

# NCV8402, NCV8402A

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

NCV8402/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
- Overvoltage 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

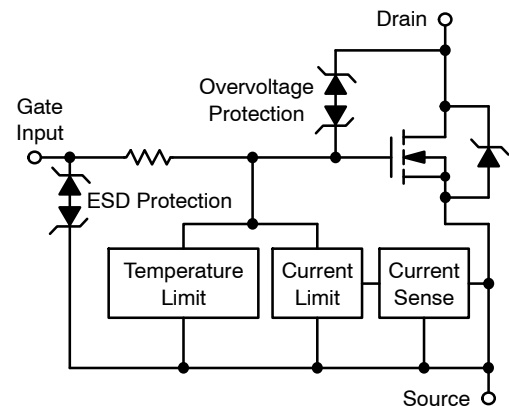


ON Semiconductor®

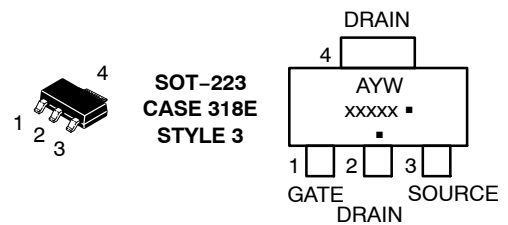
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$V_{(BR)DSS}$ (Clamped)	$R_{DS(ON)}$ TYP	$I_D$ MAX
42 V	165 mΩ @ 10 V	2.0 A*

\*Max current limit value is dependent on input condition.



### MARKING DIAGRAM



A = Assembly Location  
 Y = Year  
 W = Work Week  
 xxxxx = V8402 or 8402A  
 ■ = Pb-Free Package

(Note: Microdot may be in either location)

### ORDERING INFORMATION

Device	Package	Shipping†
NCV8402STT1G	SOT-223 (Pb-Free)	1000/Tape & Reel
NCV8402ASTT1G		
NCV8402STT3G	SOT-223 (Pb-Free)	4000/Tape & Reel
NCV8402ASTT3G		

†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.

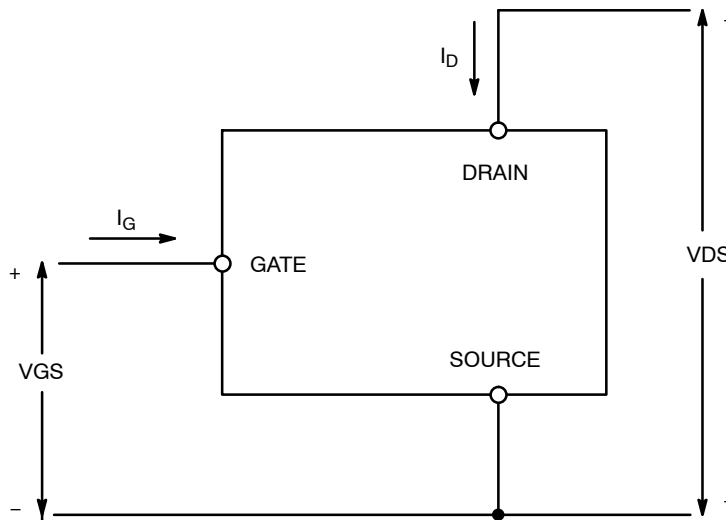
# NCV8402, NCV8402A

## MAXIMUM RATINGS (T<sub>J</sub> = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-to-Source Voltage Internally Clamped	V <sub>DSS</sub>	42	V
Drain-to-Gate Voltage Internally Clamped (R <sub>G</sub> = 1.0 MΩ)	V <sub>DGR</sub>	42	V
Gate-to-Source Voltage	V <sub>GS</sub>	± 14	V
Continuous Drain Current	I <sub>D</sub>	Internally Limited	
Power Dissipation	P <sub>D</sub>	1.1 1.7 8.9	W
Thermal Resistance	Junction-to-Ambient Steady State (Note 1)	R <sub>θJA</sub>	114 °C/W
	Junction-to-Ambient Steady State (Note 2)	R <sub>θJA</sub>	72 °C/W
	Junction-to-Tab Steady State (Note 1)	R <sub>θJT</sub>	14 °C/W
Single Pulse Drain-to-Source Avalanche Energy (V <sub>DD</sub> = 32 V, V <sub>G</sub> = 5.0 V, I <sub>PK</sub> = 1.0 A, L = 300 mH, R <sub>G(ext)</sub> = 25 Ω)	E <sub>AS</sub>	150	mJ
Load Dump Voltage (V <sub>GS</sub> = 0 and 10 V, R <sub>I</sub> = 2.0 Ω, R <sub>L</sub> = 9.0 Ω, t <sub>d</sub> = 400 ms)	V <sub>LD</sub>	87	V
Operating Junction Temperature	T <sub>J</sub>	-40 to 150	°C
Storage Temperature	T <sub>stg</sub>	-55 to 150	°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 min pad FR4 PCB, (2 oz. Cu, 0.06" thick).
2. Surface-mounted onto 2" sq. FR4 board (1" sq., 1 oz. Cu, 0.06" thick).



