

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

## NCV8401A, NCV8401B

NCV8401A/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

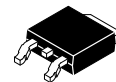
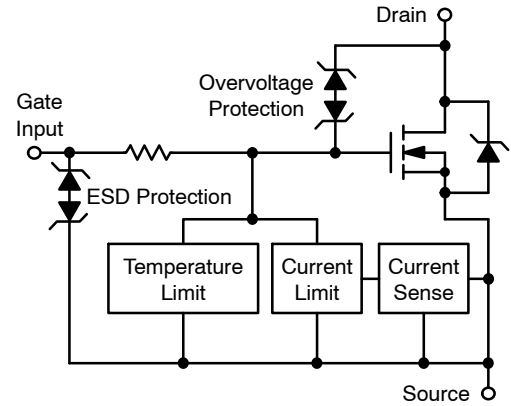
- Short Circuit Protection
- Thermal Shutdown with Automatic Restart
- Over Voltage Protection
- Integrated Clamp for Inductive Switching
- ESD Protection
- dV/dt Robustness
- Analog Drive Capability (Logic Level Input)
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control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

### Typical Applications

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

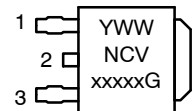
V <sub>DS</sub> (Clamped)	R <sub>DS(ON)</sub> TYP	I <sub>D</sub> MAX (Limited)
42 V	23 mΩ @ 10 V	33 A*

\*Max current may be limited below this value depending on input conditions.



**DPAK  
CASE 369C  
STYLE 2**

### MARKING DIAGRAM



Y	= Year	1	= Gate
WW	= Work Week	2	= Drain
xxxxx	= 8401A or 8401B	3	= Source
G	= Pb-Free Package		

### ORDERING INFORMATION

Device	Package	Shipping <sup>†</sup>
NCV8401ADTRKG	DPAK (Pb-Free)	2500/Tape & Reel
NCV8401BDTRKG	DPAK (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 Specification Brochure, BRD8011/D.

# NCV8401A, NCV8401B

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

Rating	Symbol	Value	Unit
Drain-to-Source Voltage Internally Clamped	$V_{DSS}$	42	V
Drain-to-Gate Voltage Internally Clamped ( $R_{GS} = 1.0\text{ M}\Omega$ )	$V_{DGR}$	42	V
Gate-to-Source Voltage	$V_{GS}$	$\pm 14$	V
Drain Current - Continuous	$I_D$	Internally Limited	
Total Power Dissipation @ $T_A = 25^\circ\text{C}$ (Note 1) @ $T_A = 25^\circ\text{C}$ (Note 2)	$P_D$	1.1 2.0	W
Thermal Resistance, Junction-to-Case Junction-to-Ambient (Note 1) Junction-to-Ambient (Note 2)	$R_{\theta JC}$ $R_{\theta JA}$ $R_{\theta JA}$	1.6 110 60	$^\circ\text{C/W}$
Single Pulse Drain-to-Source Avalanche Energy ( $V_{DD} = 25\text{ Vdc}$ , $V_{GS} = 5.0\text{ Vdc}$ , $I_L = 3.65\text{ Apk}$ , $L = 120\text{ mH}$ , $R_G = 25\ \Omega$ , $T_{Jstart} = 150^\circ\text{C}$ ) (Note 3)	$E_{AS}$	800	mJ
Load Dump Voltage ( $V_{GS} = 0$ and $10\text{ V}$ , $R_I = 2.0\ \Omega$ , $R_L = 3.0\ \Omega$ , $t_d = 400\text{ ms}$ )	$V_{LD}$	65	V
Operating Junction Temperature	$T_J$	-40 to 150	$^\circ\text{C}$
Storage Temperature	$T_{stg}$	-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. Minimum FR4 PCB, steady state.
2. Mounted onto a 2" square FR4 board  
(1" square, 2 oz. Cu 0.06" thick single-sided,  $t = \text{steady state}$ ).
3. Not subject to production testing.

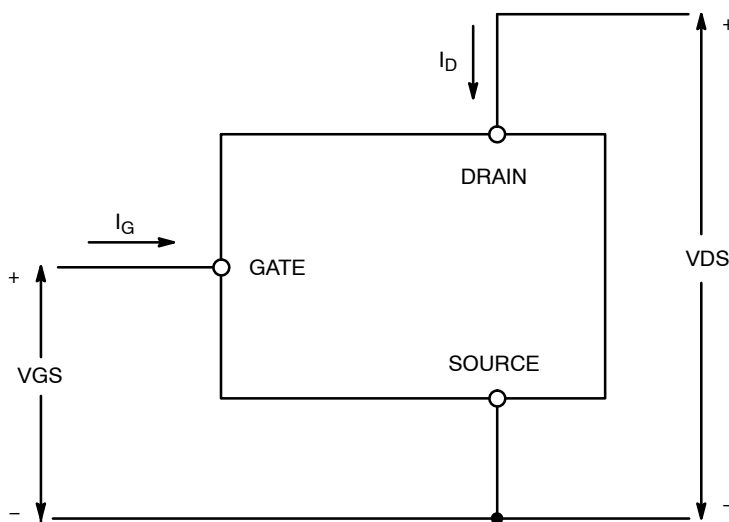


Figure 1. Voltage and Current Convention

# NCV8401A, NCV8401B

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

Characteristic	Symbol	Min	Typ	Max	Unit
<b>OFF CHARACTERISTICS</b>					
Drain-to-Source Clamped Breakdown Voltage (V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 250 μAdc) (V <sub>GS</sub> = 0 Vdc, I <sub>D</sub> = 250 μAdc, T <sub>J</sub> = 150°C) (Note 4)	V <sub>(BR)DSS</sub>	42 42	46 44	50 50	Vdc
Zero Gate Voltage Drain Current (V <sub>DS</sub> = 32 Vdc, V <sub>GS</sub> = 0 Vdc) (V <sub>DS</sub> = 32 Vdc, V <sub>GS</sub> = 0 Vdc, T <sub>J</sub> = 150°C) (Note 4)	I <sub>DSS</sub>		1.5 6.5	5.0	μAdc
Gate Input Current (V <sub>GS</sub> = 5.0 Vdc, V <sub>DS</sub> = 0 Vdc)	I <sub>GSSF</sub>		50	100	μAdc

