

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.

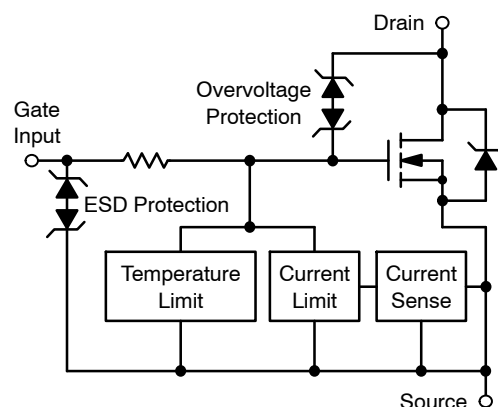
Features

- 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

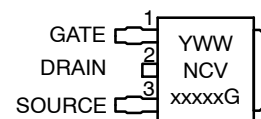
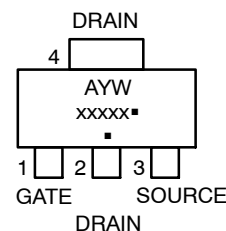
Typical Applications

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

V_{DS} (Clamped)	$R_{DS(on)}$ TYP	I_D TYP (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 page 10 of this data sheet.

NOTE: Some of the devices on this data sheet have been **DISCONTINUED**. Please refer to the table on page 10.

NCV8406A, NCV8406B

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage Internally Clamped	V _{DSS}	60	Vdc
Gate-to-Source Voltage	V _{GS}	± 14	Vdc
Drain Current Continuous	I _D	Internally Limited	
Total Power Dissipation – SOT-223 Version @ T _A = 25°C (Note 1) @ T _A = 25°C (Note 2)	P _D	1.25 1.81	W
Total Power Dissipation – DPAK Version @ T _A = 25°C (Note 1) @ T _A = 25°C (Note 2)	P _D	1.31 2.31	W
Thermal Resistance – SOT-223 Version Junction-to-Soldering Point Junction-to-Ambient (Note 1) Junction-to-Ambient (Note 2)	R _{θJS} R _{θJA} R _{θJA}	7.0 100 69	°C/W
Thermal Resistance – DPAK Version Junction-to-Soldering Point Junction-to-Ambient (Note 1) Junction-to-Ambient (Note 2)	R _{θJS} R _{θJA} R _{θJA}	1.0 95 54	°C/W
Single Pulse Inductive Load Switching Energy (Starting T _J = 25°C, V _{DD} = 50 Vdc, V _{GS} = 5.0 Vdc, I _L = 2.1 Apk, L = 50 mH, R _G = 25 Ω)	E _{AS}	110	mJ
Load Dump Voltage (V _{GS} = 0 and 10 V, R _I = 2 Ω, R _L = 7 Ω, t _d = 400 ms)	V _{LD}	75	V
Operating Junction Temperature Range	T _J	–40 to 150	°C
Storage Temperature Range	T _{stg}	–55 to 150	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. 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.

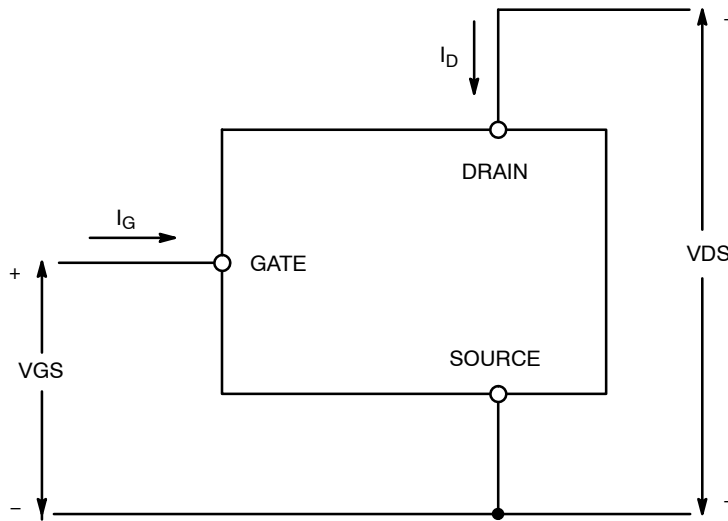


Figure 1. Voltage and Current Convention

NCV8406A, NCV8406B

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

Characteristic	Symbol	Min	Typ	Max	Unit
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OFF CHARACTERISTICS

Drain-to-Source Clamped Breakdown Voltage (V _{GS} = 0 V, I _D = 2 mA)	V _{(BR)DSS}	60	65	70	V
Zero Gate Voltage Drain Current (V _{DS} = 52 V, V _{GS} = 0 V)	I _{DSS}	–	22	100	μA
Gate Input Current (V _{GS} = 5.0 V, V _{DS} = 0 V)	I _{GSS}	–	30	100	μA

ON CHARACTERISTICS

Gate Threshold Voltage (V _{DS} = V _{GS} , I _D = 150 μA) Threshold Temperature Coefficient	V _{GS(th)}	1.2 –	1.66 4.0	2.0 –	V –mV/°C
Static Drain-to-Source On-Resistance (Note 3) (V _{GS} = 10 V, I _D = 2.0 A, T _J @ 25°C)	R _{DS(on)}	–	185	210	mΩ
Static Drain-to-Source On-Resistance (Note 3) (V _{GS} = 5.0 V, I _D = 2.0 A, T _J @ 25°C) (V _{GS} = 5.0 V, I _D = 2.0 A, T _J @ 150°C)	R _{DS(on)}	– –	210 445	240 520	mΩ
Source-Drain Forward On Voltage (I _S = 7.0 A, V _{GS} = 0 V)	V _{SD}	–	0.9	1.1	V

SWITCHING CHARACTERISTICS (Note 6)