**Figure 1. Voltage and Current Convention**

# NCV8402, NCV8402A

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

Parameter	Test Condition	Symbol	Min	Typ	Max	Unit
<b>OFF CHARACTERISTICS</b>						
Drain-to-Source Breakdown Voltage (Note 3)	V <sub>GS</sub> = 0 V, I <sub>D</sub> = 10 mA, T <sub>J</sub> = 25°C	V <sub>(BR)DSS</sub>	42	46	55	V
	V <sub>GS</sub> = 0 V, I <sub>D</sub> = 10 mA, T <sub>J</sub> = 150°C (Note 5)		40	45	55	
Zero Gate Voltage Drain Current	V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 32 V, T <sub>J</sub> = 25°C	I <sub>DSS</sub>		0.25	4.0	μA
	V <sub>GS</sub> = 0 V, V <sub>DS</sub> = 32 V, T <sub>J</sub> = 150°C (Note 5)			1.1	20	
Gate Input Current	V <sub>DS</sub> = 0 V, V <sub>GS</sub> = 5.0 V	I <sub>GSSF</sub>		50	100	μA

## ON CHARACTERISTICS (Note 3)

Gate Threshold Voltage	V <sub>GS</sub> = V <sub>DS</sub> , I <sub>D</sub> = 150 μA	V <sub>GS(th)</sub>	1.3	1.8	2.2	V
Gate Threshold Temperature Coefficient		V <sub>GS(th)</sub> /T <sub>J</sub>		4.0		-mV/°C
Static Drain-to-Source On-Resistance	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 1.7 A, T <sub>J</sub> = 25°C	R <sub>DS(on)</sub>		165	200	mΩ
	V <sub>GS</sub> = 10 V, I <sub>D</sub> = 1.7 A, T <sub>J</sub> = 150°C (Note 5)			305	400	
	V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 1.7 A, T <sub>J</sub> = 25°C			195	230	
	V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 1.7 A, T <sub>J</sub> = 150°C (Note 5)			360	460	
	V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 0.5 A, T <sub>J</sub> = 25°C			190	230	
	V <sub>GS</sub> = 5.0 V, I <sub>D</sub> = 0.5 A, T <sub>J</sub> = 150°C (Note 5)			350	460	
Source-Drain Forward On Voltage	V <sub>GS</sub> = 0 V, I <sub>S</sub> = 7.0 A	V <sub>SD</sub>		1.0		V

## SWITCHING CHARACTERISTICS (Note 5)

Turn-ON Time (10% V <sub>IN</sub> to 90% I <sub>D</sub> )	V <sub>GS</sub> = 10 V, V <sub>DD</sub> = 12 V I <sub>D</sub> = 2.5 A, R <sub>L</sub> = 4.7 Ω	t <sub>ON</sub>		25		μs
Turn-OFF Time (90% V <sub>IN</sub> to 10% I <sub>D</sub> )		t <sub>OFF</sub>		120		
Slew-Rate ON (70% V <sub>DS</sub> to 50% V <sub>DS</sub> )	V <sub>GS</sub> = 10 V, V <sub>DD</sub> = 12 V, R <sub>L</sub> = 4.7 Ω	-dV <sub>DS</sub> /dt <sub>ON</sub>		0.8		V/μs
Slew-Rate OFF (50% V <sub>DS</sub> to 70% V <sub>DS</sub> )		dV <sub>DS</sub> /dt <sub>OFF</sub>		0.3		

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

Current Limit	V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = 25°C	I <sub>LIM</sub>	3.7	4.3	5.0	A
	V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 5.0 V, T <sub>J</sub> = 150°C (Note 5)		2.3	3.0	3.7	
	V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 10 V, T <sub>J</sub> = 25°C		4.2	4.8	5.4	
	V <sub>DS</sub> = 10 V, V <sub>GS</sub> = 10 V, T <sub>J</sub> = 150°C (Note 5)		2.7	3.6	4.5	
Temperature Limit (Turn-off)	V <sub>GS</sub> = 5.0 V (Note 5)	T <sub>LIM(off)</sub>	150	175	200	°C
Thermal Hysteresis	V <sub>GS</sub> = 5.0 V	ΔT <sub>LIM(on)</sub>		15		
Temperature Limit (Turn-off)	V <sub>GS</sub> = 10 V (Note 5)	T <sub>LIM(off)</sub>	150	165	185	
Thermal Hysteresis	V <sub>GS</sub> = 10 V	ΔT <sub>LIM(on)</sub>		15		

## GATE INPUT CHARACTERISTICS (Note 5)

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>		0.05		mA
	V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V			0.4		
Thermal Limit Fault Gate Input Current	V <sub>GS</sub> = 5 V, V <sub>DS</sub> = 10 V	I <sub>GTL</sub>		0.15		mA
	V <sub>GS</sub> = 10 V, V <sub>DS</sub> = 10 V			0.7		

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

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

3. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.
4. Fault conditions are viewed as beyond the normal operating range of the part.
5. Not subject to production testing.

