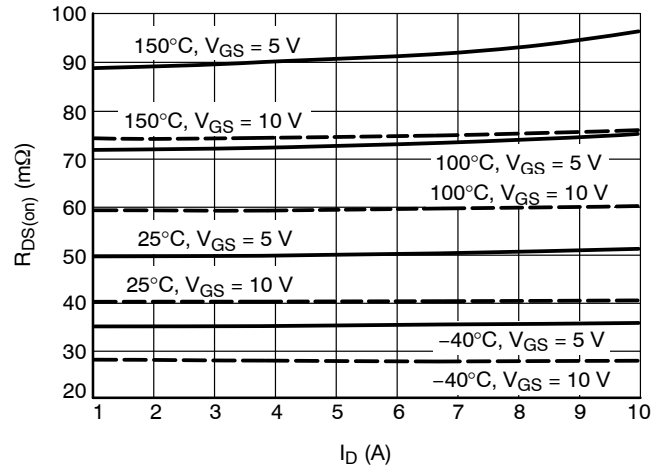


Figure 9.  $R_{DS(on)}$  vs. Drain Current

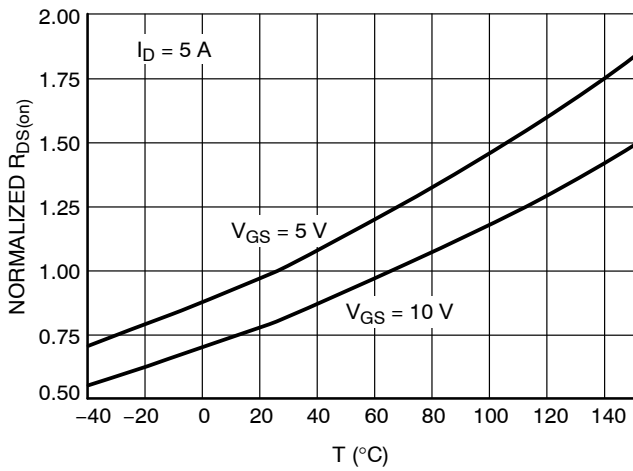


Figure 10. Normalized  $R_{DS(on)}$  vs. Temperature

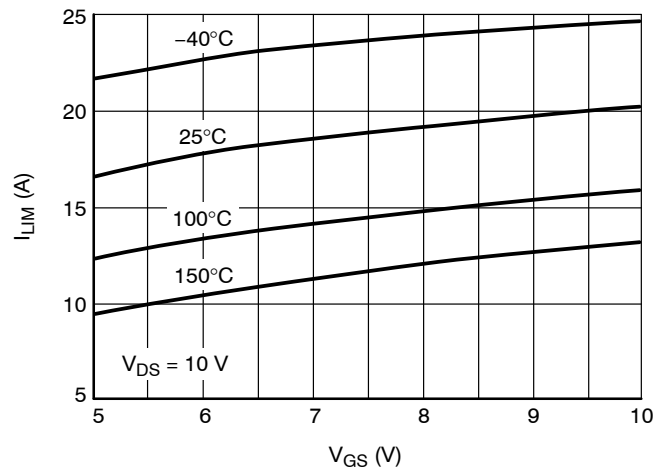


Figure 11. Current Limit vs. Gate-Source Voltage

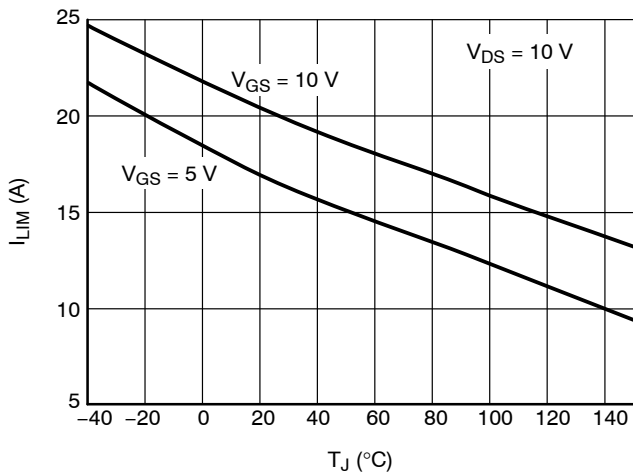


Figure 12. Current Limit vs. Junction Temperature