Turn-on Delay Time	R _L = 6.6 Ω, V _{in} = 0 to 10 V, V _{DD} = 13.8 V, I _D = 2.0 A, 10% V _{in} to 10% I _D	td(on)	–	127	–	ns
Turn-on Rise Time	R _L = 6.6 Ω, V _{in} = 0 to 10 V, V _{DD} = 13.8 V, I _D = 2.0 A, 10% I _D to 90% I _D	t _{rise}	–	486	–	ns
Turn-off Delay Time	R _L = 6.6 Ω, V _{in} = 0 to 10 V, V _{DD} = 13.8 V, I _D = 2.0 A, 90% V _{in} to 90% I _D	td(off)	–	1600	–	ns
Turn-off Fall Time	R _L = 6.6 Ω, V _{in} = 0 to 10 V, V _{DD} = 13.8 V, I _D = 2.0 A, 90% I _D to 10% I _D	t _{fall}	–	692	–	ns
Slew Rate ON	R _L = 6.6 Ω, V _{in} = 0 to 10 V, V _{DD} = 13.8 V, I _D = 2.0 A, 70% to 50% V _{DD}	dV _{DS} /dT _{on}	–	79	–	V/μs
Slew Rate OFF	R _L = 6.6 Ω, V _{in} = 0 to 10 V, V _{DD} = 13.8 V, I _D = 2.0 A, 50% to 70% V _{DD}	dV _{DS} /dT _{off}	–	27	–	V/μs

SELF PROTECTION CHARACTERISTICS (Note 4)

Current Limit	V _{DS} = 10 V, V _{GS} = 5.0 V, T _J = 25°C (Notes 5, 7) V _{DS} = 10 V, V _{GS} = 5.0 V, T _J = 150°C (Notes 5, 6, 7) V _{DS} = 10 V, V _{GS} = 10 V, T _J = 25°C (Notes 5, 7)	I _{LIM}	5.0 3.5 6.5	7.0 4.5 8.5	9.5 6.0 10.5	A
Temperature Limit (Turn-off)	V _{GS} = 5.0 V (Notes 6, 7)	T _{LIM(off)}	150	180	200	°C
Thermal Hysteresis	V _{GS} = 5.0 V	ΔT _{LIM(on)}	–	10	–	°C
Temperature Limit (Turn-off)	V _{GS} = 10 V (Notes 6, 7)	T _{LIM(off)}	150	180	200	°C
Thermal Hysteresis	V _{GS} = 10 V	ΔT _{LIM(on)}	–	20	–	°C
Input Current during Thermal Fault	V _{DS} = 0 V, V _{GS} = 5.0 V, T _J = T _J > T _(fault) (Note 6) V _{DS} = 0 V, V _{GS} = 10 V, T _J = T _J > T _(fault) (Note 6)	I _{g(fault)}	– –	5.9 12.3	–	mA

ESD ELECTRICAL CHARACTERISTICS

Electro-Static Discharge Capability Human Body Model (HBM) Machine Model (MM)	ESD	6000 500	– –	– –	V
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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.
- Refer to Application Note AND8202/D for dependence of protection features on gate voltage.