TYPICAL PERFORMANCE CURVES

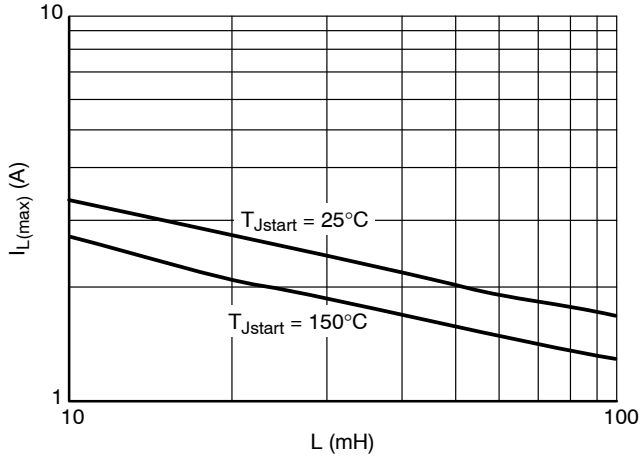


Figure 2. Single Pulse Maximum Switch-off Current vs. Load Inductance

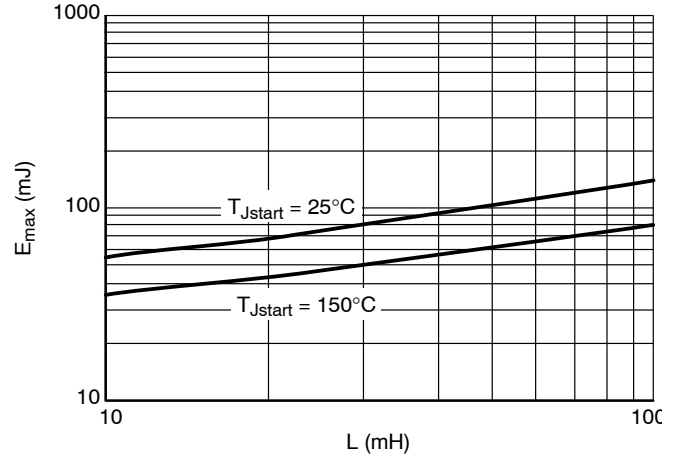


Figure 3. Single Pulse Maximum Switching Energy vs. Load Inductance

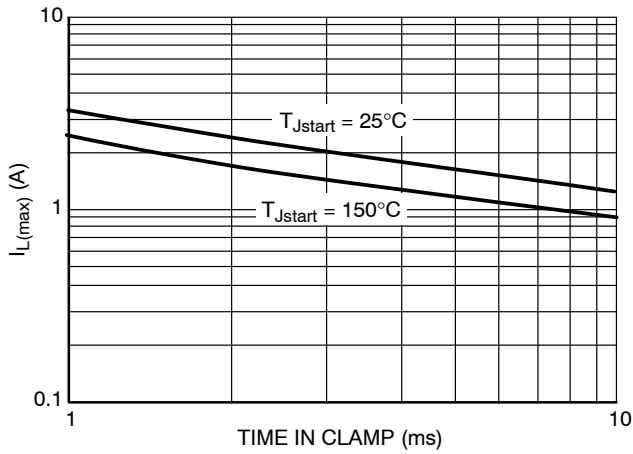


Figure 4. Single Pulse Maximum Inductive Switch-off Current vs. Time in Clamp

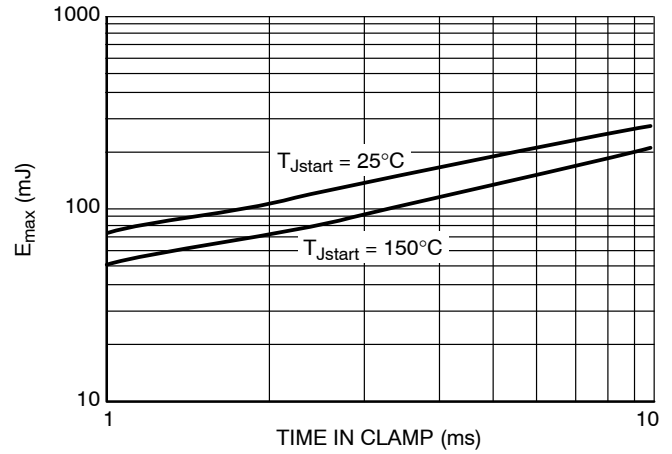


Figure 5. Single Pulse Maximum Inductive Switching Energy vs. Time in Clamp

