

Self-Protected Low Side Driver with In-Rush Current Management

NCV8415

The NCV8415 is a three terminal protected Low-Side Smart Discrete FET. The protection features include Delta Thermal Shutdown, overcurrent, overtemperature, ESD and integrated Drain-to-Gate clamping for overvoltage protection. The device also offers fault indication via the gate pin. This device is suitable for harsh automotive environments.

Features

- Short-Circuit Protection with In-Rush Current Management
- Delta Thermal Shutdown
- Thermal Shutdown with Automatic Restart
- Overvoltage Protection
- Integrated Clamp for Overvoltage Protection and Inductive Switching
- ESD Protection
- dV/dt Robustness
- Analog Drive Capability (Logic Level Input)
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC-Q101 Grade 1 Qualified and PPAP Capable
- 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

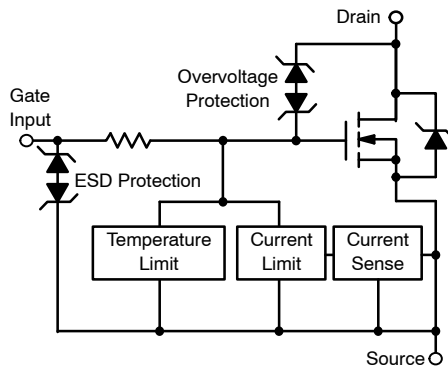
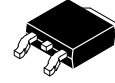


Figure 1. Block Diagram

| V _{DSS} (Clamped) | R _{DS(ON)} TYP | I _D MAX (Limited) |
|----------------------------|-------------------------|------------------------------|
| 42 V | 80 mΩ @ 10 V | 11 A |

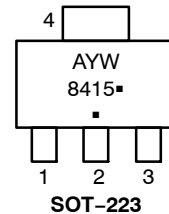


SOT-223
CASE 318E
STYLE 3

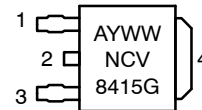


DPAK
CASE 369C
STYLE 2

MARKING DIAGRAMS



SOT-223



DPAK

Pin Marking Information
1 = Gate
2 = Drain
3 = Source
4 = Drain

A = Assembly Location
Y = Year
W, WW = Work Week
G or ■ = Pb-Free Package

(Note: Microdot may be in either location)

ORDERING INFORMATION

| Device | Package | Shipping† |
|--------------|-------------------|--------------------|
| NCV8415DTRKG | DPAK (Pb-Free) | 2500 / Tape & Reel |
| NCV8415STT1G | SOT-223 (Pb-Free) | 1000 / Tape & Reel |
| NCV8415STT3G | SOT-223 (Pb-Free) | 4000 / Tape & Reel |

†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.

MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|----------------------|--------------------|
| Drain-to-Source Voltage Internally Clamped | V_{DSS} | 42 | V |
| Drain-to-Gate Voltage Internally Clamped | V_{DG} | 42 | V |
| Gate-to-Source Voltage | V_{GS} | ± 14 | V |
| Drain Current - Continuous | I_D | Internally Limited | |
| Total Power Dissipation (SOT-223) @ $T_A = 25^\circ\text{C}$ (Note 1) @ $T_A = 25^\circ\text{C}$ (Note 2) | P_D | 1.29 | W |
| | | 2.20 | |
| Total Power Dissipation (DPAK) @ $T_A = 25^\circ\text{C}$ (Note 1) @ $T_A = 25^\circ\text{C}$ (Note 2) | | 1.54 | |
| | | 2.99 | |
| Thermal Resistance (SOT-223) Junction-to-Ambient (Note 1) Junction-to-Ambient (Note 2) Junction-to-Case (Soldering Point) | $R_{\theta JA}$ $R_{\theta JA}$ $R_{\theta JS}$ | 96.4 56.8 10.6 | $^\circ\text{C/W}$ |
| Thermal Resistance (DPAK) Junction-to-Ambient (Note 1) Junction-to-Ambient (Note 2) Junction-to-Case (Soldering Point) | $R_{\theta JA}$ $R_{\theta JA}$ $R_{\theta JS}$ | 80.8 41.8 3.2 | |
| Single Pulse Inductive Load Switching Energy ($L = 10\text{ mH}$, $I_{Lpeak} = 4.2\text{ A}$, $V_{GS} = 5\text{ V}$, $R_G = 25\ \Omega$, $T_{Jstart} = 25^\circ\text{C}$) | E_{AS} | 88 | mJ |
| Load Dump Voltage ($V_{GS} = 0$ and 10 V , $R_L = 10\ \Omega$) (Note 3) | U_S^* | 52 | V |
| Operating Junction Temperature | T_J | -40 to 150 | $^\circ\text{C}$ |
| Storage Temperature | $T_{storage}$ | -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. Mounted onto a $80 \times 80 \times 1.6\text{ mm}$ single layer FR4 board (100 sq mm, 1 oz. Cu, steady state).
2. Mounted onto a $80 \times 80 \times 1.6\text{ mm}$ single layer FR4 board (645 sq mm, 1 oz. Cu, steady state).
3. Load Dump Test B (with centralized load dump suppression) according to ISO16750-2 standard. Guaranteed by design. Not tested in production. Passed Class C according to ISO16750-1.

ESD ELECTRICAL CHARACTERISTICS (Note 4, 5)

| Parameter | Test Condition | Symbol | Min | Typ | Max | Unit |
|-------------------------------------|----------------------------|--------|------|-----|-----|------|
| Electro-Static Discharge Capability | Human Body Model (HBM) | ESD | 4000 | - | - | V |
| | Charged Device Model (CDM) | | 1000 | - | - | |

4. Not tested in production.
5. This device series incorporates ESD protection and is tested by the following methods:
ESD Human Body Model tested per AEC-Q100-002 (JS-001-2017).
Field Induced Charge Device Model ESD characterization is not performed on plastic molded packages with body sizes smaller than $2 \times 2\text{ mm}$ due to the inability of a small package body to acquire and retain enough charge to meet the minimum CDM discharge current waveform characteristic defined in JEDEC JS-002-2018.

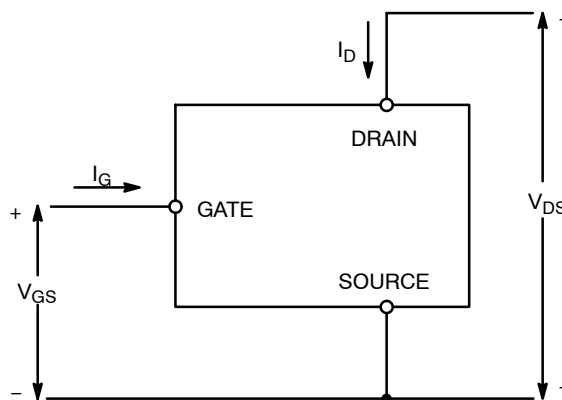


Figure 2. Voltage and Current Convention

NCV8415

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

| Parameter | Test Condition | Symbol | Min | Typ | Max | Unit |
|-----------------------------------|--|----------------------|-----|-----|-----|------|
| OFF CHARACTERISTICS | | | | | | |
| Drain-to-Source Breakdown Voltage | V _{GS} = 0 V, I _D = 10 mA | V _{(BR)DSS} | 42 | 46 | 51 | V |
| | V _{GS} = 0 V, I _D = 10 mA, T _J = 150°C (Note 6) | | 42 | 44 | 51 | |
| Zero Gate Voltage Drain Current | V _{GS} = 0 V, V _{DS} = 32 V | I _{DSS} | – | 0.6 | 2.0 | μA |
| | V _{GS} = 0 V, V _{DS} = 32 V, T _J = 150°C (Note 6) | | – | 2.4 | 10 | |
| Gate Input Current | V _{GS} = 5 V, V _{DS} = 0 V | I _{GSS} | – | 50 | 70 | |