## ON CHARACTERISTICS

Gate Threshold Voltage (V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1.2 mAdc) Threshold Temperature Coefficient	V <sub>GS(th)</sub>	1.0	1.8 5.0	2.0	Vdc -mV/°C
Static Drain-to-Source On-Resistance (Note 5) (V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 5.0 Adc, T <sub>J</sub> @ 25°C) (V <sub>GS</sub> = 10 Vdc, I <sub>D</sub> = 5.0 Adc, T <sub>J</sub> @ 150°C) (Note 4)	R <sub>DS(on)</sub>		23 43	29 55	mΩ
Static Drain-to-Source On-Resistance (Note 5) (V <sub>GS</sub> = 5.0 Vdc, I <sub>D</sub> = 5.0 Adc, T <sub>J</sub> @ 25°C) (V <sub>GS</sub> = 5.0 Vdc, I <sub>D</sub> = 5.0 Adc, T <sub>J</sub> @ 150°C) (Note 4)	R <sub>DS(on)</sub>		28 50	34 60	mΩ
Source-Drain Forward On Voltage (I <sub>S</sub> = 5 A, V <sub>GS</sub> = 0 V)	V <sub>SD</sub>		0.80	1.1	V

## SWITCHING CHARACTERISTICS (Note 4)

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 I <sub>D</sub> = 1.0 A, Ext R <sub>G</sub> = 2.5 Ω	t <sub>ON</sub>	41	50	μs
Turn-OFF Time (90% V <sub>IN</sub> to 10% I <sub>D</sub> )		t <sub>OFF</sub>	129	150	
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, I <sub>D</sub> = 1.0 A, Ext R <sub>G</sub> = 2.5 Ω	t <sub>ON</sub>	16	25	μs
Turn-OFF Time (90% V <sub>IN</sub> to 10% I <sub>D</sub> )		t <sub>OFF</sub>	164	180	
Slew-Rate ON (80% V <sub>DS</sub> to 50% V <sub>DS</sub> )	V <sub>in</sub> = 0 to 10 V, V <sub>DD</sub> = 12 V, R <sub>L</sub> = 4.7 Ω	-dV <sub>DS</sub> /dt <sub>ON</sub>	1.27	2.0	V/μs
Slew-Rate OFF (50% V <sub>DS</sub> to 80% V <sub>DS</sub> )		dV <sub>DS</sub> /dt <sub>OFF</sub>	0.36	0.75	

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

Current Limit	V <sub>GS</sub> = 5.0 V, V <sub>DS</sub> = 10 V V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = 150°C (Notes 4, 6)	I <sub>LIM</sub>	25 11	30 16	35 21	Adc
	V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V V <sub>GS</sub> = 10 V, T <sub>J</sub> = 150°C (Notes 4, 6)		30 18	35 25	40 28	
Temperature Limit (Turn-off)	V <sub>GS</sub> = 5.0 V (Notes 4, 6)	T <sub>LIM(off)</sub>	150	175	200	°C
Thermal Hysteresis	V <sub>GS</sub> = 5.0 V	ΔT <sub>LIM(on)</sub>		15		°C
Temperature Limit (Turn-off)	V <sub>GS</sub> = 10 V (Notes 4, 6)	T <sub>LIM(off)</sub>	150	165	185	°C
Thermal Hysteresis	V <sub>GS</sub> = 10 V	ΔT <sub>LIM(on)</sub>		15		°C

## GATE INPUT CHARACTERISTICS (Note 4)

Device ON Gate Input Current	V <sub>GS</sub> = 5 V I <sub>D</sub> = 1.0 A	I <sub>GON</sub>		50	100	μA
	V <sub>GS</sub> = 10 V I <sub>D</sub> = 1.0 A			400	700	
Current Limit Gate Input Current	V <sub>GS</sub> = 5 V, V <sub>DS</sub> = 10 V	I <sub>GCL</sub>		0.1	0.5	mA
	V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V			0.7	1.0	
Thermal Limit Fault Gate Input Current	V <sub>GS</sub> = 5 V, V <sub>DS</sub> = 10 V	I <sub>GTL</sub>		0.6	1.0	mA
	V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V			2.0	4.0	