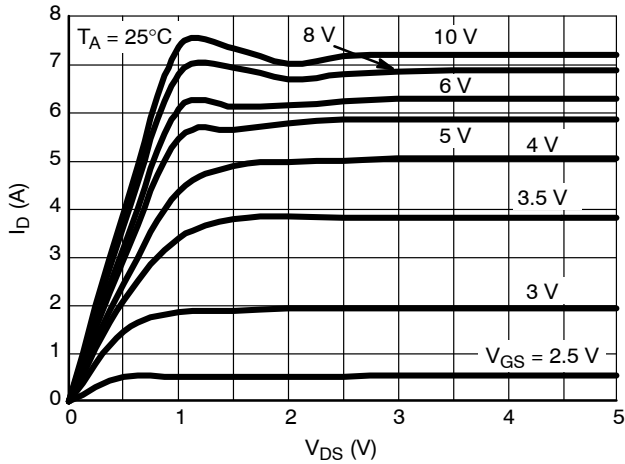


Figure 6. On-state Output Characteristics

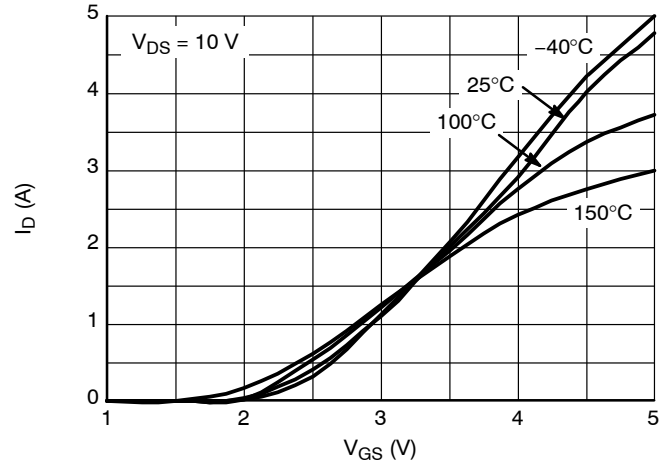


Figure 7. Transfer Characteristics

TYPICAL PERFORMANCE CURVES

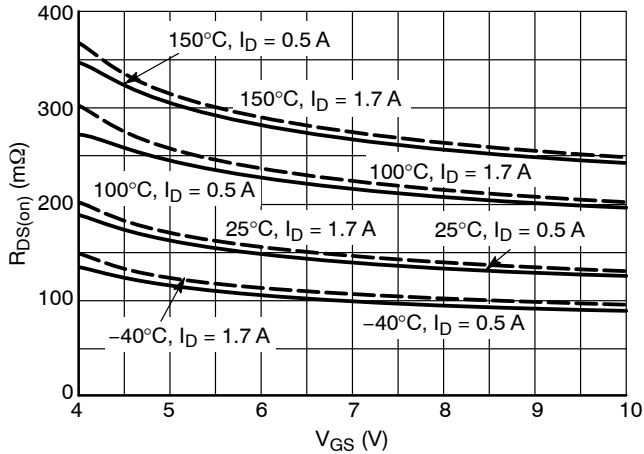


Figure 8.  $R_{DS(on)}$  vs. Gate-Source Voltage

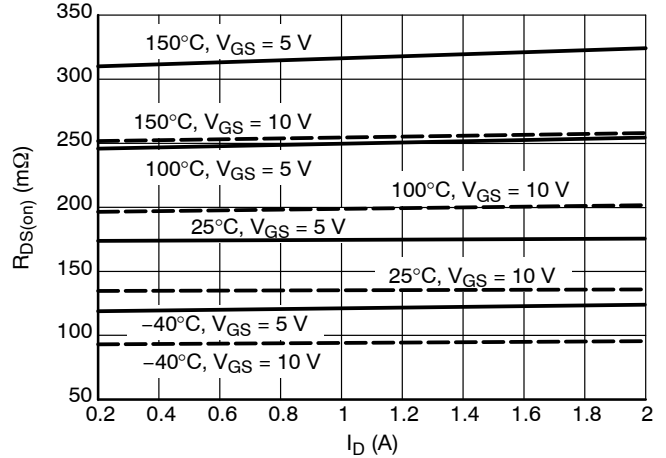


Figure 9.  $R_{DS(on)}$  vs. Drain Current

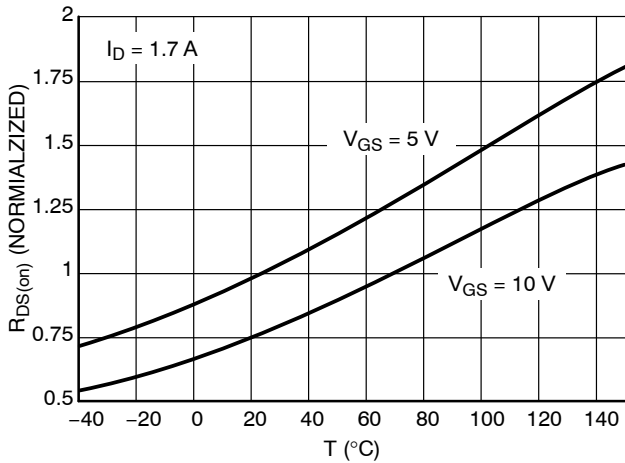


Figure 10. Normalized  $R_{DS(on)}$  vs. Temperature