ON CHARACTERISTICS

| | | | | | | |
|--|--|-------------------------------------|-----|------|------|-------|
| Gate Threshold Voltage | V _{GS} = V _{DS} , I _D = 150 μA | V _{GS(th)} | 1.0 | 1.6 | 2.0 | V |
| Gate Threshold Temperature Coefficient | V _{GS} = V _{DS} , I _D = 150 μA (Note 6) | V _{GS(th)} /T _J | – | –4.0 | – | mV/°C |
| Static Drain-to-Source On Resistance | V _{GS} = 10 V, I _D = 1.4 A | R _{DS(ON)} | – | 80 | 100 | mΩ |
| | V _{GS} = 10 V, I _D = 1.4 A, T _J = 150°C (Note 6) | | – | 150 | 190 | |
| | V _{GS} = 5.0 V, I _D = 1.4 A | | – | 105 | 120 | |
| | V _{GS} = 5.0 V, I _D = 1.4 A, T _J = 150°C (Note 6) | | – | 185 | 210 | |
| | V _{GS} = 5.0 V, I _D = 0.5 A | | – | 105 | 120 | |
| | V _{GS} = 5.0 V, I _D = 0.5 A, T _J = 150°C (Note 6) | | – | 185 | 210 | |
| Source-Drain Forward On Voltage | I _S = 7 A, V _{GS} = 0 V | V _{SD} | – | 0.88 | 1.10 | V |

SWITCHING CHARACTERISTICS (Note 6)

| | | | | | | | |
|--|---|-------------------------------------|-----|------|----|----|------|
| Turn-On Time (10% V _{GS} to 90% I _D) | V _{GS} = 0 V to 5 V, V _{DD} = 12 V, I _D = 1 A | t _{ON} | – | 30 | 35 | μs | |
| Turn-Off Time (90% V _{GS} to 10% I _D) | | t _{OFF} | – | 44 | 55 | | |
| Turn-On Time (10% V _{GS} to 90% I _D) | V _{GS} = 0 V to 10 V, V _{DD} = 12 V, I _D = 1 A | t _{ON} | – | 13 | 20 | μs | |
| Turn-Off Time (90% V _{GS} to 10% I _D) | | t _{OFF} | – | 70 | 90 | | |
| Turn-On Rise Time (10% I _D to 90% I _D) | | t _{rise} | – | 9 | 15 | | |
| Turn-Off Fall Time (90% I _D to 10% I _D) | | t _{fall} | – | 29 | 40 | | |
| Slew Rate On (80% V _{DS} to 50% V _{DS}) | | –dV _{DS} /dt _{ON} | 0.5 | 1.63 | – | | V/μs |
| Slew Rate Off (50% V _{DS} to 80% V _{DS}) | | dV _{DS} /dt _{OFF} | 0.4 | 0.55 | – | | |

SELF PROTECTION CHARACTERISTICS

| | | | | | | |
|------------------------------|---|-----------------------|-----|-----|-----|----|
| Current Limit | V _{GS} = 5 V, V _{DS} = 10 V (Note 7) | I _{LIM} | 7.0 | 8.8 | 11 | A |
| | V _{GS} = 5 V, V _{DS} = 10 V, T _J = 150°C (Notes 6, 7) | | 6.4 | 7.9 | 9.1 | |
| | V _{GS} = 10 V, V _{DS} = 10 V (Notes 6, 7) | | 5.2 | 8.2 | 11 | |
| | V _{GS} = 10 V, V _{DS} = 10 V, T _J = 150°C (Notes 6, 7) | | 5.0 | 7.4 | 10 | |
| Temperature Limit (Turn-Off) | V _{GS} = 5.0 V (Notes 6, 7) | T _{LIM(OFF)} | 150 | 175 | 185 | °C |
| Thermal Hysteresis | | ΔT _{LIM(ON)} | – | 15 | – | |
| Temperature Limit (Turn-Off) | V _{GS} = 10 V (Notes 6, 7) | T _{LIM(OFF)} | 150 | 185 | 200 | °C |
| Thermal Hysteresis | | ΔT _{LIM(ON)} | – | 15 | – | |

GATE INPUT CHARACTERISTICS (Note 6)

| | | | | | | |
|----------------------------------|--|------------------|-----|-----|-----|----|
| Device ON Gate Input Current | V _{GS} = 5 V, V _{DS} = 10 V, I _D = 1 A | I _{GON} | 35 | 50 | 70 | μA |
| | V _{GS} = 10 V, V _{DS} = 10 V, I _D = 1 A | | 250 | 310 | 450 | |
| Current Limit Gate Input Current | V _{GS} = 5 V, V _{DS} = 10 V | I _{GCL} | 45 | 76 | 95 | μA |
| | V _{GS} = 10 V, V _{DS} = 10 V | | 320 | 450 | 550 | |
| Thermal Limit Gate Input Current | V _{GS} = 5 V, V _{DS} = 10 V, I _D = 0 A | I _{GTL} | 210 | 240 | 260 | μA |
| | V _{GS} = 10 V, V _{DS} = 10 V, I _D = 0 A | | 620 | 700 | 830 | |

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.