## ESD ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = 25°C unless otherwise noted) (Note 4)

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

4. Not subject to production testing.

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

6. Refer to Application Note AND8202/D for dependence of protection features on gate voltage.

TYPICAL PERFORMANCE CURVES

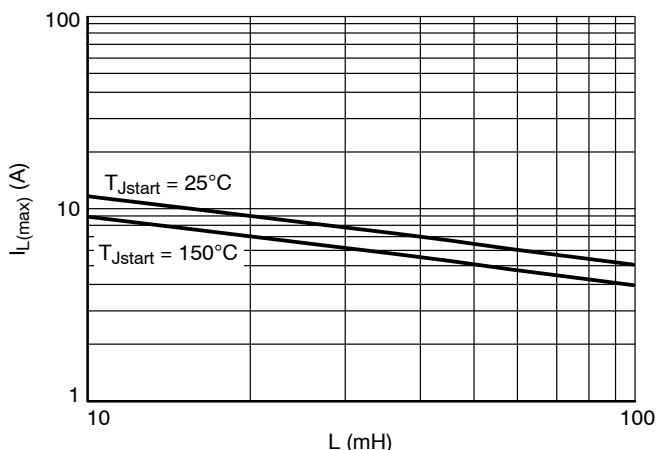


Figure 2. Single Pulse Maximum Switch-off Current vs. Load Inductance

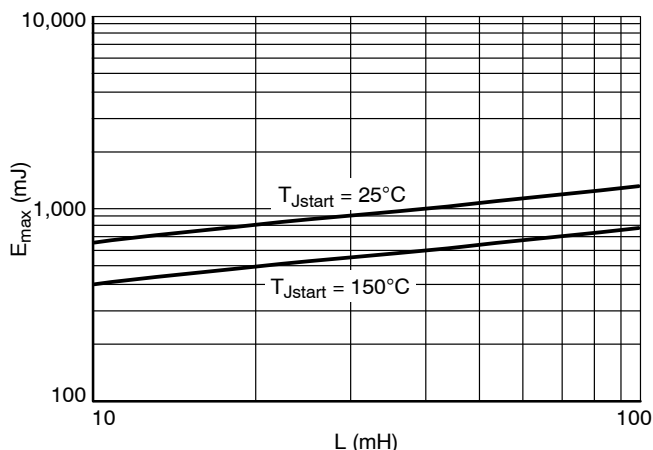


Figure 3. Single Pulse Maximum Switching Energy vs. Load Inductance

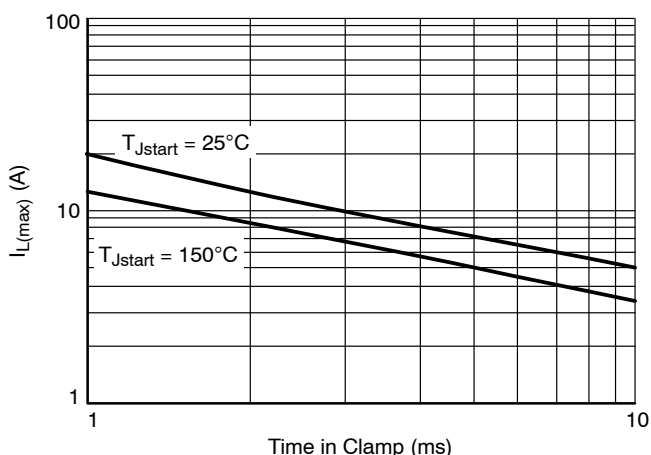


Figure 4. Single Pulse Maximum Inductive Switch-off Current vs. Time in Clamp

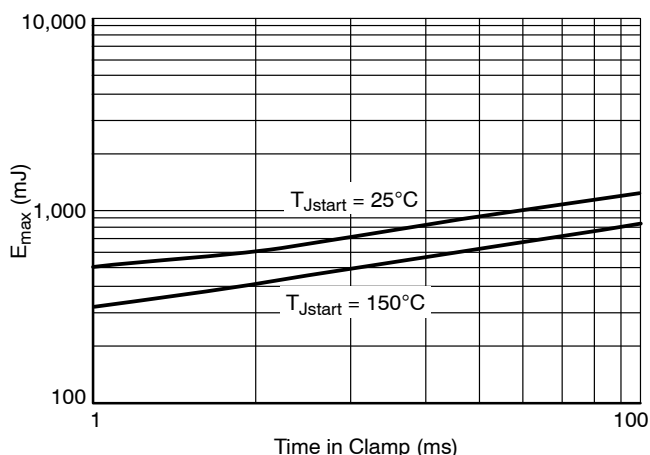


Figure 5. Single Pulse Maximum Inductive Switching Energy vs. Time in Clamp

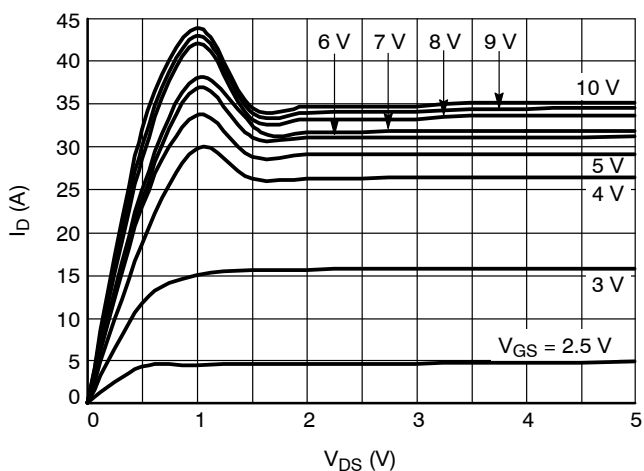


Figure 6. On-state Output Characteristics at 25°C

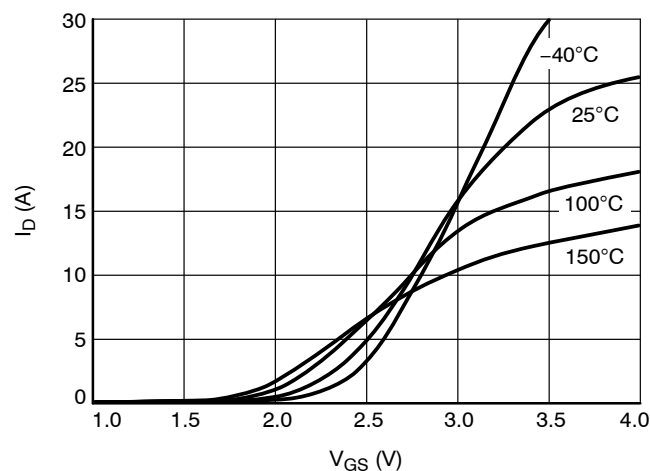


Figure 7. Transfer Characteristics ( $V_{DS} = 10\text{ V}$ )