TYPICAL PERFORMANCE CURVES

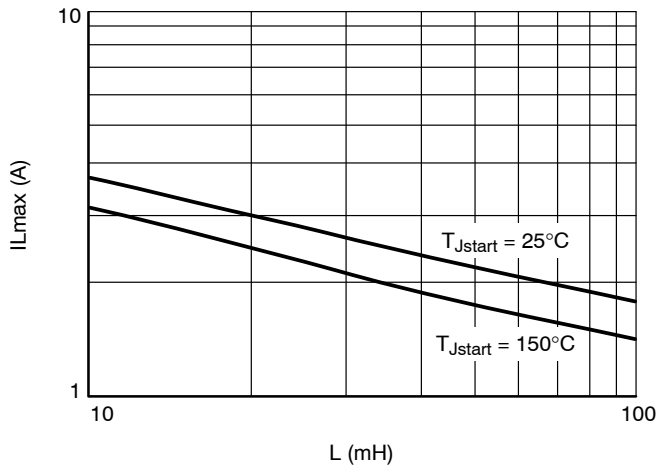


Figure 2. Single Pulse Maximum Switch-off Current vs. Load Inductance

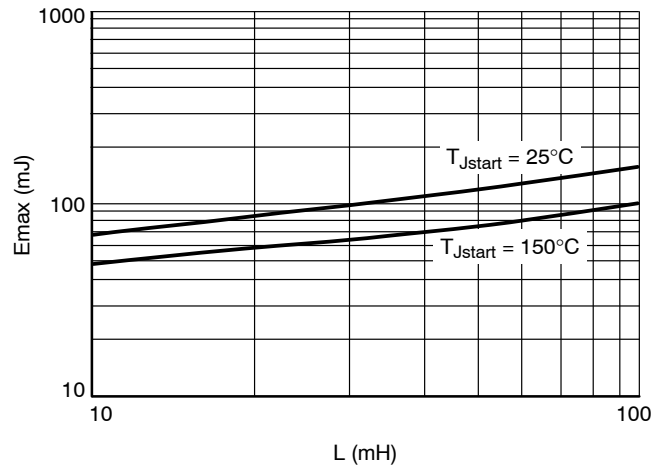


Figure 3. Single-Pulse Maximum Switching Energy vs. Load Inductance

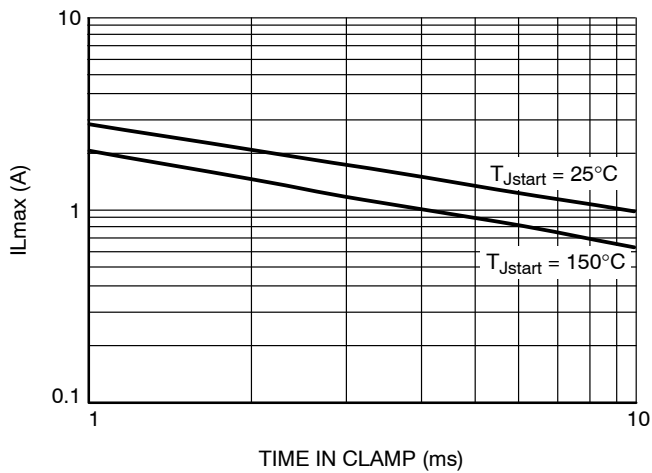


Figure 4. Single Pulse Maximum Inductive Switch-off Current vs. Time in Clamp

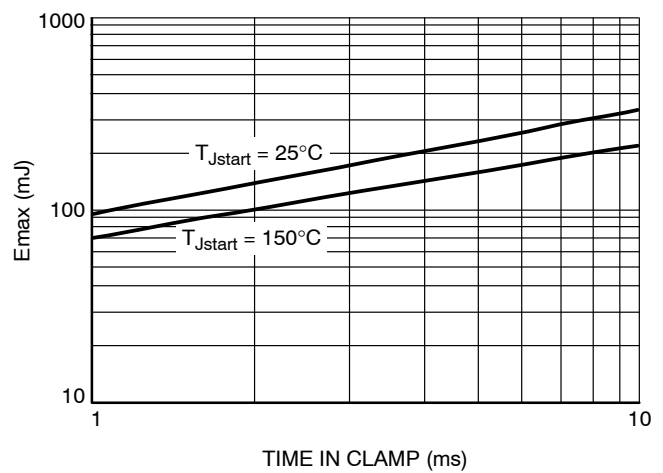


Figure 5. Single-Pulse Maximum Inductive Switching Energy vs. Time in Clamp

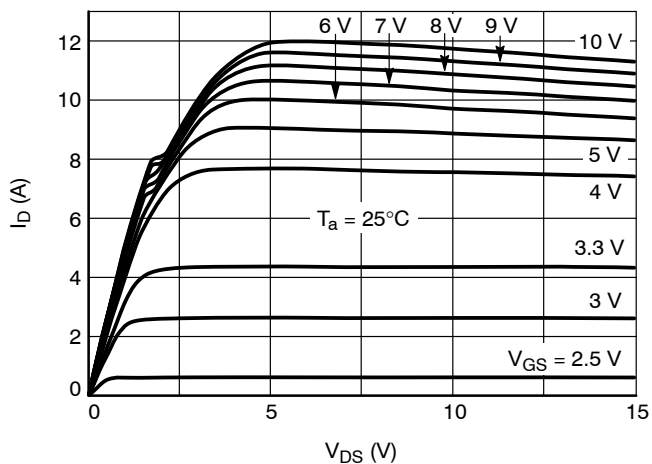


Figure 6. On-state Output Characteristics