6. Not subject to production testing.

7. Refer to Apps Note AND8202D for dependence of protection features on gate voltage.

TYPICAL PERFORMANCE CURVES

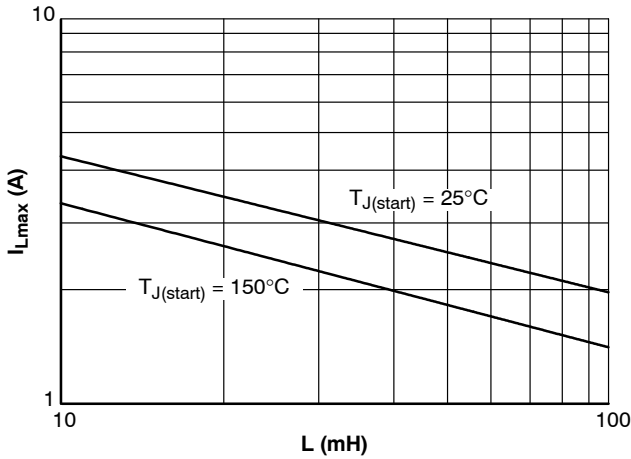


Figure 3. Single Pulse Maximum Switch-Off Current vs. Load Inductance

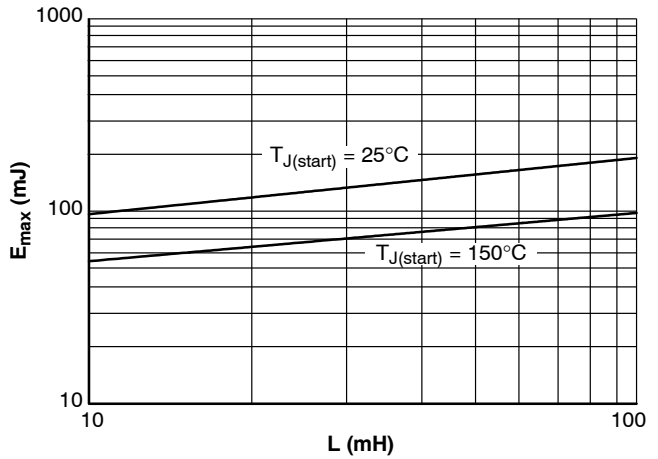


Figure 4. Single Pulse Maximum Switching Energy vs. Load Inductance

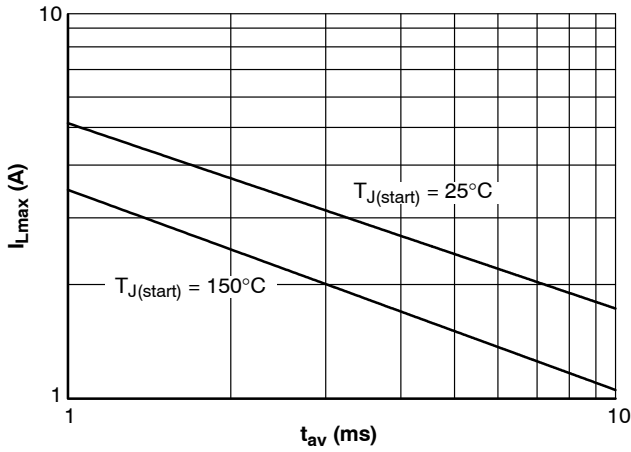


Figure 5. Single Pulse Maximum Inductive Switch-Off Current vs. Time in Avalanche