TYPICAL PERFORMANCE CURVES

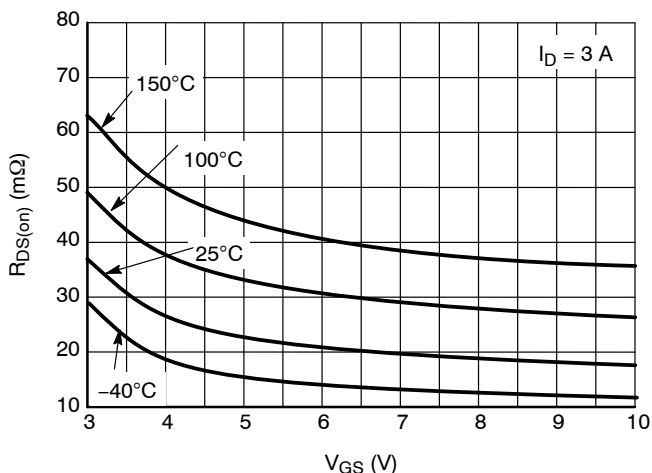


Figure 8.  $R_{DS(on)}$  vs. Gate-Source Voltage

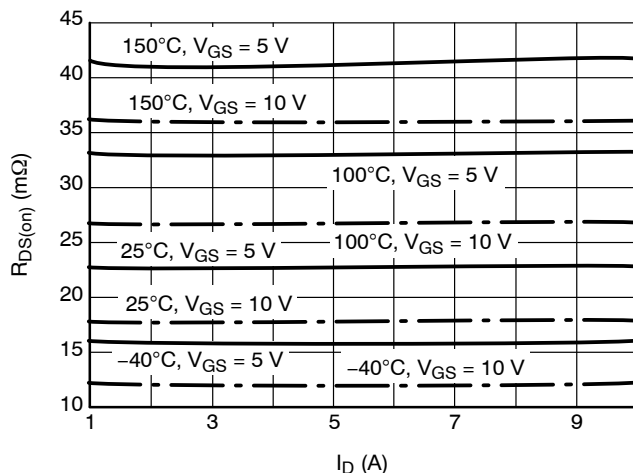


Figure 9.  $R_{DS(on)}$  vs. Drain Current

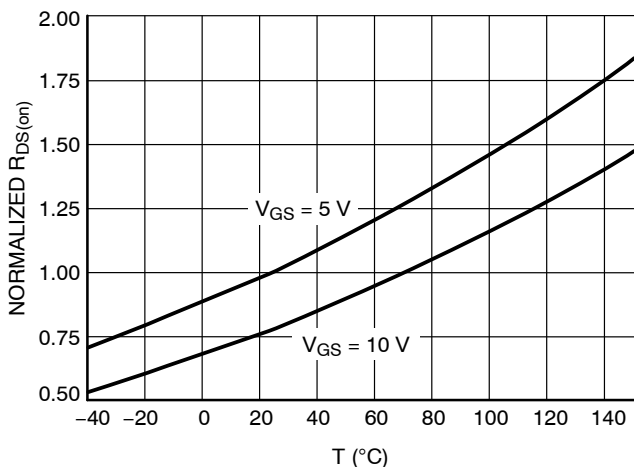


Figure 10. Normalized  $R_{DS(on)}$  vs. Temperature ( $I_D = 5 A$ )

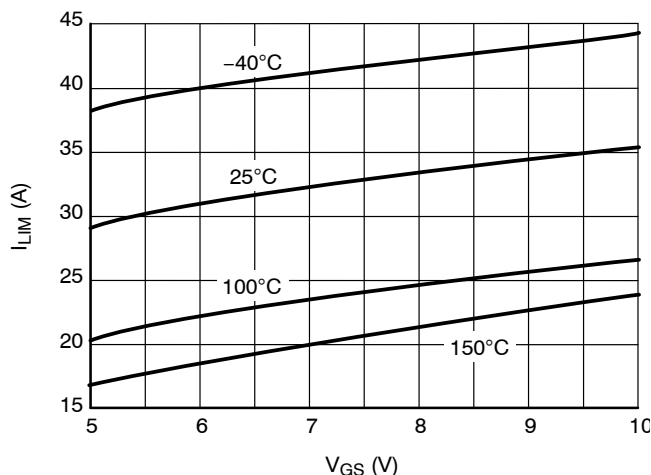


Figure 11. Current Limit vs. Gate-Source Voltage ( $V_{DS} = 10 V$ )