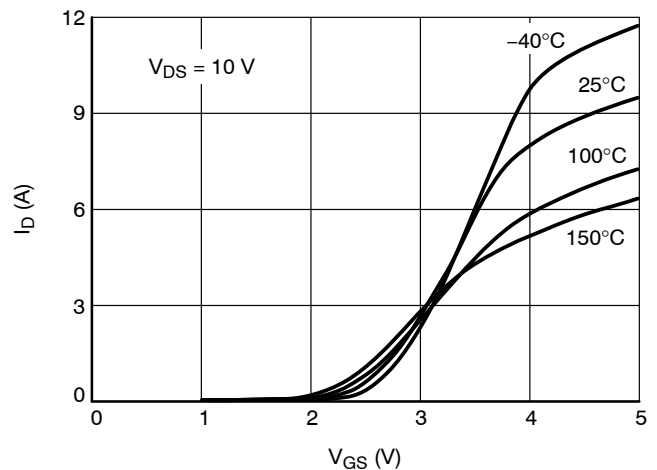


Figure 7. Transfer Characteristics

TYPICAL PERFORMANCE CURVES

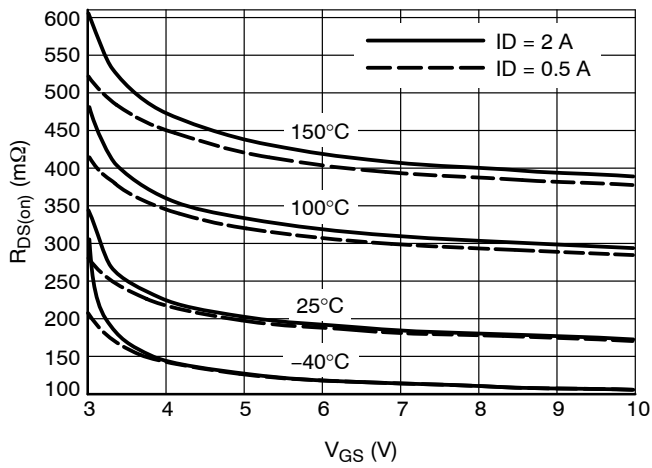


Figure 8. $R_{DS(on)}$ vs. Gate-Source Voltage

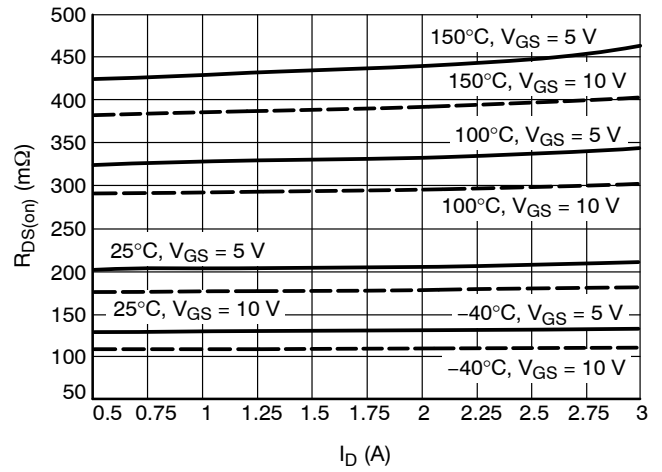


Figure 9. $R_{DS(on)}$ vs. Drain Current

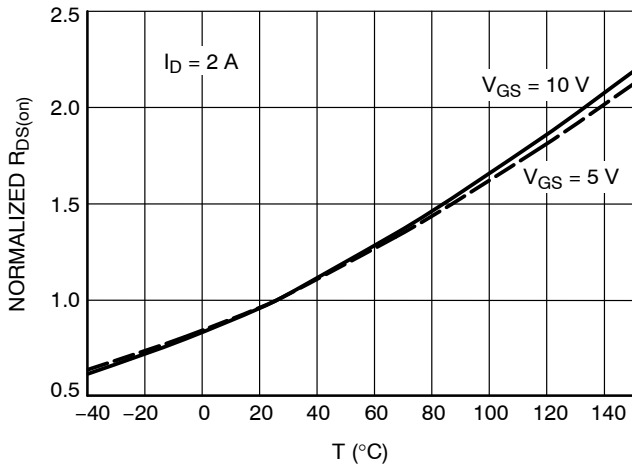


Figure 10. Normalized $R_{DS(on)}$ vs. Temperature

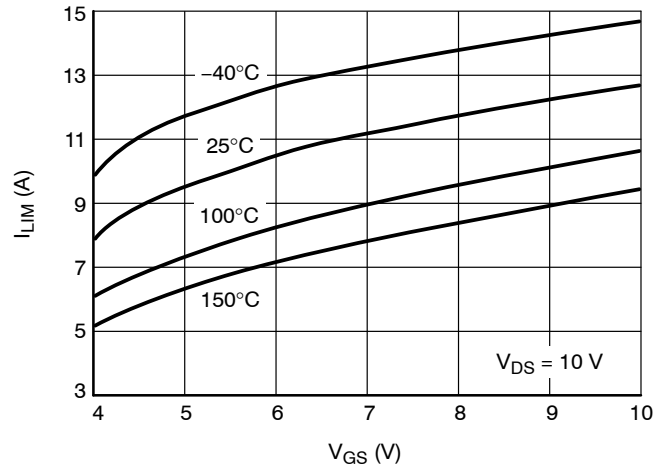


Figure 11. Current Limit vs. Gate-Source Voltage

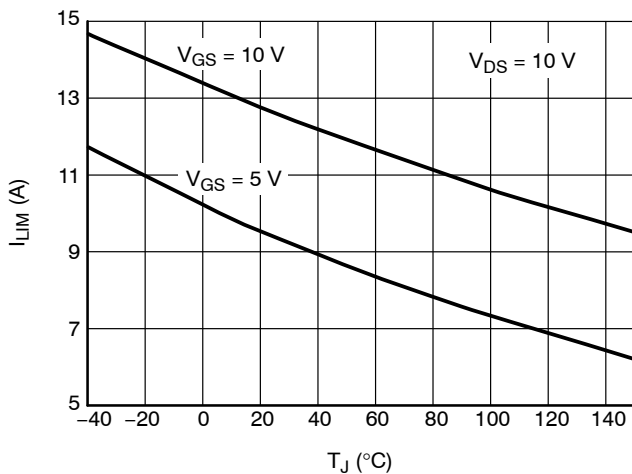


Figure 12. Current Limit vs. Junction Temperature

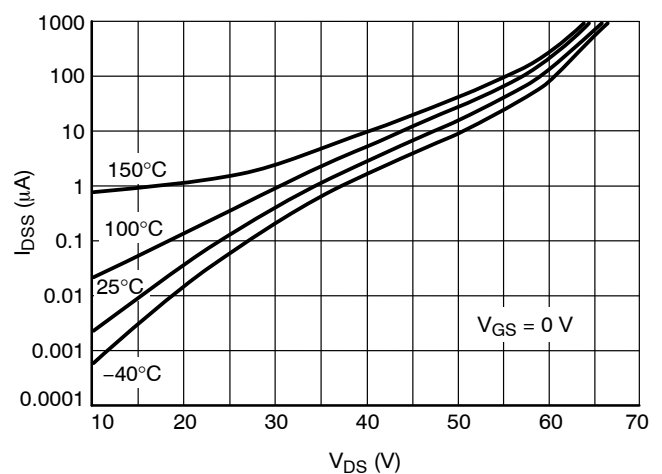