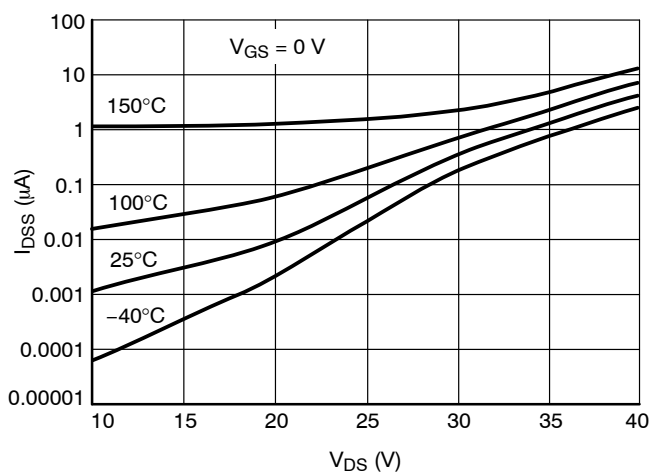


Figure 13. Drain-to-Source Leakage Current

TYPICAL PERFORMANCE CURVES

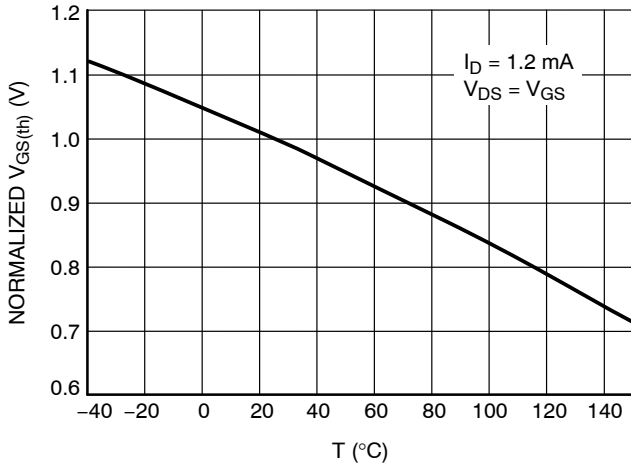


Figure 14. Normalized Threshold Voltage vs. Temperature

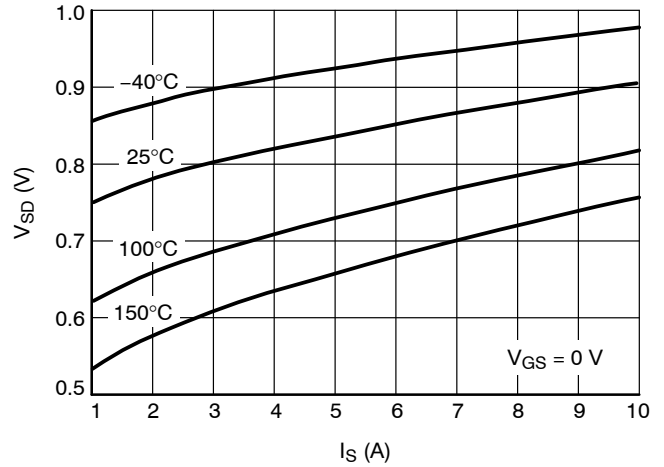


Figure 15. Source-Drain Diode Forward Characteristics

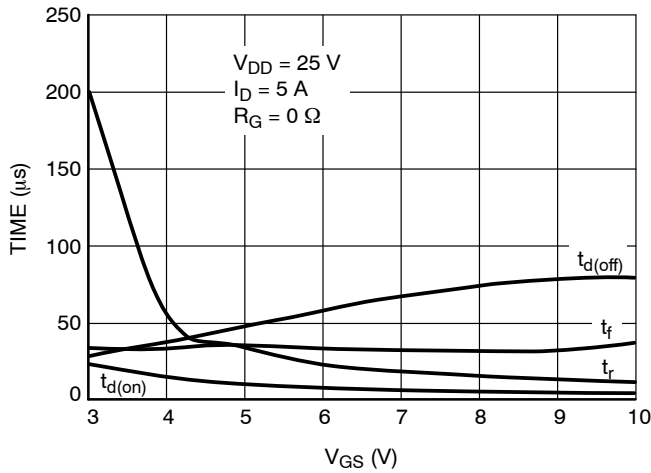


Figure 16. Resistive Load Switching Time vs. Gate-Source Voltage