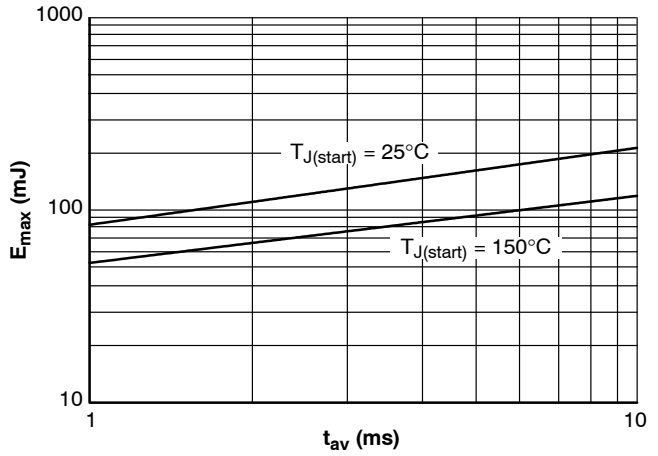


Figure 6. Single Pulse Maximum Inductive Switching Energy vs. Time in Avalanche

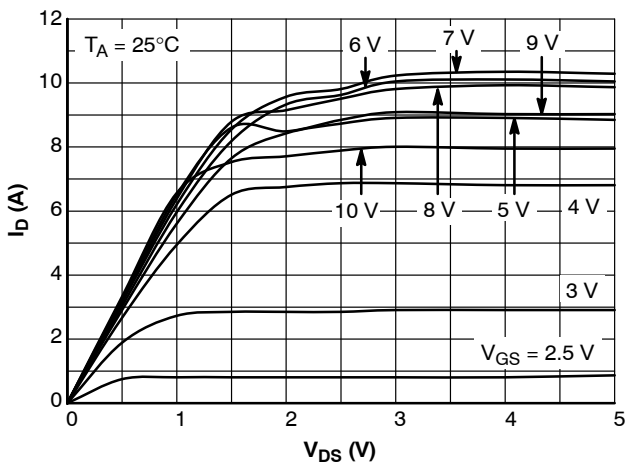


Figure 7. On-State Output Characteristics

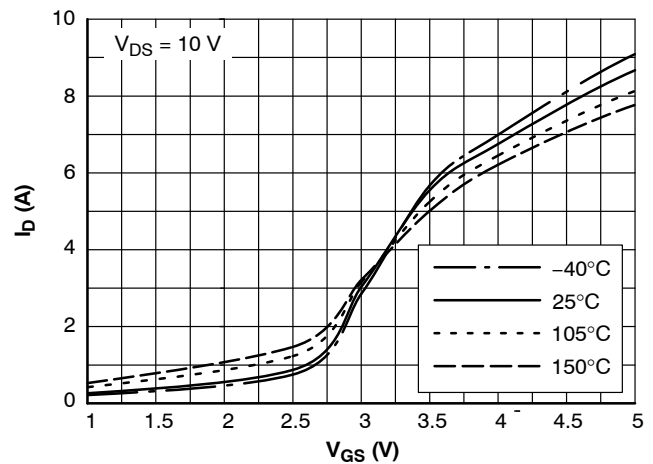


Figure 8. Transfer Characteristics

TYPICAL PERFORMANCE CURVES

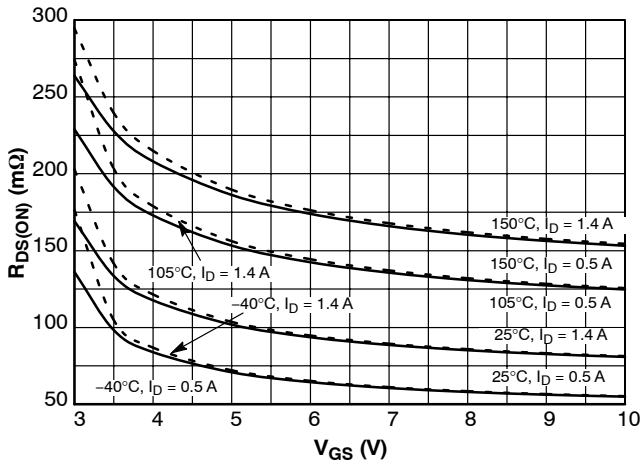


Figure 9. $R_{DS(ON)}$ vs. Gate-Source Voltage

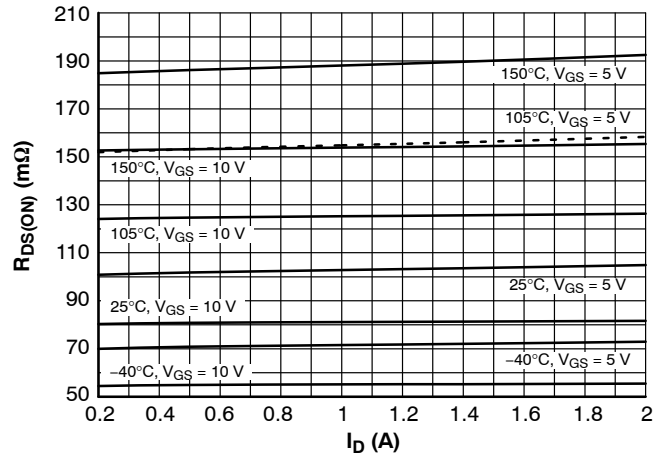


Figure 10. $R_{DS(ON)}$ vs. Drain Current

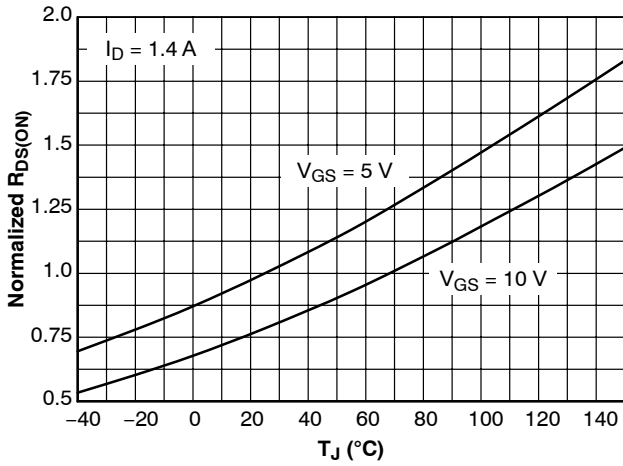


Figure 11. Normalized $R_{DS(ON)}$ vs. Temperature

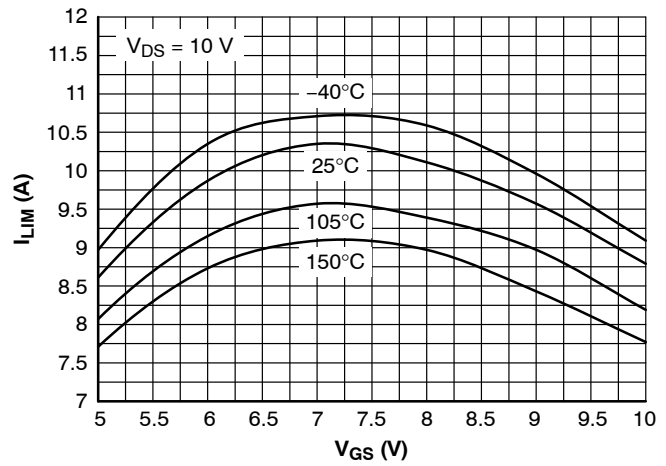


Figure 12. Current Limit vs. Gate-Source Voltage

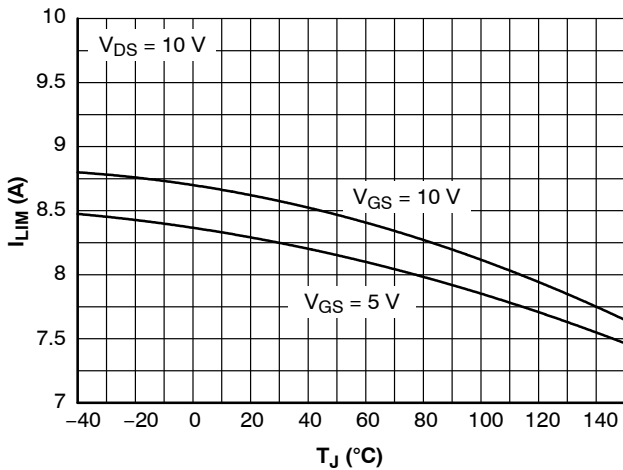


Figure 13. Current Limit vs. Junction Temperature

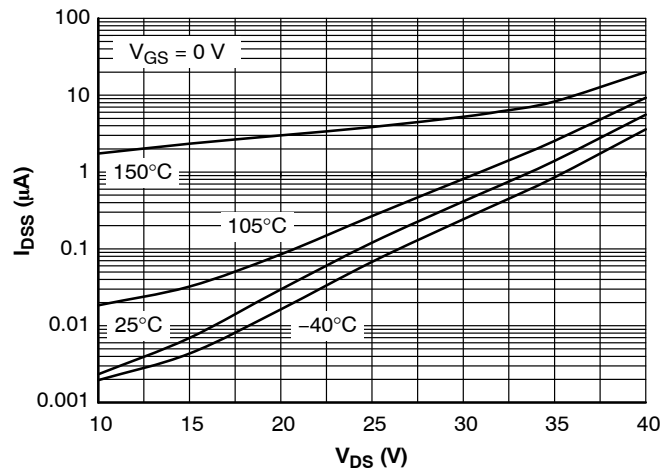


Figure 14. Drain-to-Source Leakage Current

TYPICAL PERFORMANCE CURVES

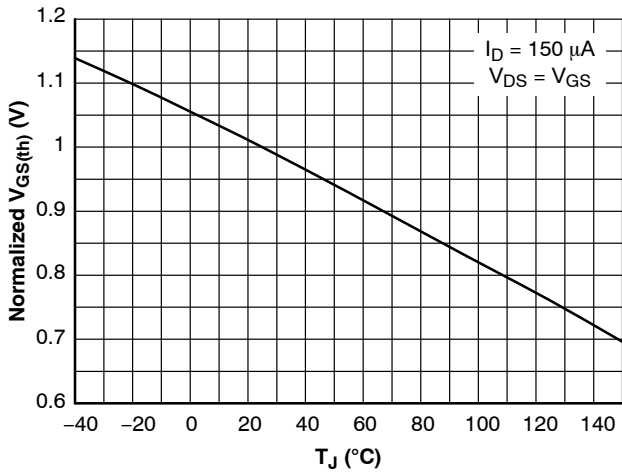