Figure 13. Drain-to-Source Leakage Current

TYPICAL PERFORMANCE CURVES

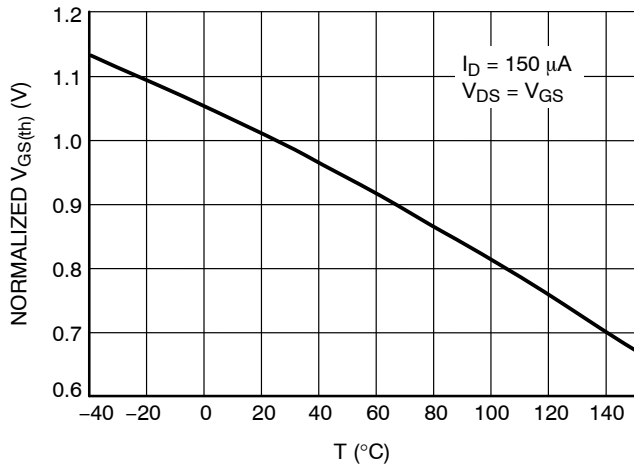


Figure 14. Normalized Threshold Voltage vs. Temperature

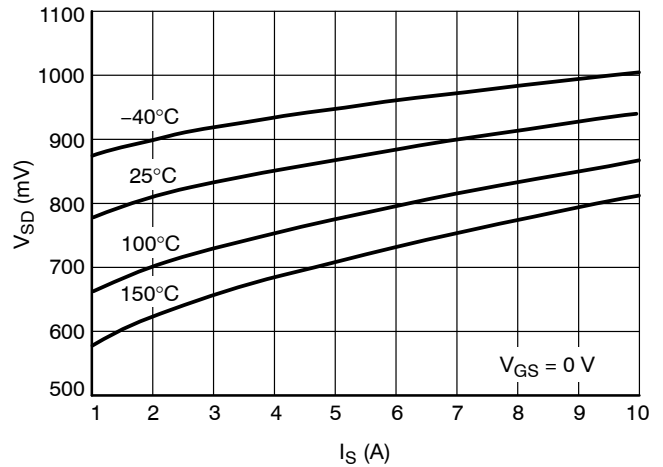


Figure 15. Source-Drain Diode Forward Characteristics

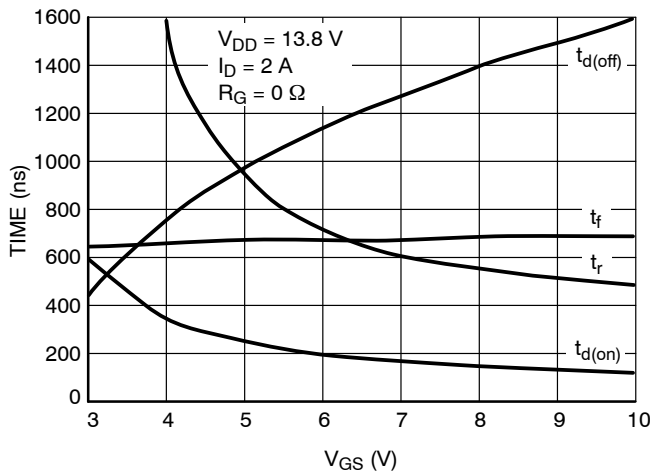


Figure 16. Resistive Load Switching Time vs. Gate-Source Voltage

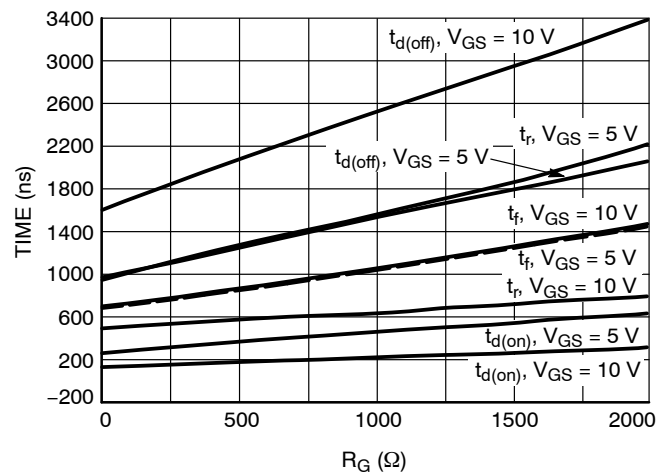


Figure 17. Resistive Load Switching Time vs. Gate Resistance

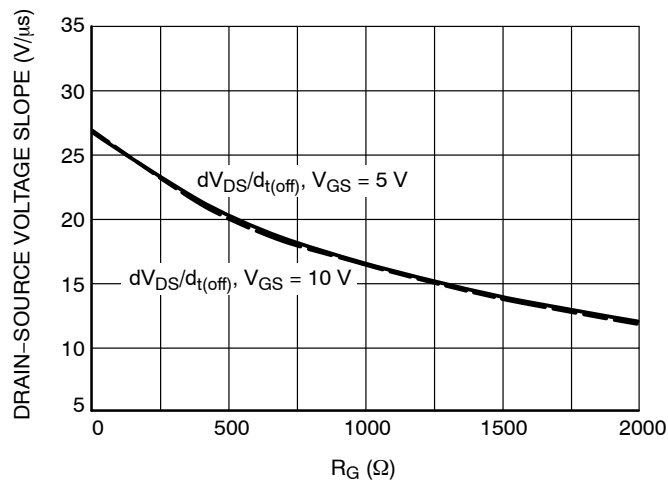


Figure 18. Drain-Source Voltage Slope during Turn On and Turn Off vs. Gate Resistance