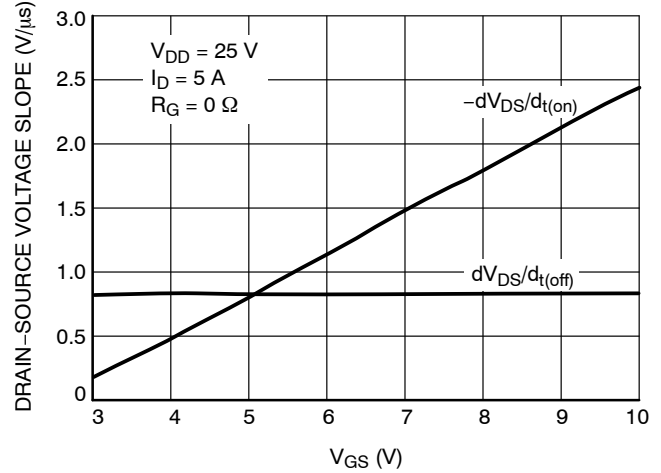


Figure 17. Resistive Load Switching Drain-Source Voltage Slope vs. Gate-Source Voltage

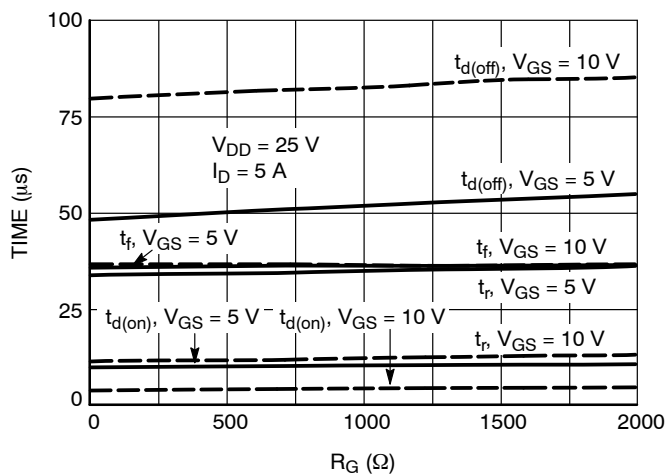


Figure 18. Resistive Load Switching Time vs. Gate Resistance

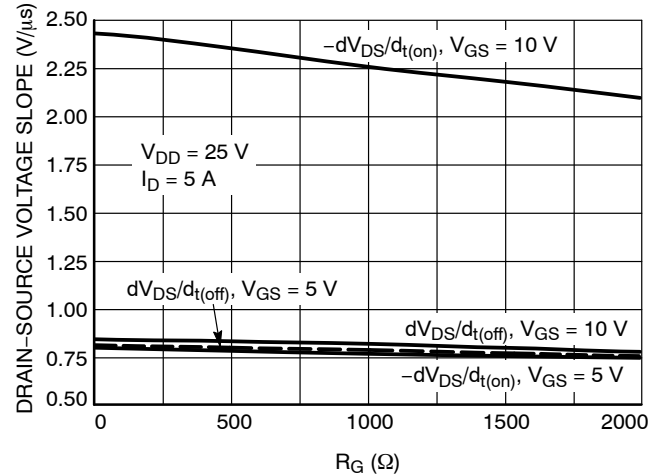


Figure 19. Drain-Source Voltage Slope during Turn On and Turn Off vs. Gate Resistance