Figure 15. Normalized Threshold Voltage vs. Temperature

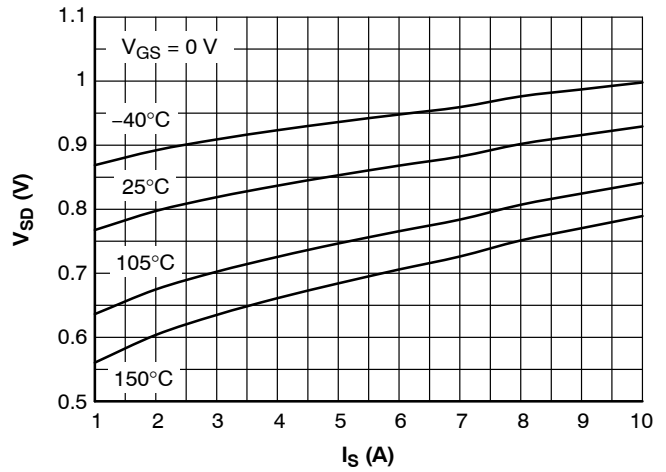


Figure 16. Source-Drain Diode Forward Characteristics

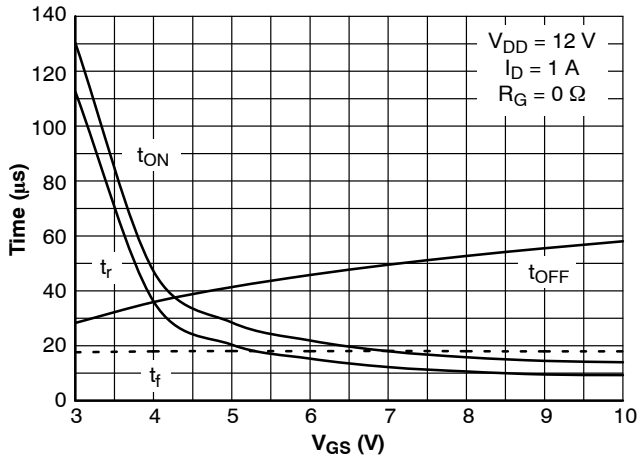


Figure 17. Resistive Load Switching Time vs. Gate-Source Voltage

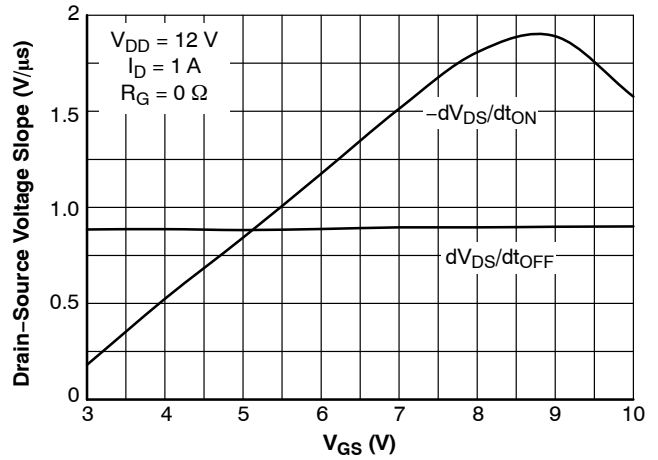


Figure 18. Resistive Load Switching Drain-Source Voltage Slope vs. Gate-Source Voltage

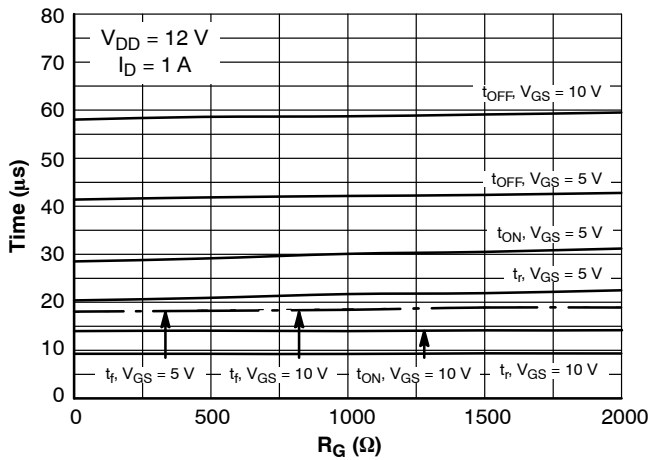


Figure 19. Resistive Load Switching Time vs. Gate Resistance

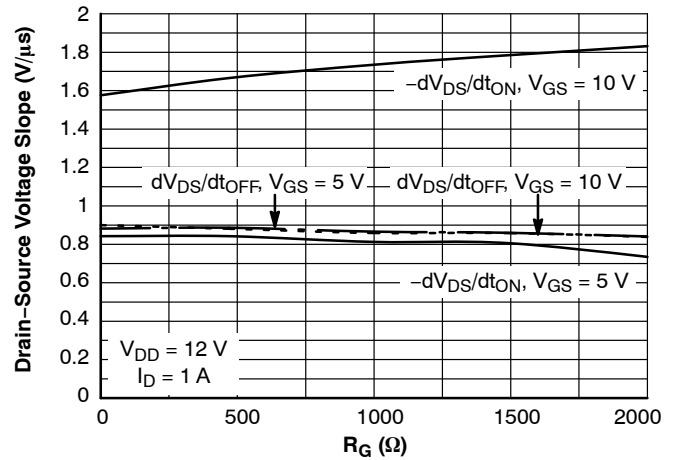


Figure 20. Resistive Load Switching Drain-Source Voltage Slope vs. Gate Resistance

TYPICAL PERFORMANCE CURVES

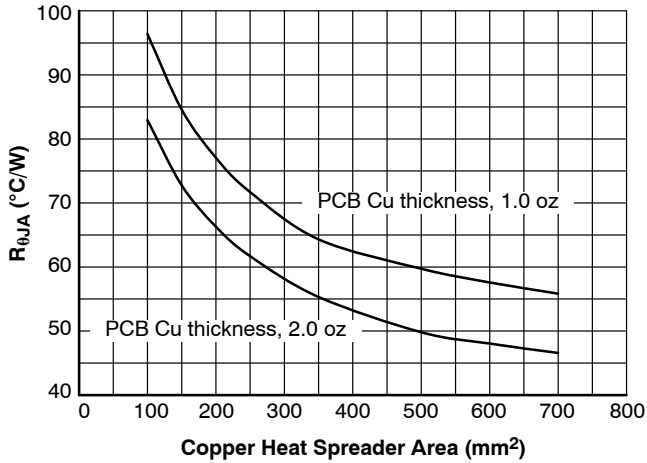


Figure 21. $R_{\theta JA}$ vs. Copper Area (SOT-223)

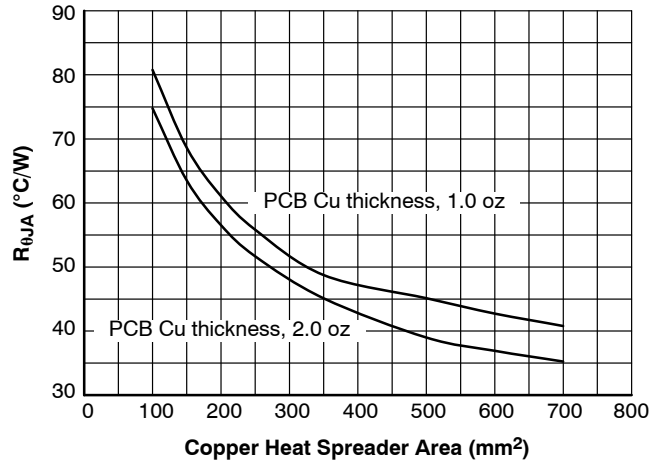


Figure 22. $R_{\theta JA}$ vs. Copper Area (DPAK)

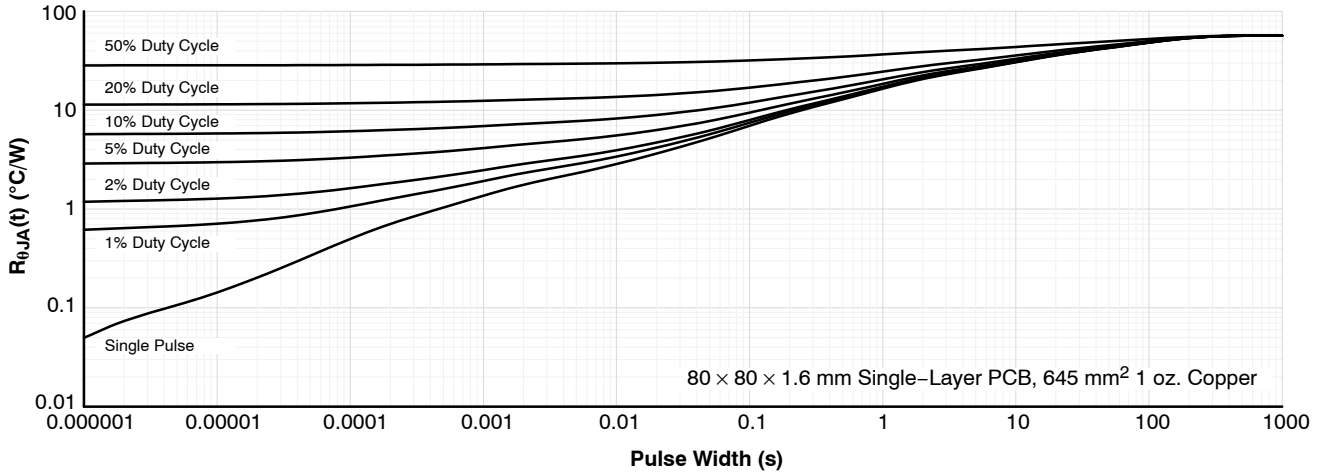


Figure 23. Transient Thermal Resistance (SOT-223)