TYPICAL PERFORMANCE CURVES

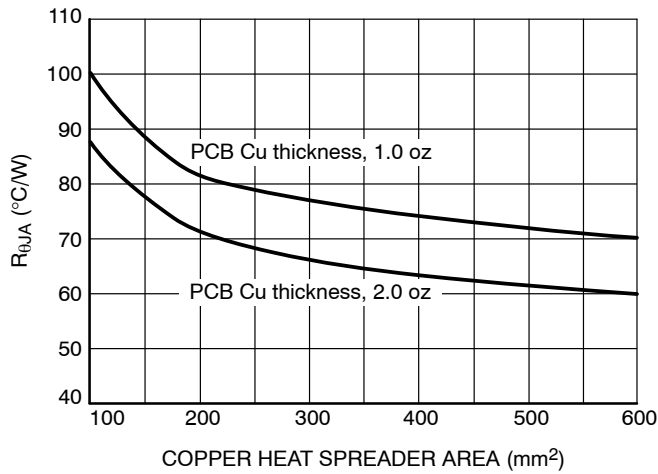


Figure 19. $R_{\theta JA}$ vs. Copper Area – SOT-223

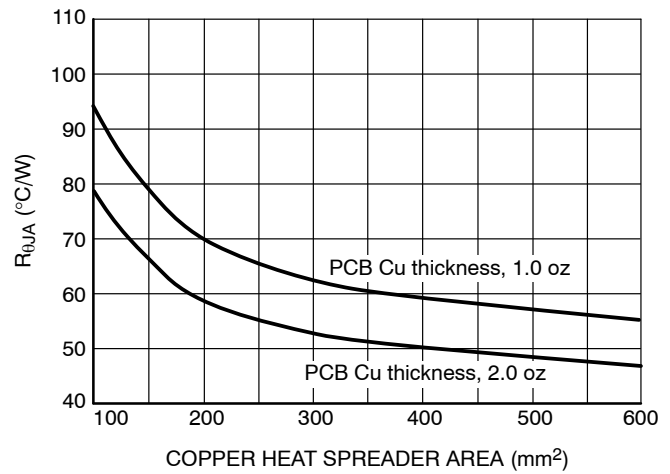


Figure 20. $R_{\theta JA}$ vs. Copper Area – DPAK

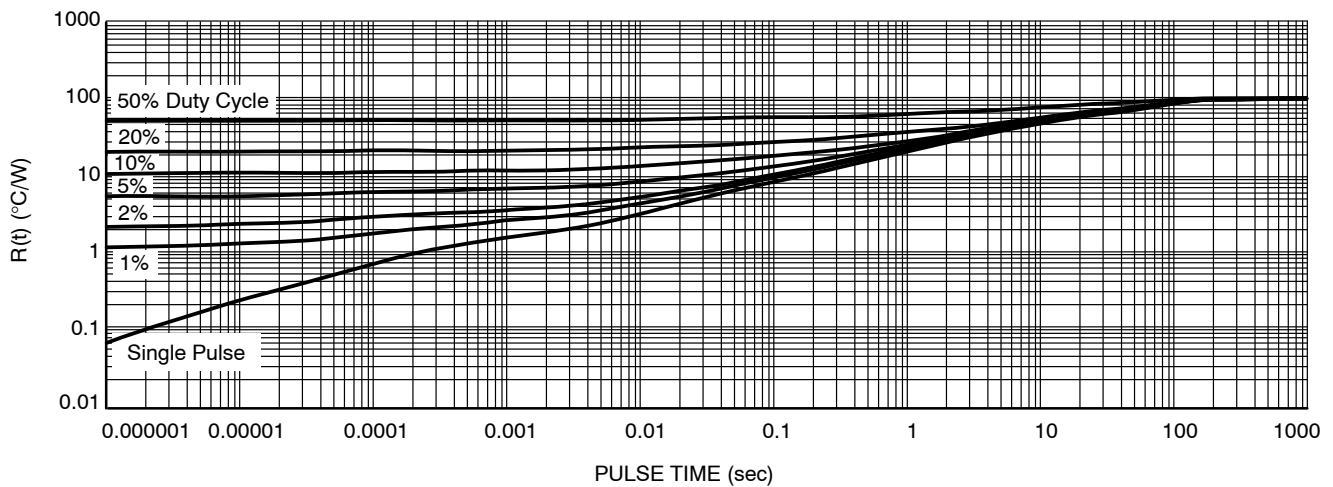


Figure 21. Transient Thermal Resistance – SOT-223 Version

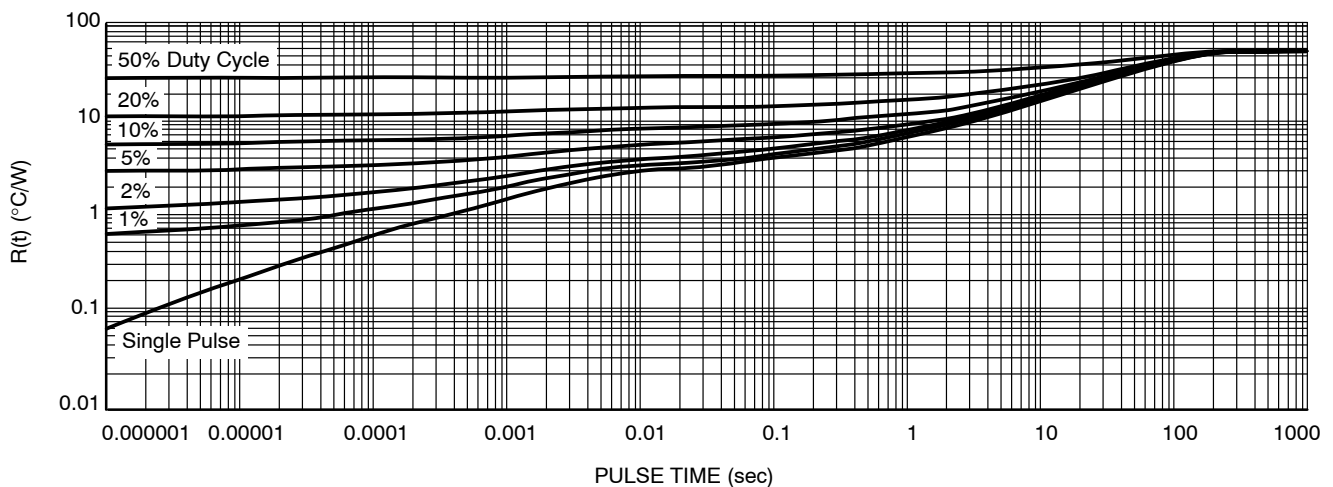


Figure 22. Transient Thermal Resistance – DPAK Version

NCV8406A, NCV8406B

TEST CIRCUITS AND WAVEFORMS

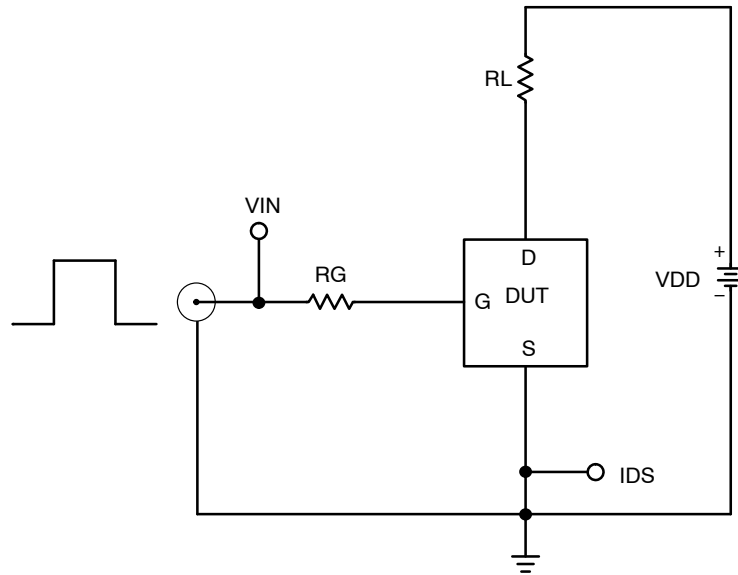


Figure 23. Resistive Load Switching Test Circuit

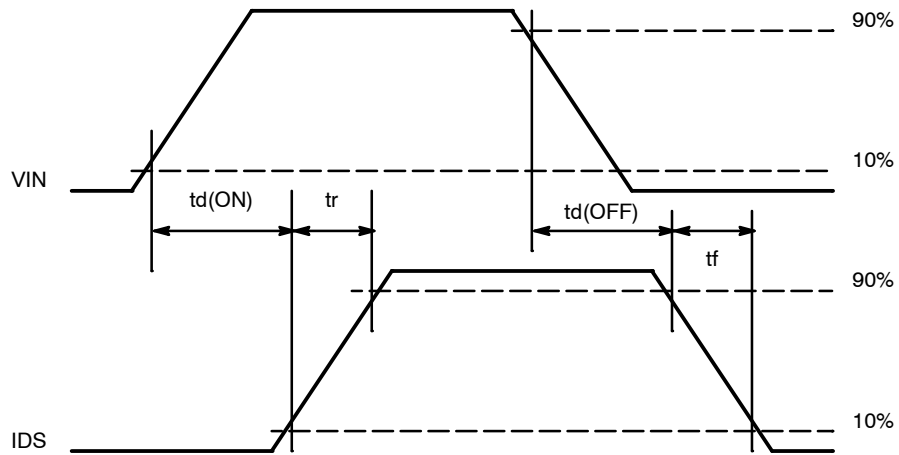


Figure 24. Resistive Load Switching Waveforms

TEST CIRCUITS AND WAVEFORMS

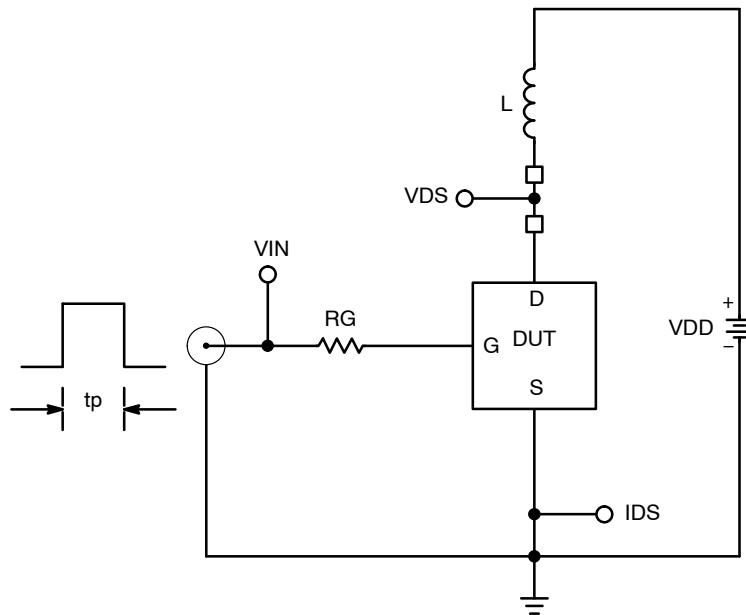


Figure 25. Inductive Load Switching Test Circuit