TYPICAL PERFORMANCE CURVES

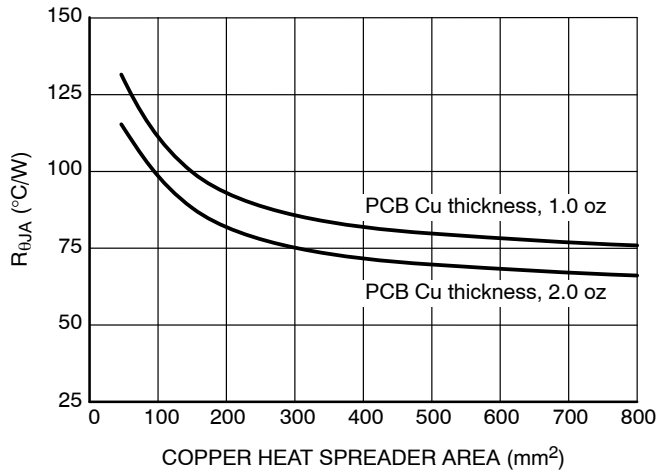


Figure 20.  $R_{\theta JA}$  vs. Copper Area – SOT-223

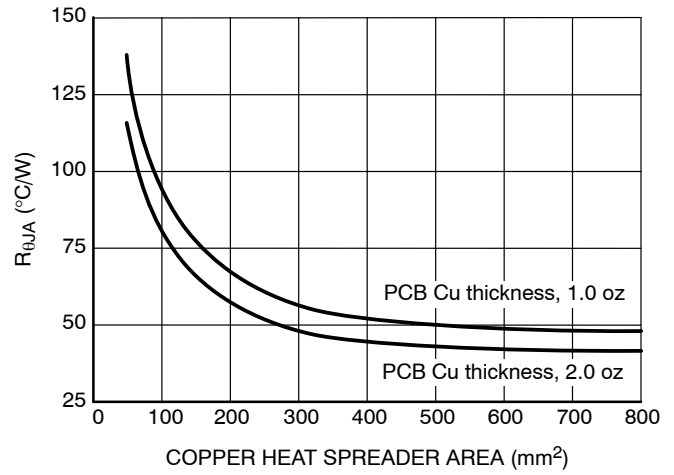


Figure 21.  $R_{\theta JA}$  vs. Copper Area – DPAK

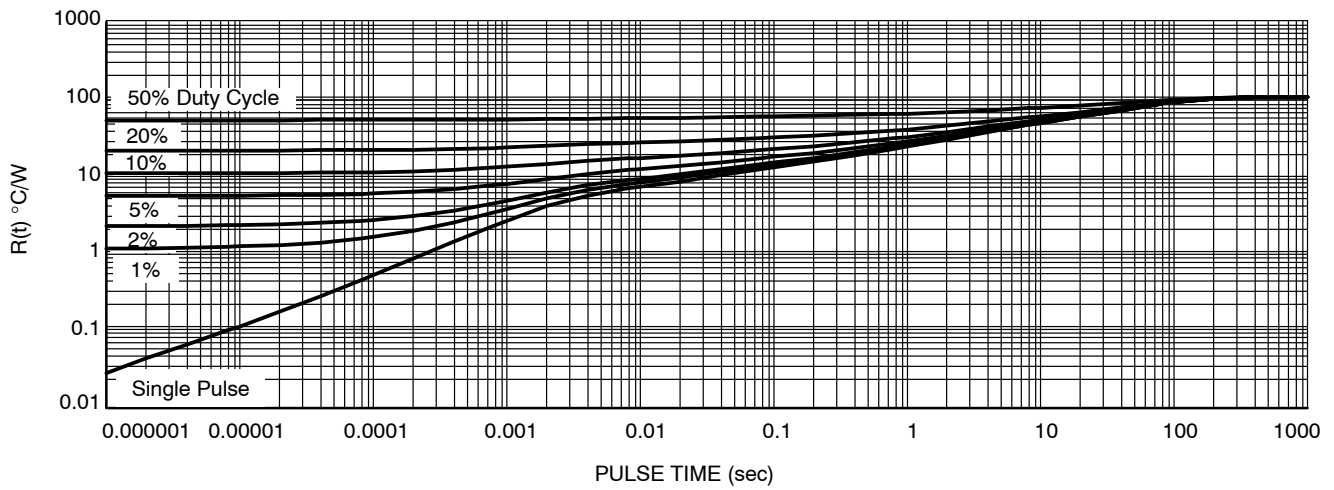


Figure 22. Transient Thermal Resistance – SOT-223 Version

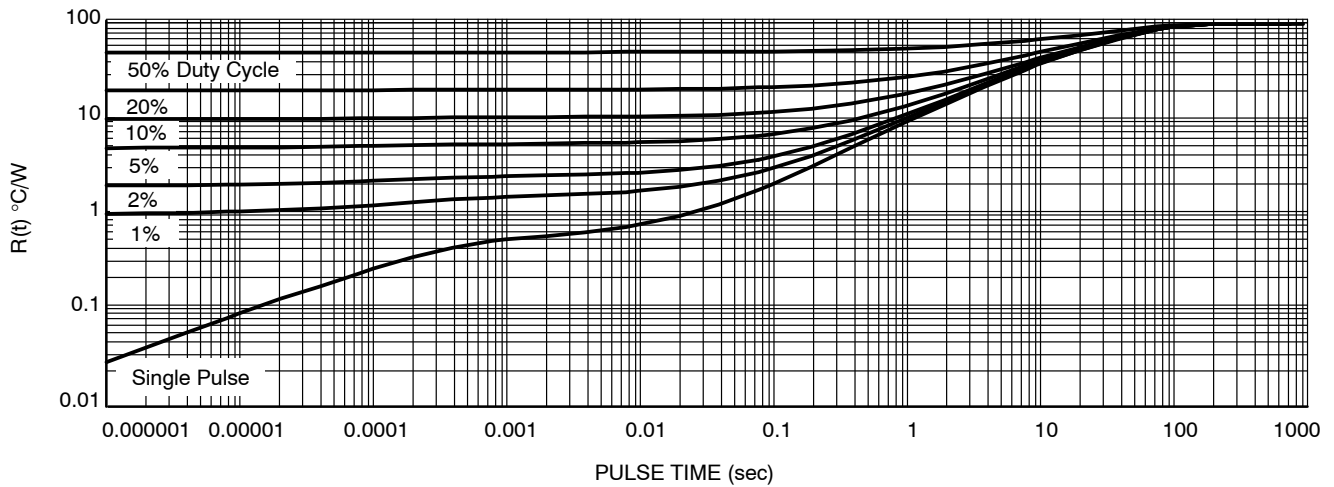


Figure 23. Transient Thermal Resistance – DPAK Version