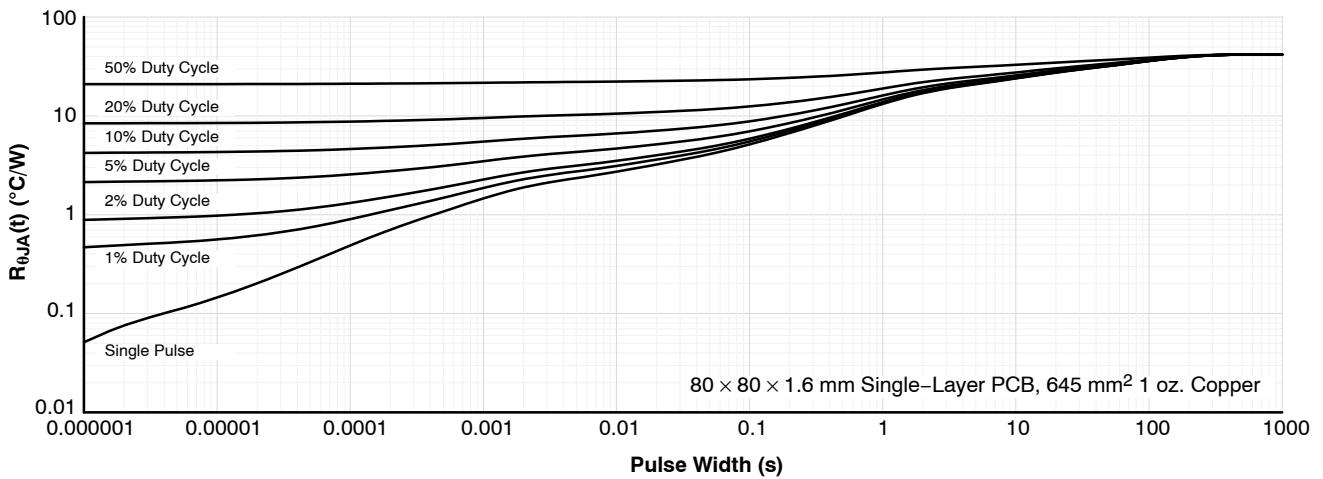


Figure 24. Transient Thermal Resistance (DPAK)

APPLICATION INFORMATION

Circuit Protection Features

The NCV8415 has three main protections. Current Limit, Thermal Shutdown and Delta Thermal Shutdown. These protections establish robustness of the NCV8415.

Current Limit and Short Circuit Protection

The NCV8415 has current sense element. In the event that the drain current reaches designed current limit level, integrated Current Limit protection establishes its constant level.

Delta Thermal Shutdown

Delta Thermal Shutdown (DTSD) Protection increases higher reliability of the NCV8415. DTSD consist of two independent temperature sensors – cold and hot sensors. The NCV8415 establishes a slow junction temperature rise by sensing the difference between the hot and cold sensors. ON/OFF output cycling is designed with hysteresis that results in a controlled saw tooth temperature profile (Figure 26). The die temperature slowly rises (DTSD) until the absolute temperature shutdown (TSD) is reached around 175°C.

Thermal Shutdown with Automatic Restart

Internal Thermal Shutdown (TSD) circuitry is provided to protect the NCV8415 in the event that the maximum

junction temperature is exceeded. When activated at typically 175°C, the NCV8415 turns off. This feature is provided to prevent failures from accidental overheating.

EMC Performance

To improve the EMC performance/robustness, connect a small ceramic capacitor to the drain pin as close to the device as possible according to Figure 25.