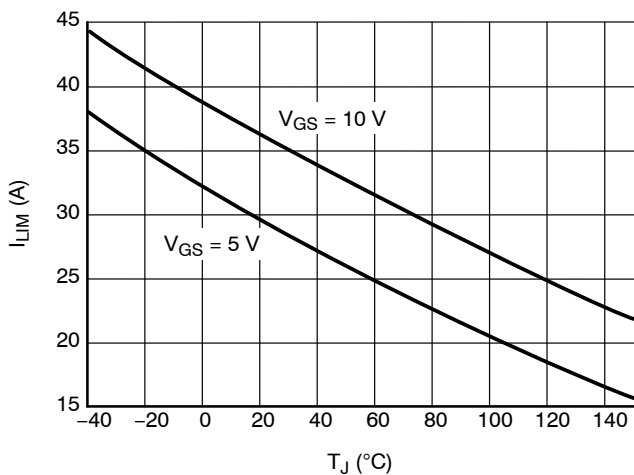


Figure 12. Current Limit vs. Junction Temperature ( $V_{DS} = 10 V$ )

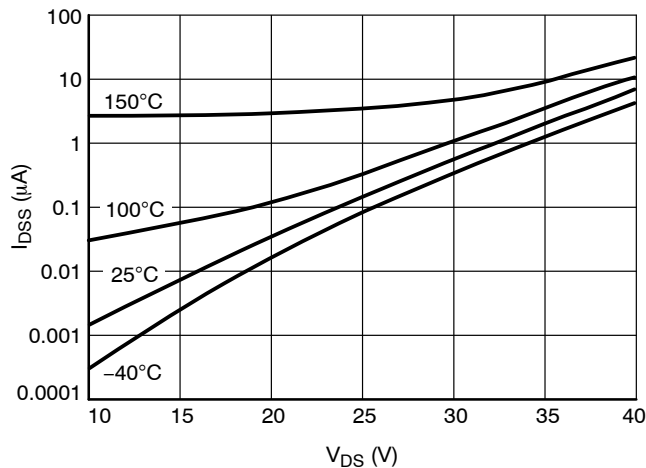


Figure 13. Drain-to-Source Leakage Current ( $V_{GS} = 0 V$ )

# NCV8401A, NCV8401B

## TYPICAL PERFORMANCE CURVES

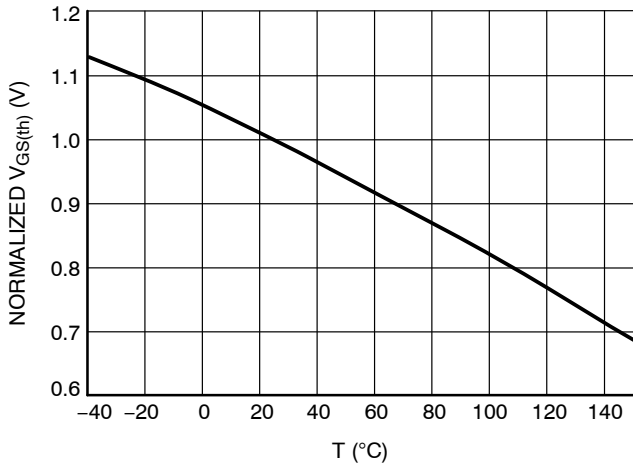


Figure 14. Normalized Threshold Voltage vs. Temperature ( $I_D = 1.2$  mA,  $V_{DS} = V_{GS}$ )

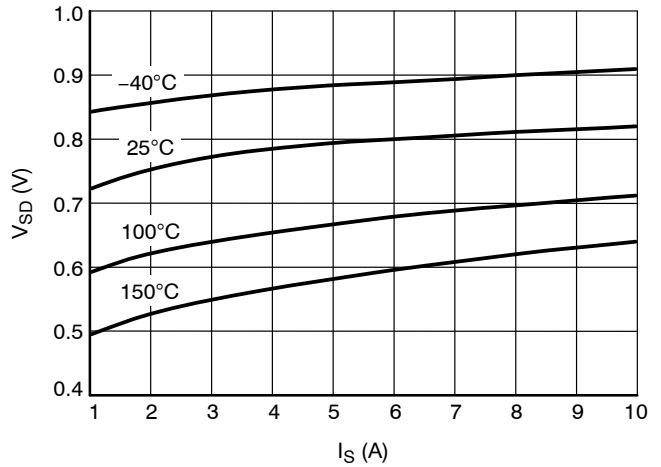


Figure 15. Source-Drain Diode Forward Characteristics ( $V_{GS} = 0$  V)

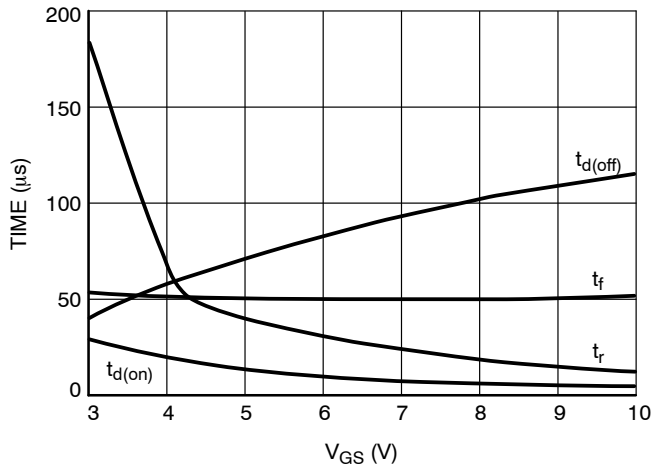


Figure 16. Resistive Load Switching Time vs. Gate-Source Voltage ( $V_{DD} = 25$  V,  $I_D = 5$  A,  $R_G = 0$   $\Omega$ )