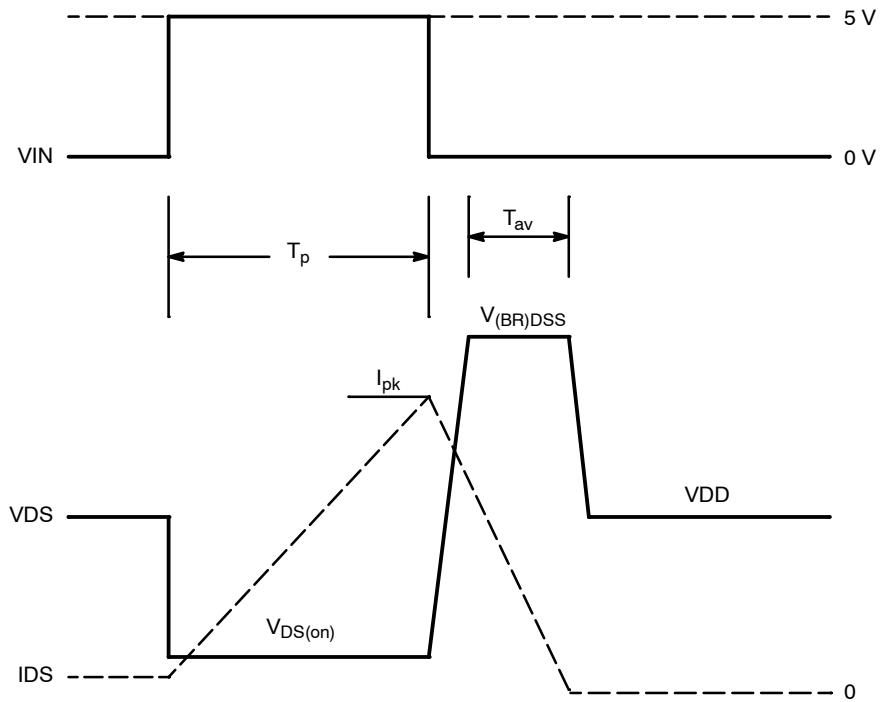


Figure 26. Inductive Load Switching Waveforms

NCV8406A, NCV8406B

ORDERING INFORMATION

Device	Package	Shipping [†]
NCV8406ASTT1G	SOT-223 (Pb-Free)	1000 / Tape & Reel
NCV8406ASTT3G	SOT-223 (Pb-Free)	4000 / Tape & Reel
NCV8406BDTRKG	DPAK (Pb-Free)	2500 / Tape & Reel

DISCONTINUED (Note 8)

NCV8406ADTRKG	DPAK (Pb-Free)	2500 / Tape & Reel
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[†]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.

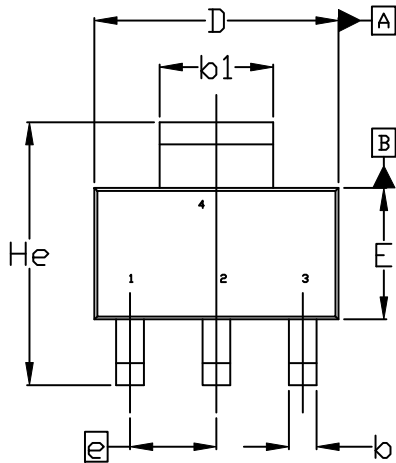
8. **DISCONTINUED:** This device is not recommended for new design. Please contact your **onsemi** representative for information. The most current information on this device may be available on www.onsemi.com.