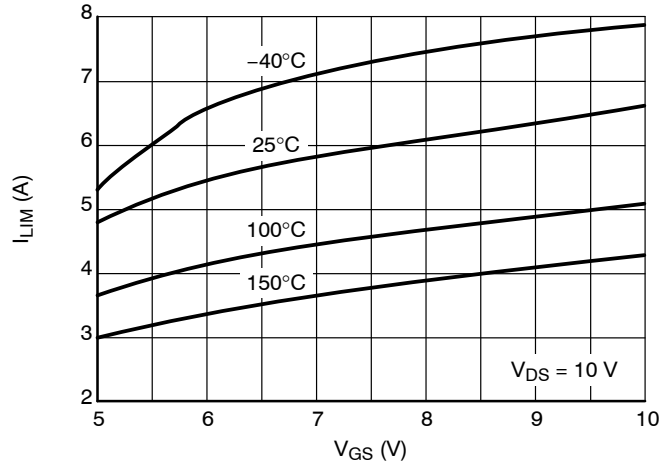


Figure 11. Current Limit vs. Gate-Source Voltage

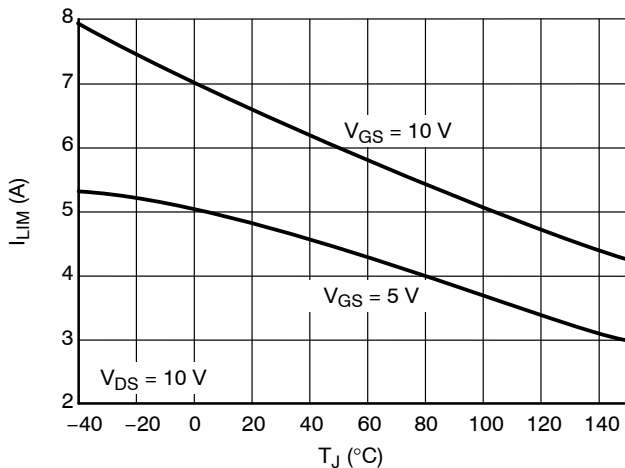


Figure 12. Current Limit vs. Junction Temperature

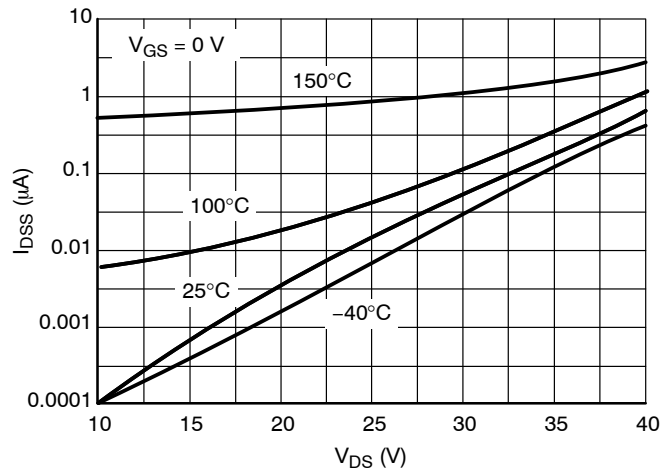


Figure 13. Drain-to-Source Leakage Current

TYPICAL PERFORMANCE CURVES

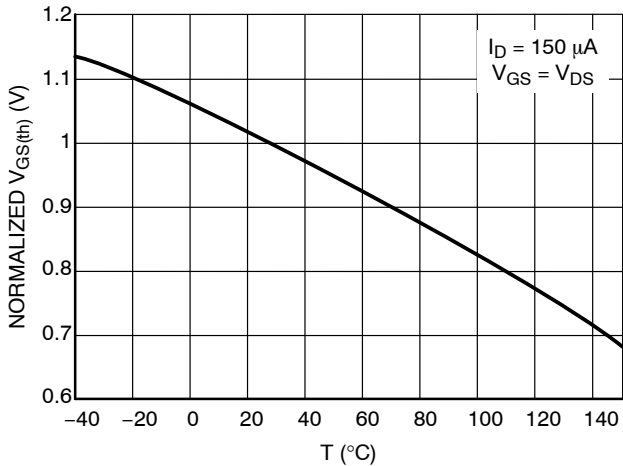


Figure 14. Normalized Threshold Voltage vs. Temperature

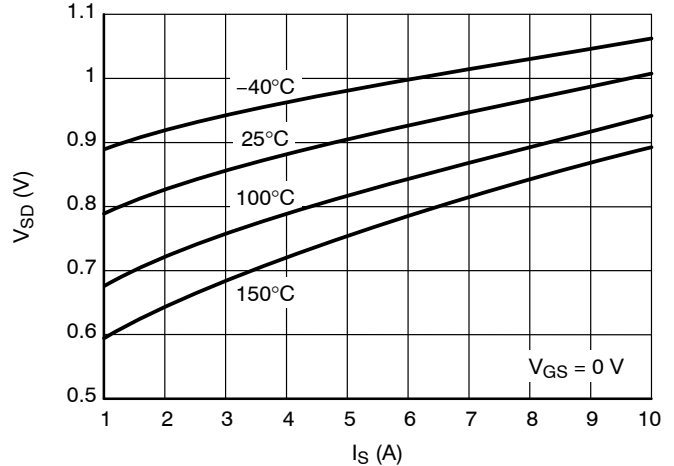


Figure 15. Source-Drain Diode Forward Characteristics