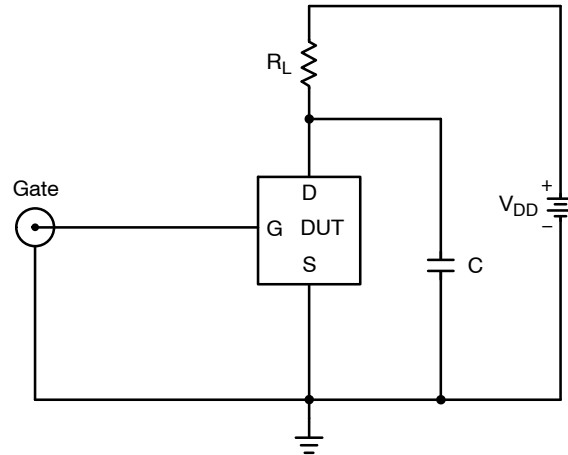


Figure 25. EMC Capacitor Placement

TEST CIRCUITS AND WAVEFORMS

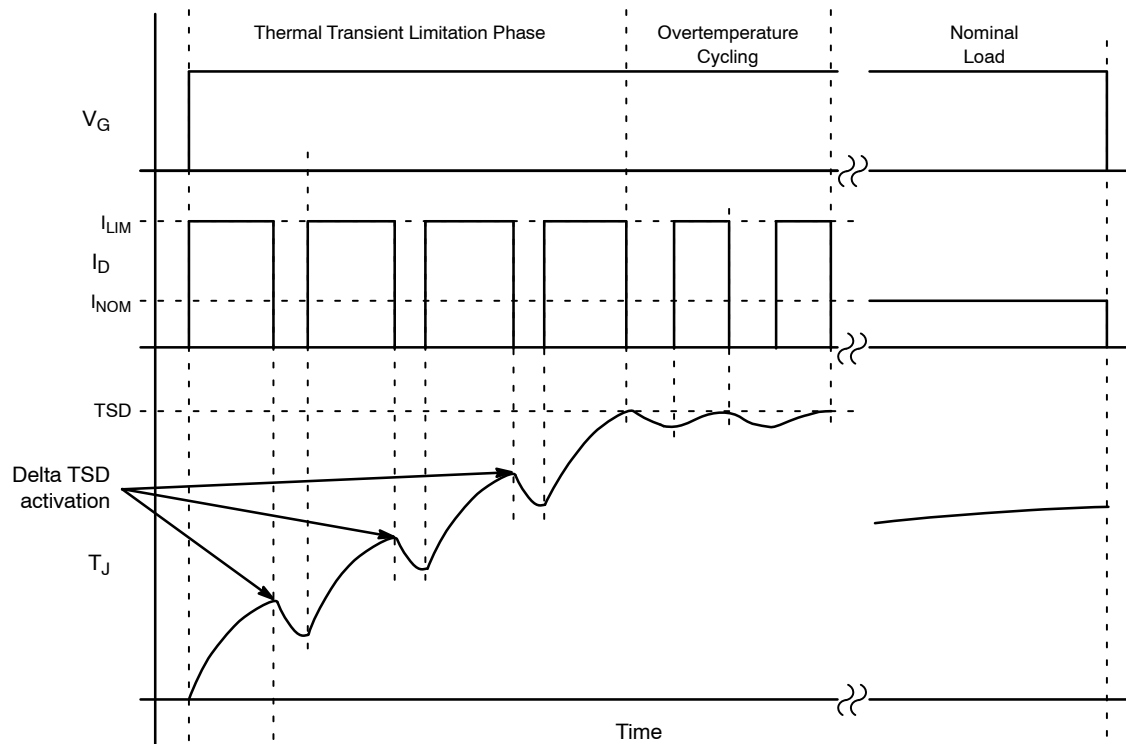


Figure 26. Overload Protection Behavior

TEST CIRCUITS AND WAVEFORMS

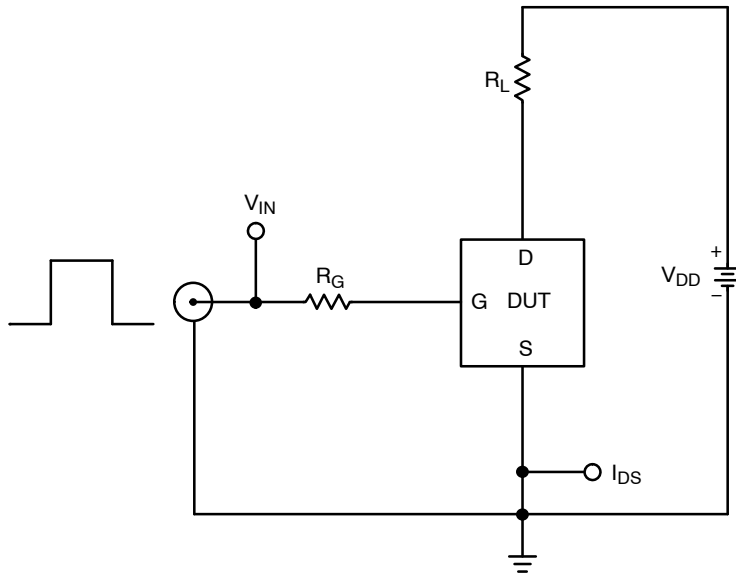


Figure 27. Resistive Load Switching Test Circuit

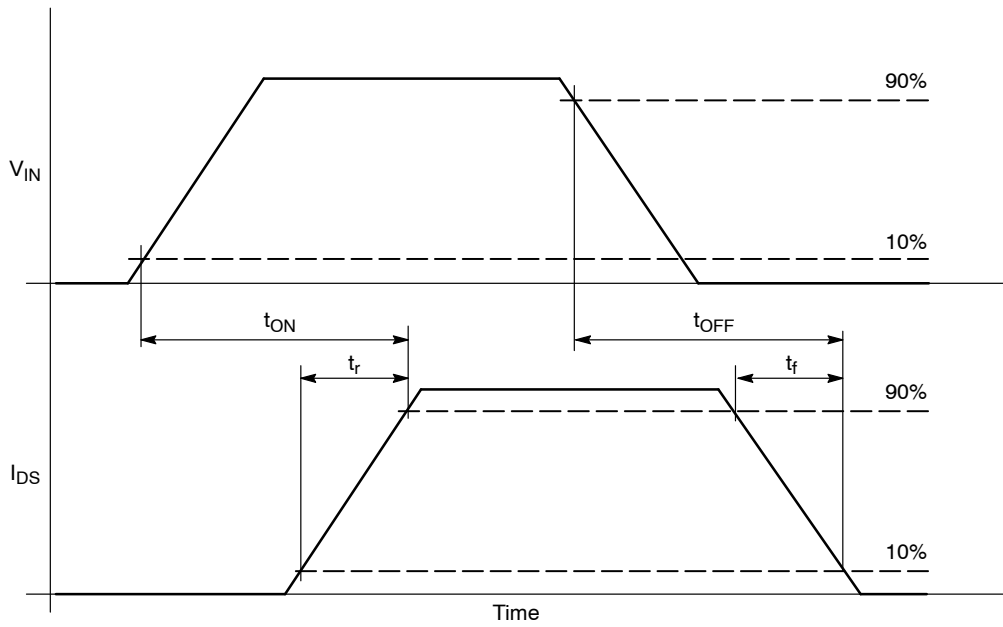


Figure 28. Resistive Load Switching Waveforms

TEST CIRCUITS AND WAVEFORMS

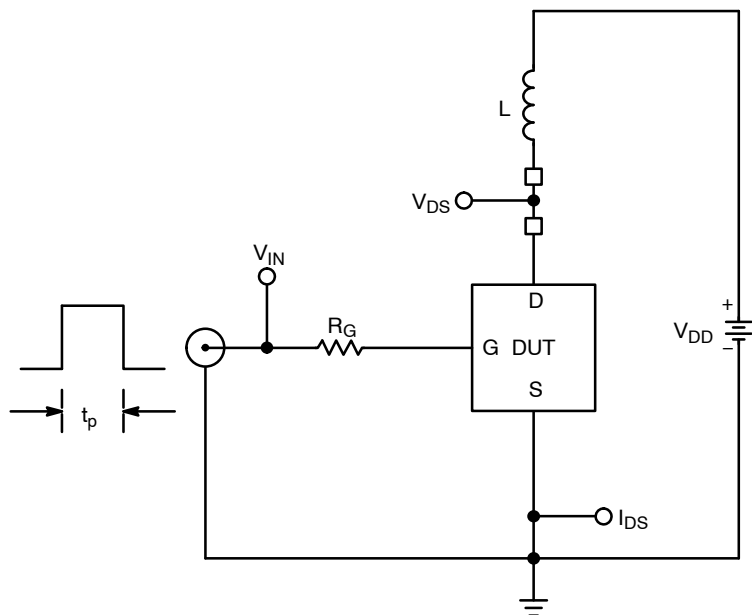


Figure 29. Inductive Load Switching Test Circuit

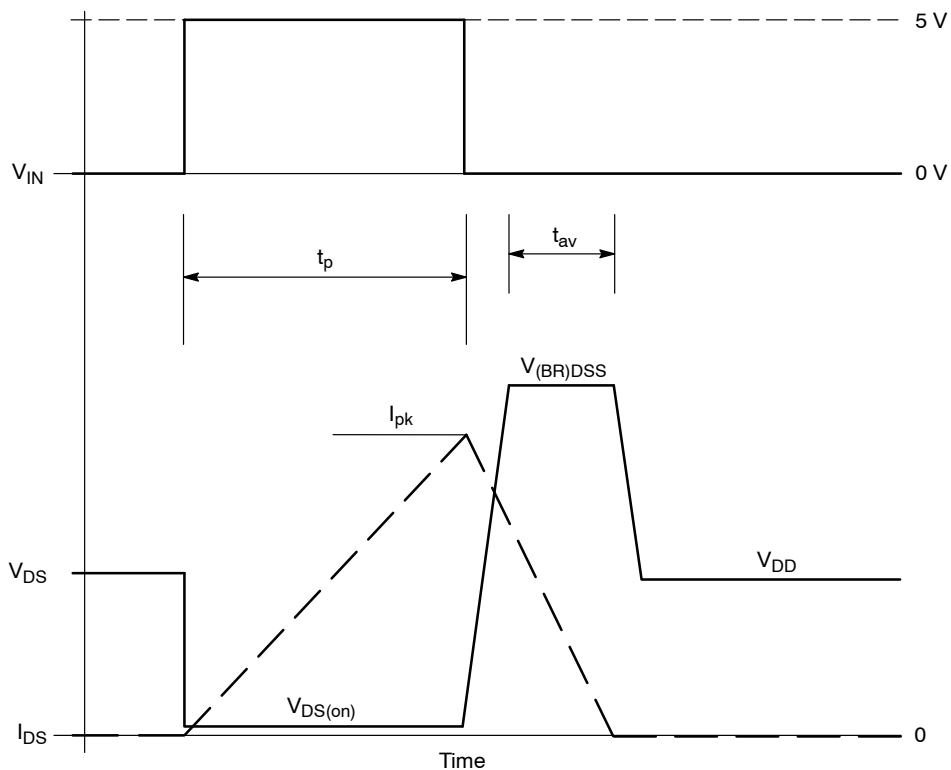
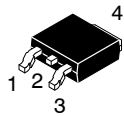


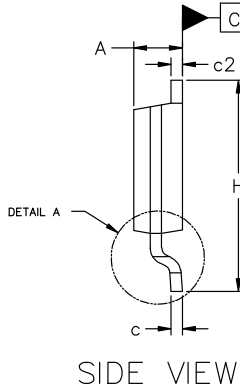
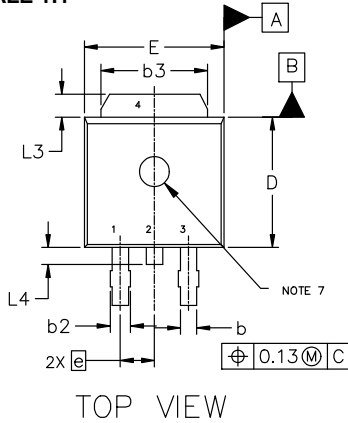
Figure 30. Inductive Load Switching Waveforms



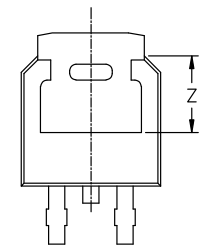
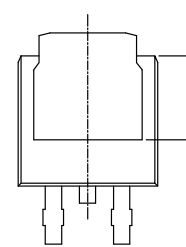
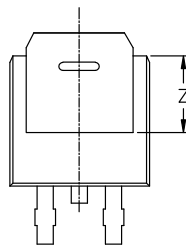
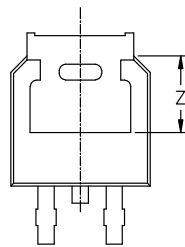
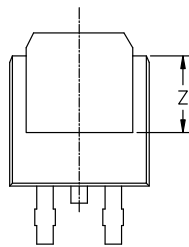
DPAK3 6.10x6.54x2.28, 2.29P
CASE 369C
ISSUE J

DATE 12 AUG 2025

SCALE 1:1



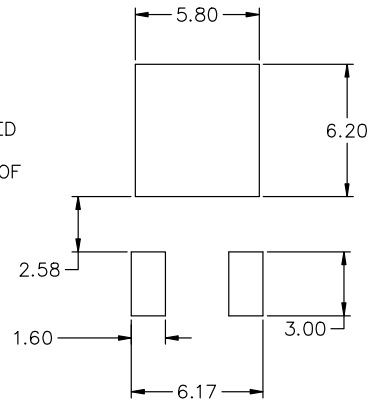
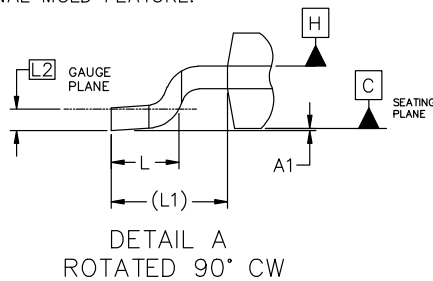
| MILLIMETERS | | | |
|-------------|----------|------|-------|
| DIM | MIN | NOM | MAX |
| A | 2.18 | 2.28 | 2.38 |
| A1 | 0.00 | --- | 0.13 |
| b | 0.63 | 0.76 | 0.89 |
| b2 | 0.72 | 0.93 | 1.14 |
| b3 | 4.57 | 5.02 | 5.46 |
| c | 0.46 | 0.54 | 0.61 |
| c2 | 0.46 | 0.54 | 0.61 |
| D | 5.97 | 6.10 | 6.22 |
| E | 6.35 | 6.54 | 6.73 |
| e | 2.29 BSC | | |
| H | 9.40 | 9.91 | 10.41 |