SCALE 1:1

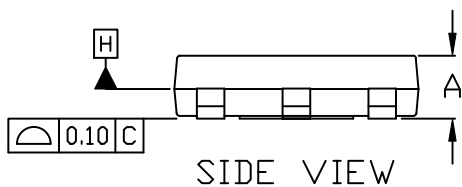
SOT-223 (TO-261)
CASE 318E-04
ISSUE R

DATE 02 OCT 2018

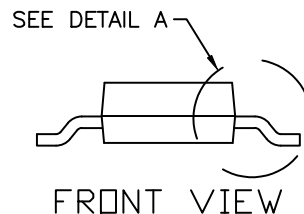


TOP VIEW

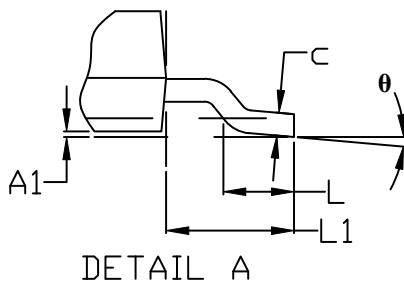
$\oplus 0.10 \text{ (M)}$ C A B
NOTE 5



SIDE VIEW



FRONT VIEW

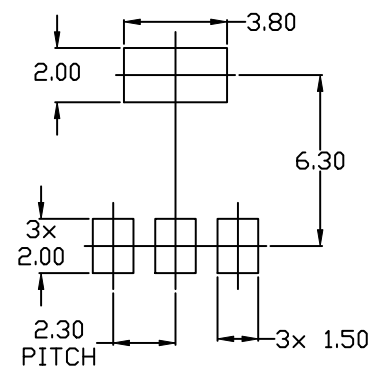


DETAIL A

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS
3. DIMENSIONS D & E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.200MM PER SIDE.
4. DATUMS A AND B ARE DETERMINED AT DATUM H.
5. A1 IS DEFINED AS THE VERTICAL DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT OF THE PACKAGE BODY.
6. POSITIONAL TOLERANCE APPLIES TO DIMENSIONS b AND b1.

MILLIMETERS			
DIM	MIN.	NOM.	MAX.
A	1.50	1.63	1.75
A1	0.02	0.06	0.10
b	0.60	0.75	0.89
b1	2.90	3.06	3.20
c	0.24	0.29	0.35
D	6.30	6.50	6.70
E	3.30	3.50	3.70
e	2.30 BSC		
L	0.20	---	---
L1	1.50	1.75	2.00
He	6.70	7.00	7.30
θ	0°	---	10°



RECOMMENDED MOUNTING
FOOTPRINT

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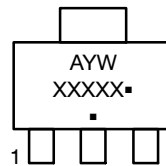
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SOT-223 (TO-261)
CASE 318E-04
ISSUE R

DATE 02 OCT 2018

STYLE 1: PIN 1. BASE 2. COLLECTOR 3. EMITTER 4. COLLECTOR	STYLE 2: PIN 1. ANODE 2. CATHODE 3. NC 4. CATHODE	STYLE 3: PIN 1. GATE 2. DRAIN 3. SOURCE 4. DRAIN	STYLE 4: PIN 1. SOURCE 2. DRAIN 3. GATE 4. DRAIN	STYLE 5: PIN 1. DRAIN 2. GATE 3. SOURCE 4. GATE
STYLE 6: PIN 1. RETURN 2. INPUT 3. OUTPUT 4. INPUT	STYLE 7: PIN 1. ANODE 1 2. CATHODE 3. ANODE 2 4. CATHODE	STYLE 8: CANCELLED	STYLE 9: PIN 1. INPUT 2. GROUND 3. LOGIC 4. GROUND	STYLE 10: PIN 1. CATHODE 2. ANODE 3. GATE 4. ANODE
STYLE 11: PIN 1. MT 1 2. MT 2 3. GATE 4. MT 2	STYLE 12: PIN 1. INPUT 2. OUTPUT 3. NC 4. OUTPUT	STYLE 13: PIN 1. GATE 2. COLLECTOR 3. EMITTER 4. COLLECTOR		

**GENERIC
MARKING DIAGRAM***

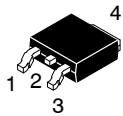


A = Assembly Location
 Y = Year
 W = Work Week
 XXXXX = Specific Device Code
 ■ = Pb-Free Package

(Note: Microdot may be in either location)
 *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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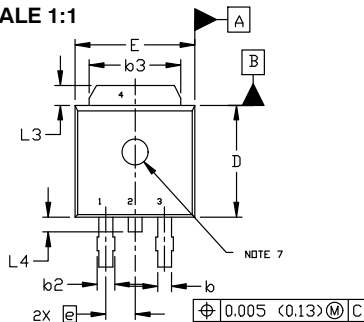
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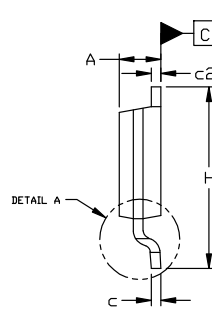
DPAK (SINGLE GAUGE)
CASE 369C
ISSUE G

DATE 31 MAY 2023

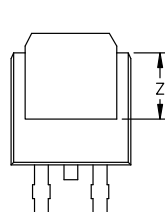
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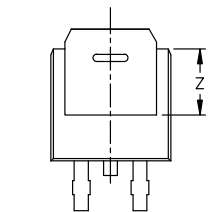
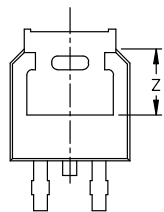
TOP VIEW



SIDE VIEW

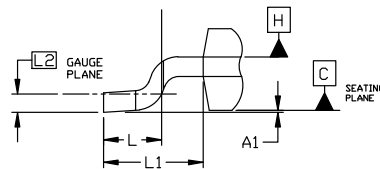
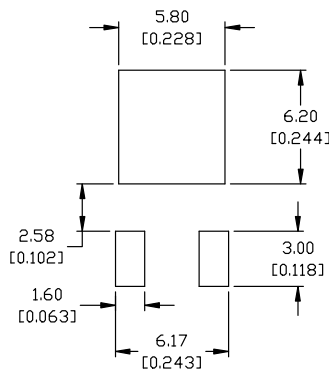


BOTTOM VIEW



BOTTOM VIEW

ALTERNATE
CONSTRUCTIONS



DETAIL A
ROTATED 90° CW

NOTES:

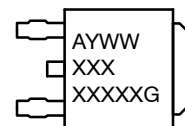
1. DIMENSIONING AND TOLERANCING ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3, AND Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
5. 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*



IC



Discrete

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

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, SOLDERRM/D.

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

*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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