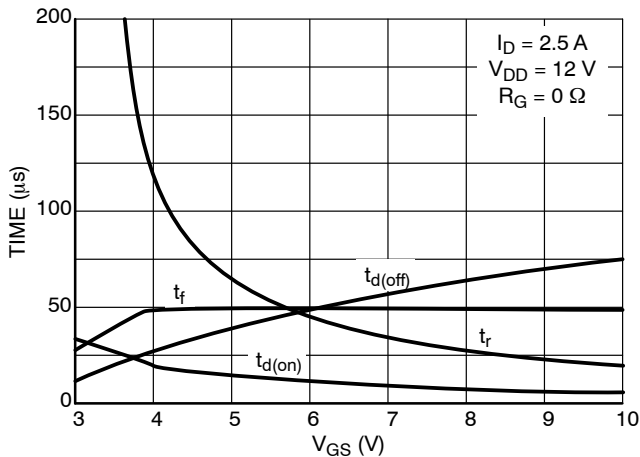


Figure 16. Resistive Load Switching Time vs. Gate-Source Voltage

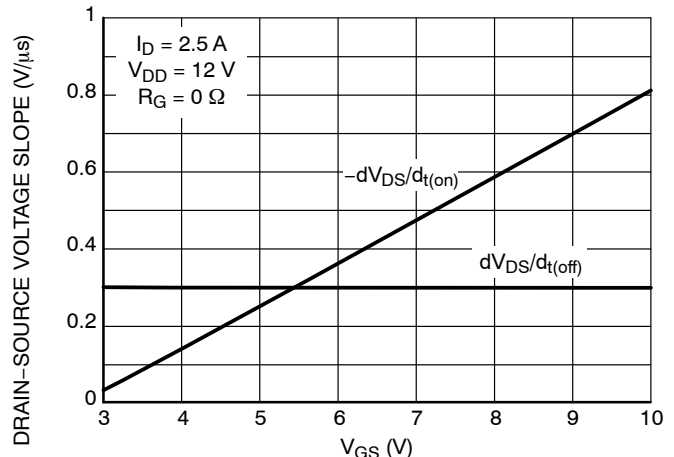


Figure 17. Resistive Load Switching Drain-Source Voltage Slope vs. Gate-Source Voltage

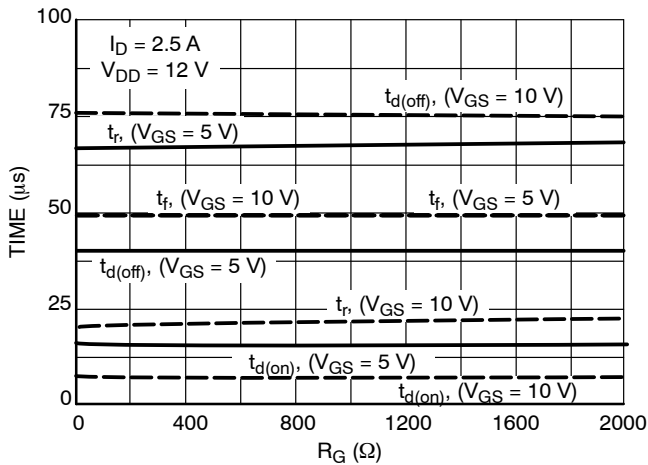


Figure 18. Resistive Load Switching Time vs. Gate Resistance

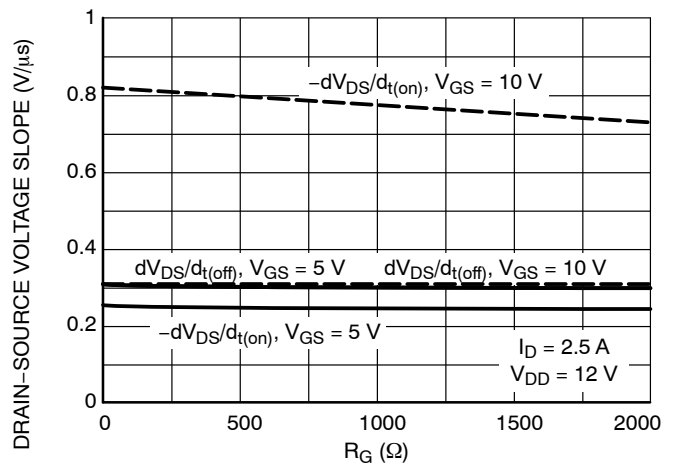


Figure 19. Drain-Source Voltage Slope during Turn On and Turn Off vs. Gate Resistance