| L | 1.40 | 1.59 | 1.78 |
| L1 | 2.90 REF | | |
| L2 | 0.51 BSC | | |
| L3 | 0.89 | --- | 1.27 |
| L4 | --- | --- | 1.01 |
| Z | 3.93 | --- | --- |



ALTERNATE CONSTRUCTIONS

NOTES:

1. DIMENSIONING AND TOLERANCING ASME Y14.5M, 2018.
2. CONTROLLING DIMENSION: MILLIMETERS.
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 0.15mm 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.



RECOMMENDED MOUNTING FOOTPRINT*

*FOR ADDITIONAL INFORMATION ON OUR PB-FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ONSEMI SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERRM/D.

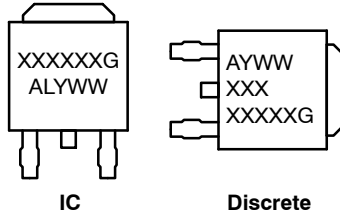
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DPAK3 6.10x6.54x2.28, 2.29P
CASE 369C
ISSUE J

DATE 12 AUG 2025

**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.

- | | | | | |
|--|--|---|---|--|
| <p>STYLE 1: PIN 1. BASE 2. COLLECTOR 3. EMITTER 4. COLLECTOR</p> | <p>STYLE 2: PIN 1. GATE 2. DRAIN 3. SOURCE 4. DRAIN</p> | <p>STYLE 3: PIN 1. ANODE 2. CATHODE 3. ANODE 4. CATHODE</p> | <p>STYLE 4: PIN 1. CATHODE 2. ANODE 3. GATE 4. ANODE</p> | <p>STYLE 5: PIN 1. GATE 2. ANODE 3. CATHODE 4. ANODE</p> |
| <p>STYLE 6: PIN 1. MT1 2. MT2 3. GATE 4. MT2</p> | <p>STYLE 7: PIN 1. GATE 2. COLLECTOR 3. EMITTER 4. COLLECTOR</p> | <p>STYLE 8: PIN 1. N/C 2. CATHODE 3. ANODE 4. CATHODE</p> | <p>STYLE 9: PIN 1. ANODE 2. CATHODE 3. RESISTOR ADJUST 4. CATHODE</p> | <p>STYLE 10: PIN 1. CATHODE 2. ANODE 3. CATHODE 4. ANODE</p> |

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