# NCV8403, NCV8403A

## TEST CIRCUITS AND WAVEFORMS

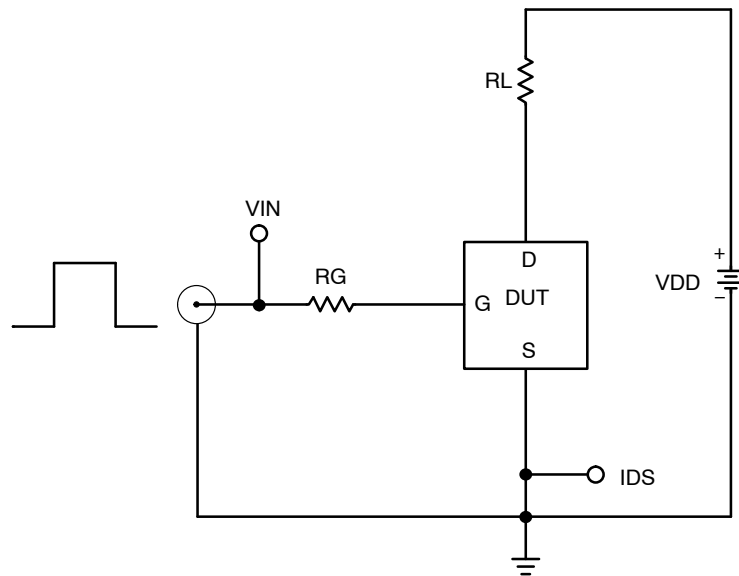


Figure 24. Resistive Load Switching Test Circuit

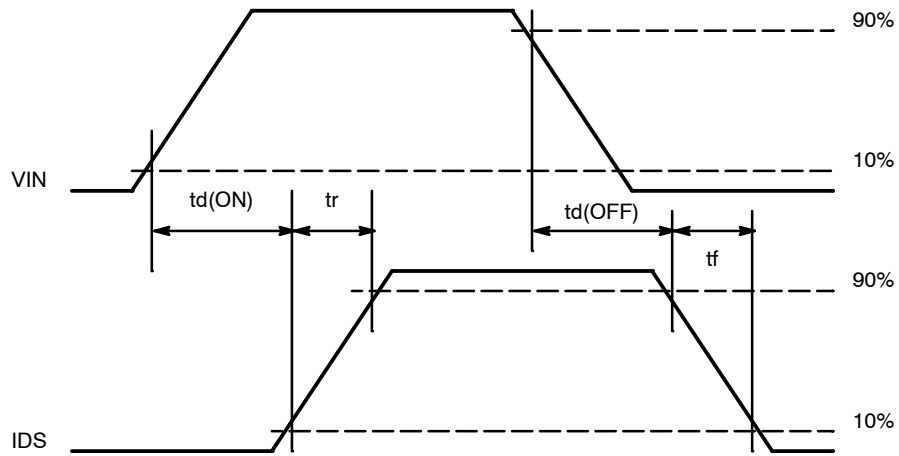


Figure 25. Resistive Load Switching Waveforms

# NCV8403, NCV8403A

## TEST CIRCUITS AND WAVEFORMS

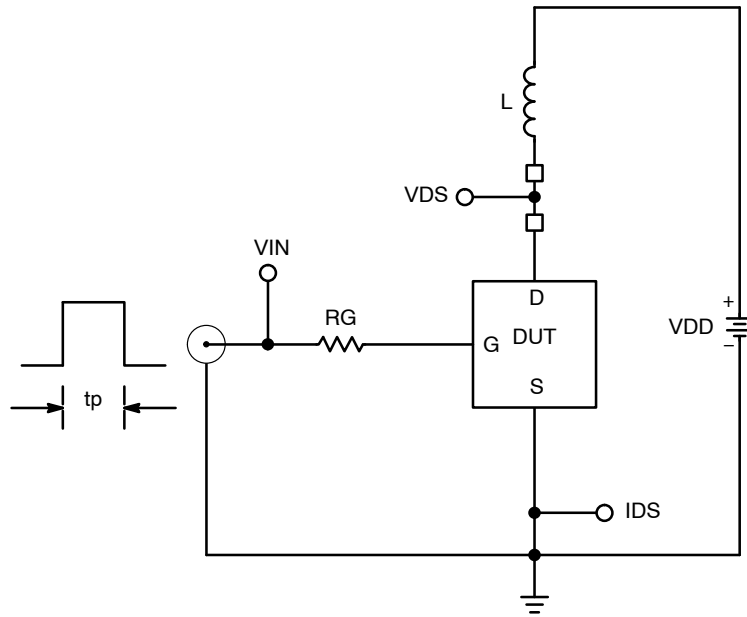


Figure 26. Inductive Load Switching Test Circuit

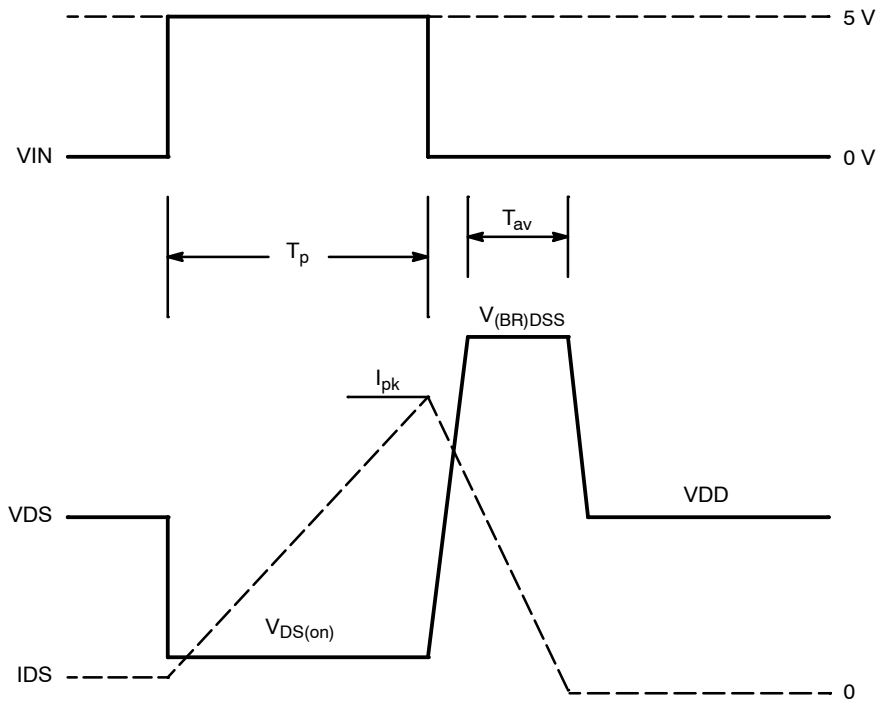


Figure 27. Inductive Load Switching Waveforms