# NCV8402, NCV8402A

## TYPICAL PERFORMANCE CURVES

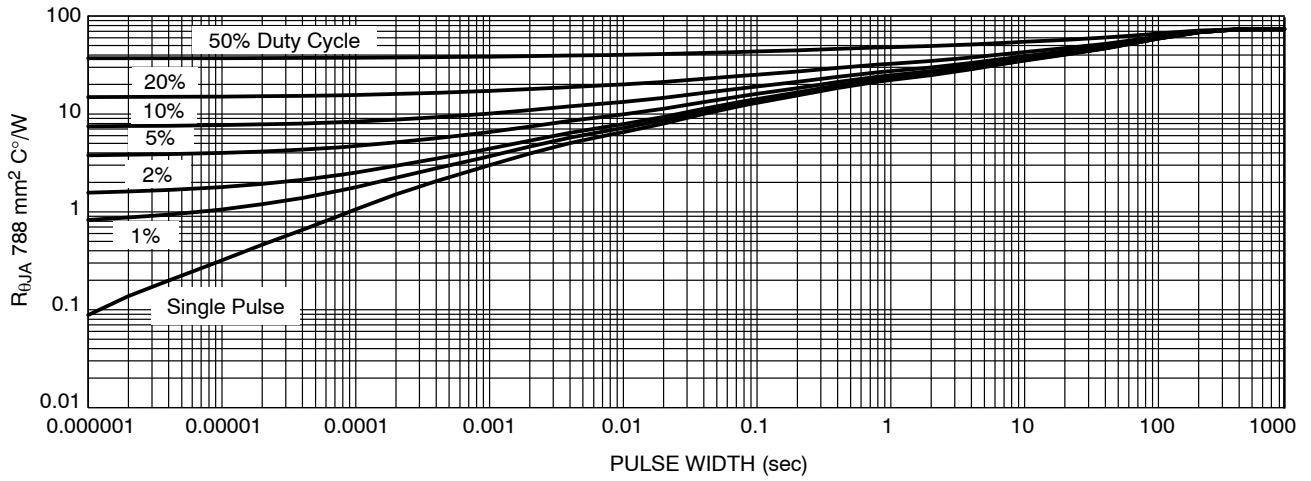


Figure 20. Transient Thermal Resistance

# NCV8402, NCV8402A

## TEST CIRCUITS AND WAVEFORMS

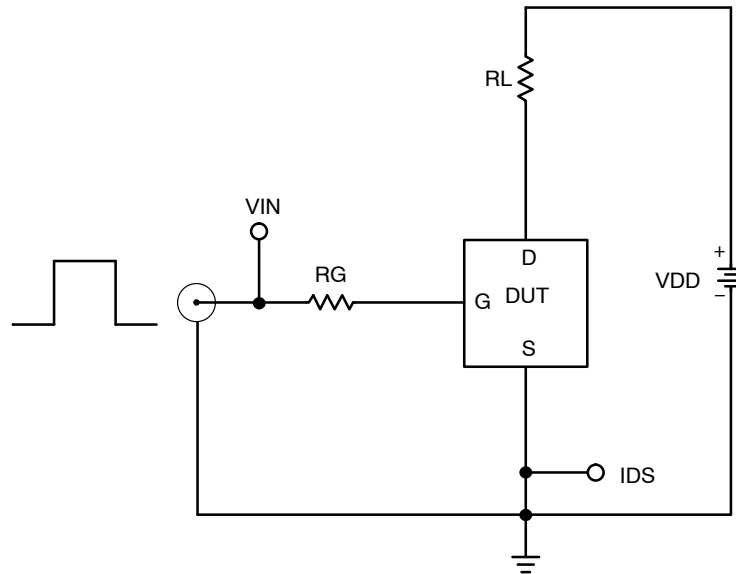


Figure 21. Resistive Load Switching Test Circuit

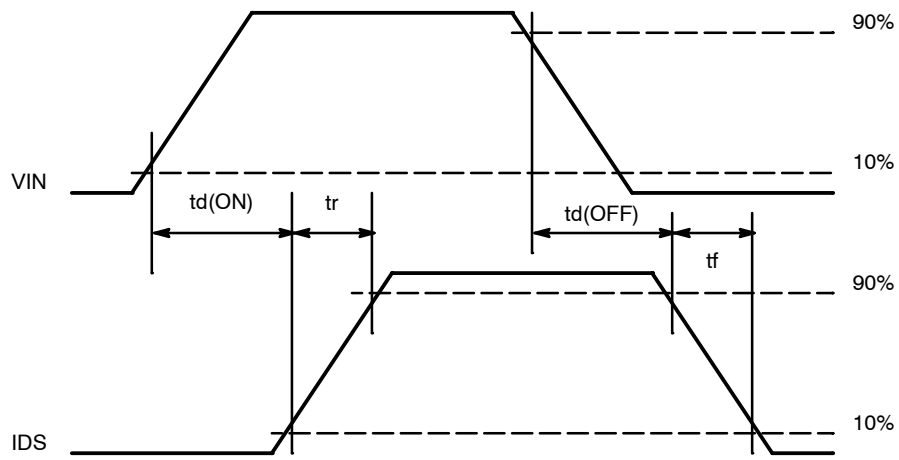


Figure 22. Resistive Load Switching Waveforms



# NCV8402, NCV8402A

## TEST CIRCUITS AND WAVEFORMS

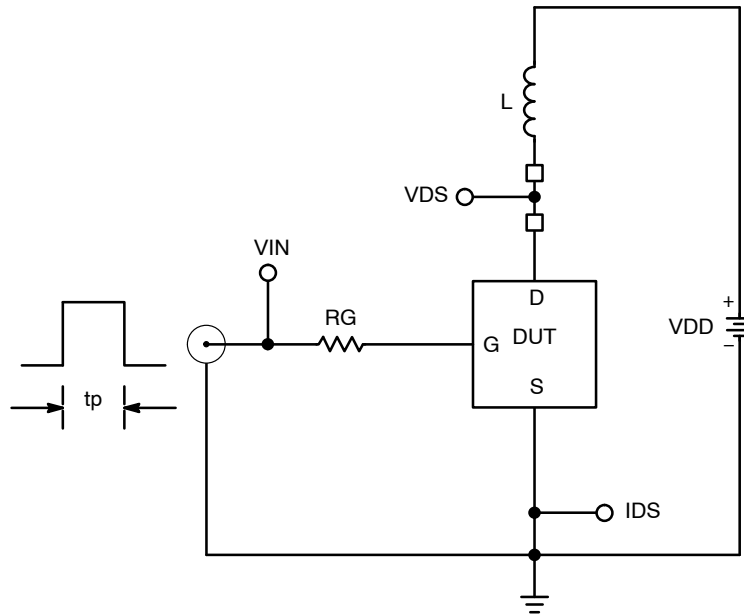


Figure 23. Inductive Load Switching Test Circuit