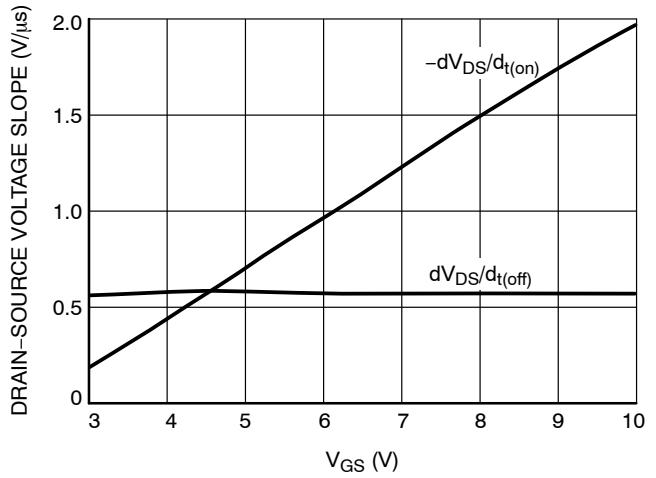


Figure 17. Resistive Load Switching Drain-Source Voltage Slope vs. Gate-Source Voltage ( $V_{DD} = 25$  V,  $I_D = 5$  A,  $R_G = 0$   $\Omega$ )

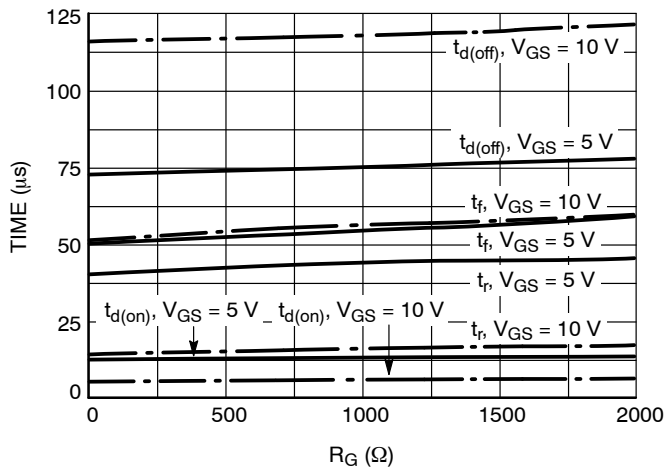


Figure 18. Resistive Load Switching Time vs. Gate Resistance ( $V_{DD} = 25$  V,  $I_D = 5$  A)

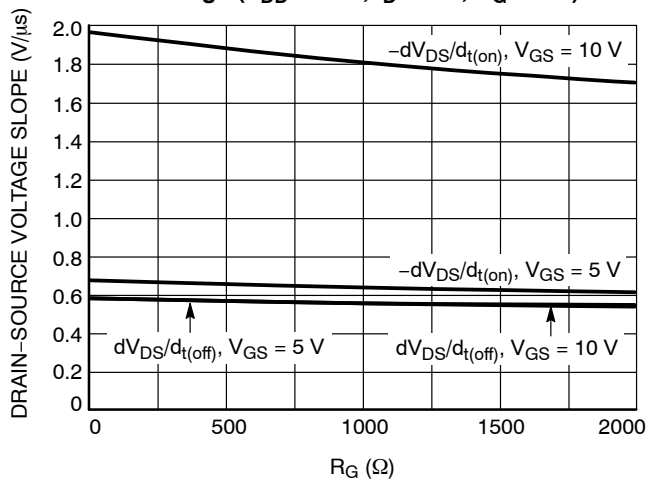


Figure 19. Drain-Source Voltage Slope during Turn On and Turn Off vs. Gate Resistance ( $V_{DD} = 25$  V,  $I_D = 5$  A)