## NCV8403, NCV8403A

### ORDERING INFORMATION

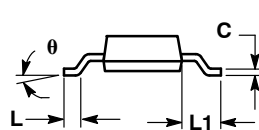
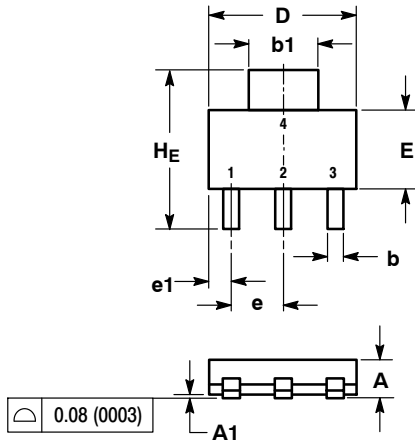
| Device        | Package              | Shipping <sup>†</sup> |
|---------------|----------------------|-----------------------|
| NCV8403STT1G  | SOT-223<br>(Pb-Free) | 1000 / Tape & Reel    |
| NCV8403STT3G  | SOT-223<br>(Pb-Free) | 4000 / Tape & Reel    |
| NCV8403DTRKG  | DPAK<br>(Pb-Free)    | 2500 / Tape & Reel    |
| NCV8403ASTT1G | SOT-223<br>(Pb-Free) | 1000 / Tape & Reel    |
| NCV8403ASTT3G | SOT-223<br>(Pb-Free) | 4000 / Tape & Reel    |
| NCV8403ADTRKG | DPAK<br>(Pb-Free)    | 2500 / Tape & Reel    |

<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.

# NCV8403, NCV8403A

## PACKAGE DIMENSIONS

SOT-223 (TO-261)  
CASE 318E-04  
ISSUE N

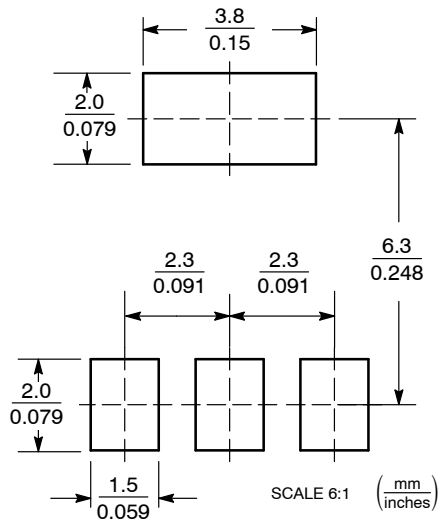


NOTES:  
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.  
2. CONTROLLING DIMENSION: INCH.