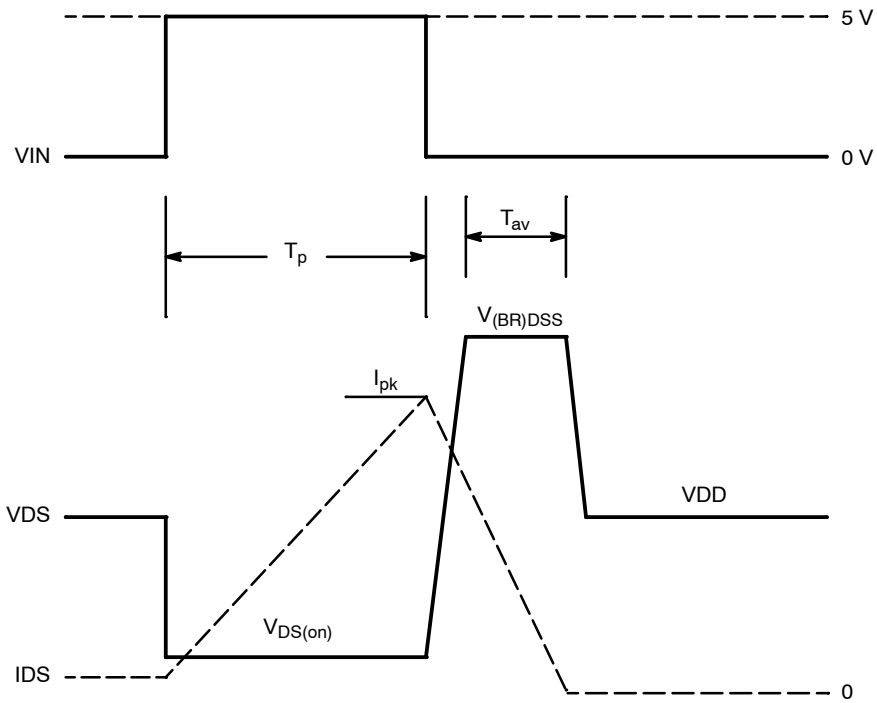
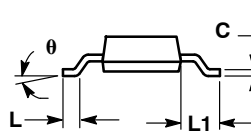
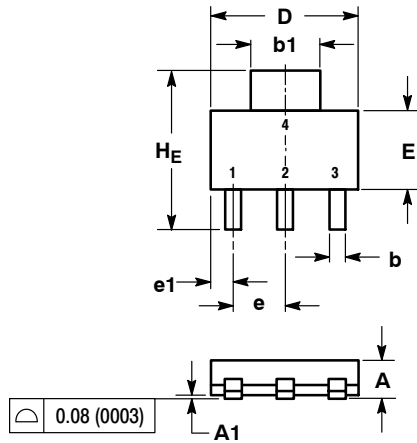


Figure 24. Inductive Load Switching Waveforms

# NCV8402, NCV8402A

## PACKAGE DIMENSIONS

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

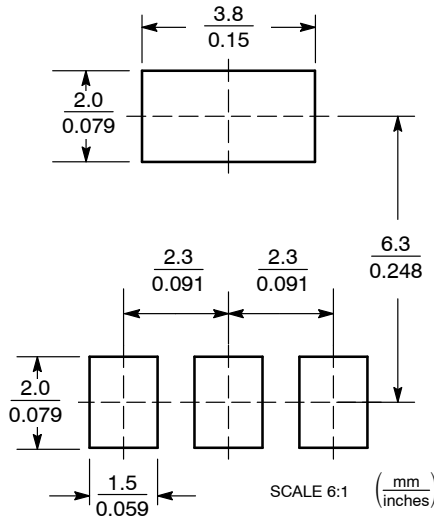


- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.  
2. CONTROLLING DIMENSION: INCH.

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



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