# NCV8401A, NCV8401B

## TYPICAL PERFORMANCE CURVES

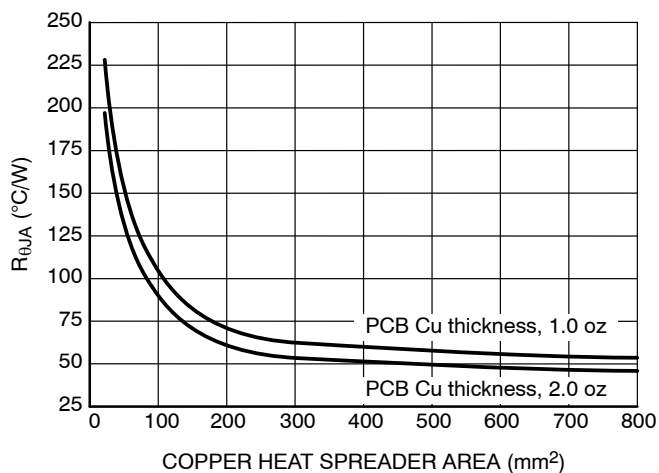


Figure 20. R<sub>θJA</sub> vs. Copper Area

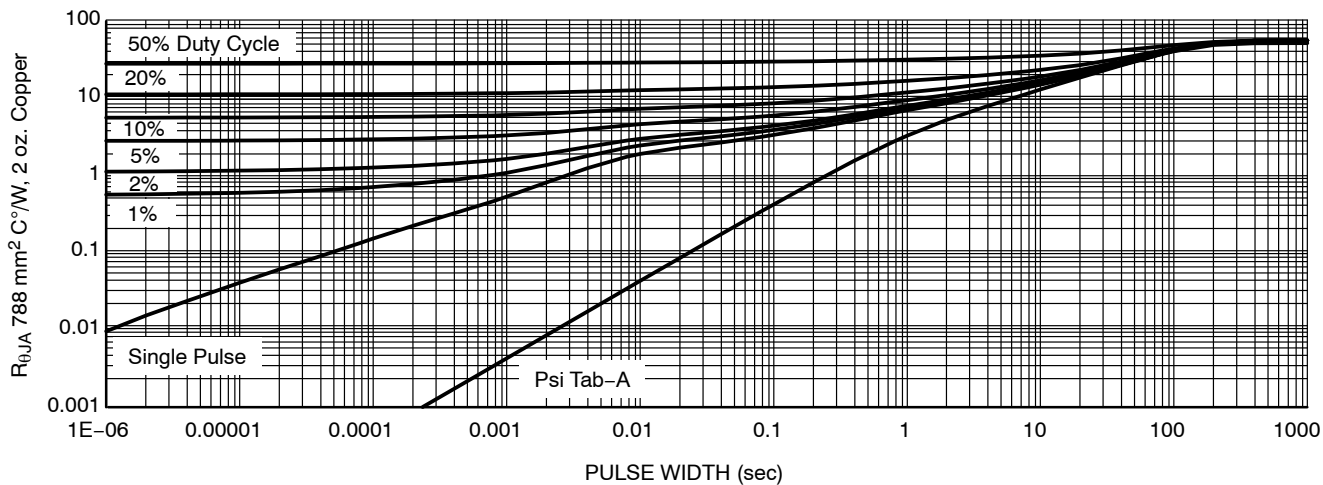


Figure 21. Transient Thermal Resistance

# NCV8401A, NCV8401B

## TEST CIRCUITS AND WAVEFORMS

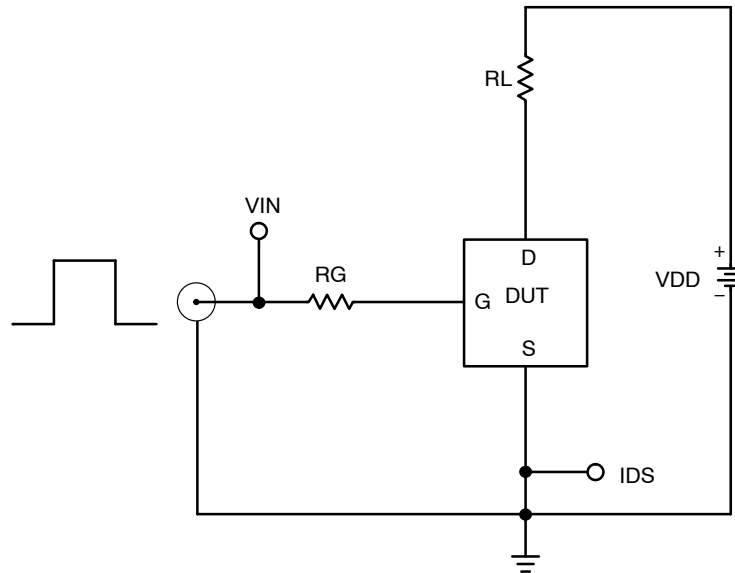


Figure 22. Resistive Load Switching Test Circuit

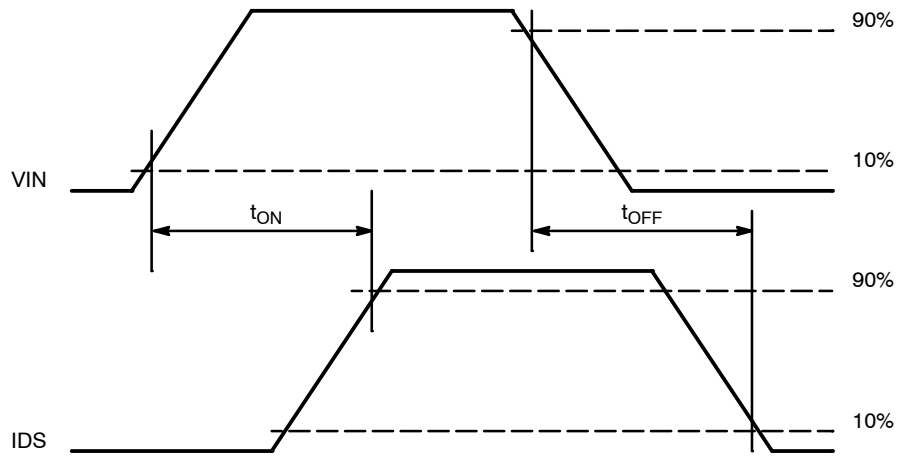


Figure 23. Resistive Load Switching Waveforms



# NCV8401A, NCV8401B

## TEST CIRCUITS AND WAVEFORMS

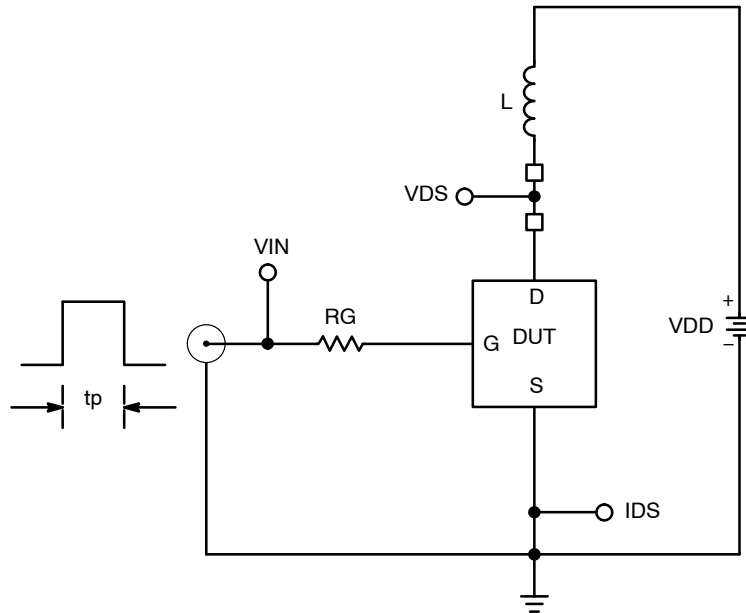


Figure 24. Inductive Load Switching Test Circuit

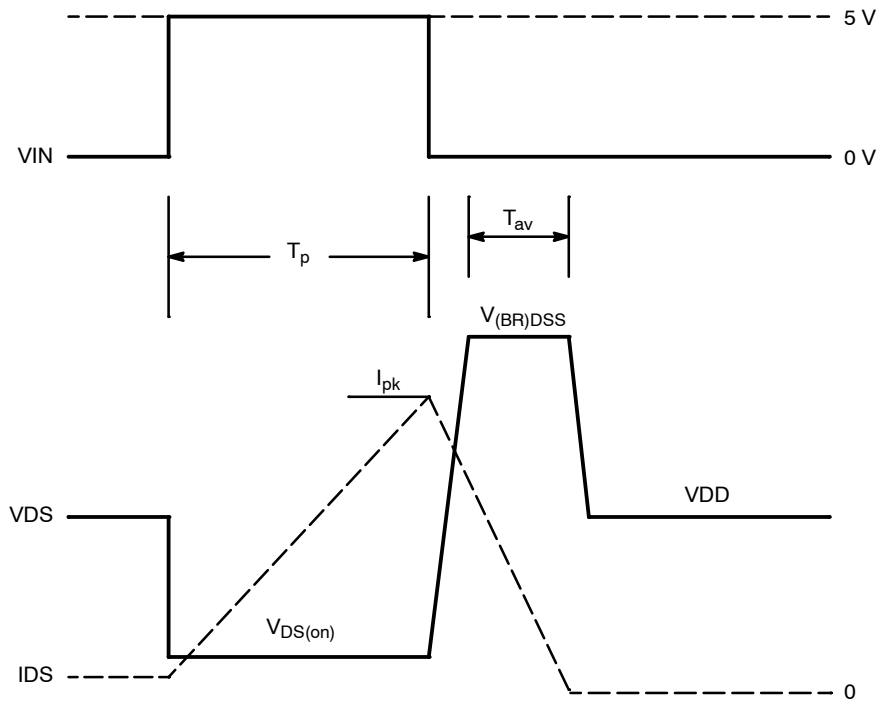
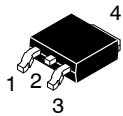


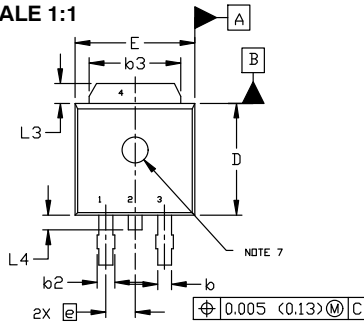
Figure 25. Inductive Load Switching Waveforms



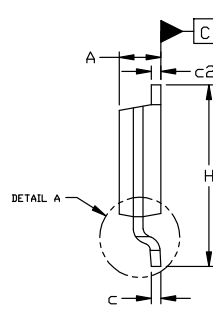
DPAK (SINGLE GAUGE)  
CASE 369C  