| DIM | MILLIMETERS |      |      | INCHES |       |       |
|-----|-------------|------|------|--------|-------|-------|
|     | MIN         | NOM  | MAX  | MIN    | NOM   | MAX   |
| A   | 1.50        | 1.63 | 1.75 | 0.060  | 0.064 | 0.068 |
| A1  | 0.02        | 0.06 | 0.10 | 0.001  | 0.002 | 0.004 |
| b   | 0.60        | 0.75 | 0.89 | 0.024  | 0.030 | 0.035 |
| b1  | 2.90        | 3.06 | 3.20 | 0.115  | 0.121 | 0.126 |
| c   | 0.24        | 0.29 | 0.35 | 0.009  | 0.012 | 0.014 |
| D   | 6.30        | 6.50 | 6.70 | 0.249  | 0.256 | 0.263 |
| E   | 3.30        | 3.50 | 3.70 | 0.130  | 0.138 | 0.145 |
| e   | 2.20        | 2.30 | 2.40 | 0.087  | 0.091 | 0.094 |
| e1  | 0.85        | 0.94 | 1.05 | 0.033  | 0.037 | 0.041 |
| L   | 0.20        | ---  | ---  | 0.008  | ---   | ---   |
| L1  | 1.50        | 1.75 | 2.00 | 0.060  | 0.069 | 0.078 |
| HE  | 6.70        | 7.00 | 7.30 | 0.264  | 0.276 | 0.287 |
| θ   | 0°          | —    | 10°  | 0°     | —     | 10°   |

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

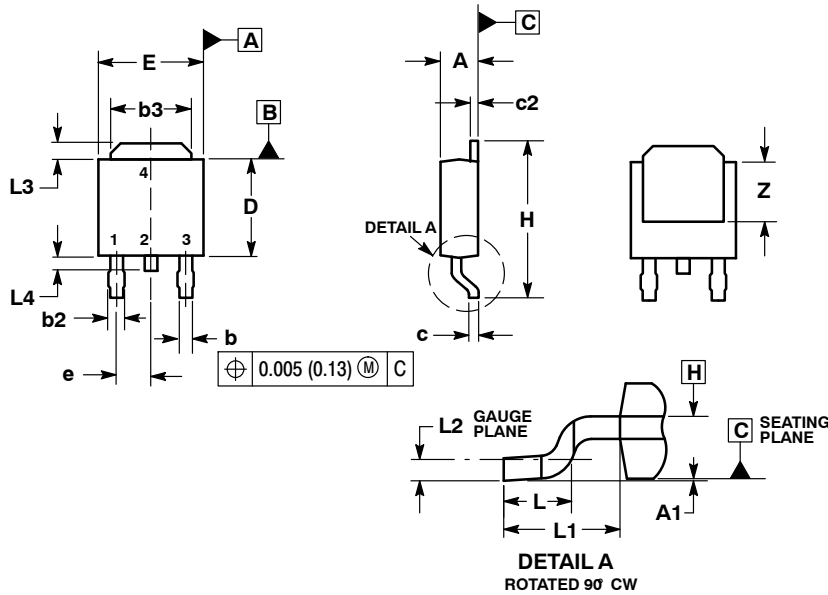
## SOLDERING FOOTPRINT



# NCV8403, NCV8403A

## PACKAGE DIMENSIONS

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

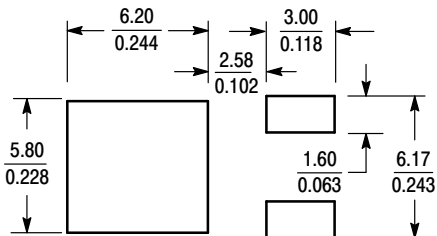


#### NOTES:

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.

| 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  | 0.030     | 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        | ---   |

### 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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