ISSUE G

DATE 31 MAY 2023

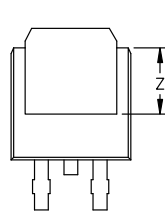
SCALE 1:1



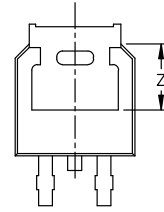
TOP VIEW



SIDE VIEW

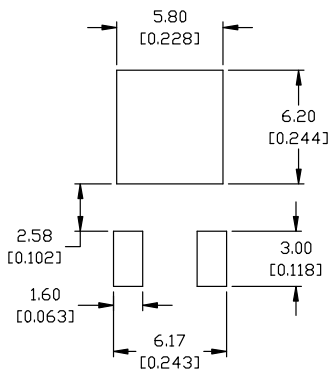


BOTTOM VIEW



BOTTOM VIEW

ALTERNATE CONSTRUCTIONS



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.

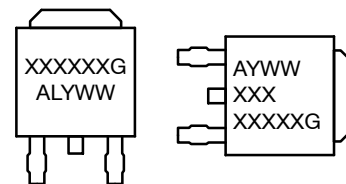
- STYLE 1: PIN 1. BASE  
2. COLLECTOR  
3. EMITTER  
4. COLLECTOR
- STYLE 2: PIN 1. GATE  
2. DRAIN  
3. SOURCE  
4. DRAIN
- STYLE 3: PIN 1. ANODE  
2. CATHODE  
3. ANODE  
4. CATHODE
- STYLE 4: PIN 1. CATHODE  
2. ANODE  
3. GATE  
4. ANODE
- STYLE 5: PIN 1. GATE  
2. ANODE  
3. CATHODE  
4. ANODE
- 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

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

\*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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