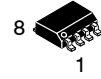


# 3.75 kV<sub>RMS</sub>, 4.5-A/9-A Isolated Single Channel Gate Driver



SOIC-8 NB  
CASE 751-07

## NCV51152

The NCV51152 is a family of isolated single-channel gate driver with 4.5-A/9-A source and sink peak current respectively. They are designed for fast switching to drive power MOSFETs, and SiC MOSFET power switches. The NCV51152 offers short and matched propagation delays. The NCV51152xA provides a split output that controls the rise and fall times individually. The NCV51152xB has its V<sub>CC</sub> UVLO referenced to GND2 to get a true UVLO.

The NCV51152 is available in a 4 mm SOIC-8 package and can support isolation voltage up to 3.75 kV<sub>RMS</sub>.

The NCV51152 offers other important protection function such as independent under-voltage lockout for both-side driver.

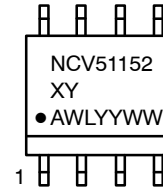
### Features

- Feature Options
  - ◆ Separated Outputs (NCV51152xA)
  - ◆ Wide Bias Voltage Range Including Negative V<sub>EE</sub> and V<sub>CC</sub> UVLO Referenced to GND2 (NCV51152xB)
- 3-V to 20-V Input Supply Voltage
- Output Supply Voltage from 6.5 V to 30 V with 5-V and 8-V for MOSFET, 12-V and 17-V for SiC, Threshold
- 4.5-A Peak Source, 9-A Peak Sink Output Current Capability
- 200 V/ns dV/dt Immunity
- Negative 5-V Handling Capability on Input Pins
- Propagation Delay Typical 36 ns with
  - ◆ 5 ns Max Delay Matching
- Gate Clamping During Short Circuit (NCV51152xA)
- AEC-Q100 Qualified for Automotive Application Requirements
- Isolation & Safety
  - ◆ 3.75 kV<sub>RMS</sub> Isolation for 1 Minute (per UL1577 Requirements) (Planned)
  - ◆ CQC Certification per GB4943.1-2011 (Planned)
  - ◆ SGS FIMO Certification per IEC 62386-1 (Planned)

### Typical Applications

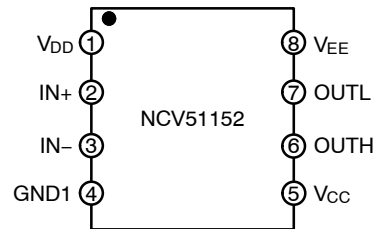
- On-board Chargers
- xEV DC-DC Converters
- Traction Inverters
- Charging Stations

### MARKING DIAGRAM

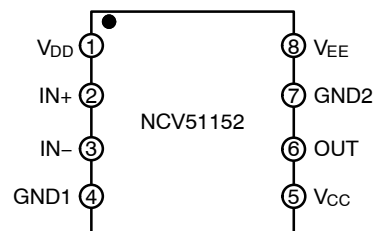


- NCV51152 = Specific Device Code
- X = A or B or C or D for UVLO Option
- Y = A: Split Output, or B: V<sub>EE</sub>\_GND2 for True UVLO
- A = Assembly Location
- WL = Wafer Lot
- YY = Year
- WW = Work Week

### PIN CONNECTIONS



NCV51152xA



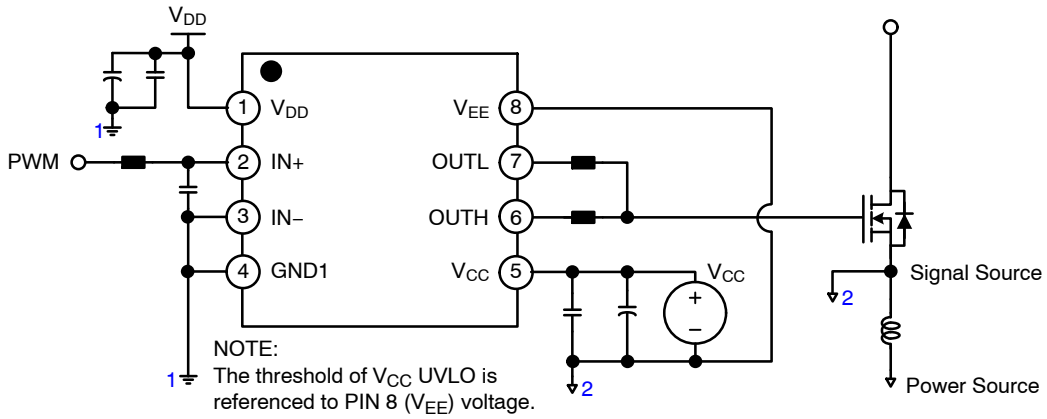
NCV51152xB

### ORDERING INFORMATION

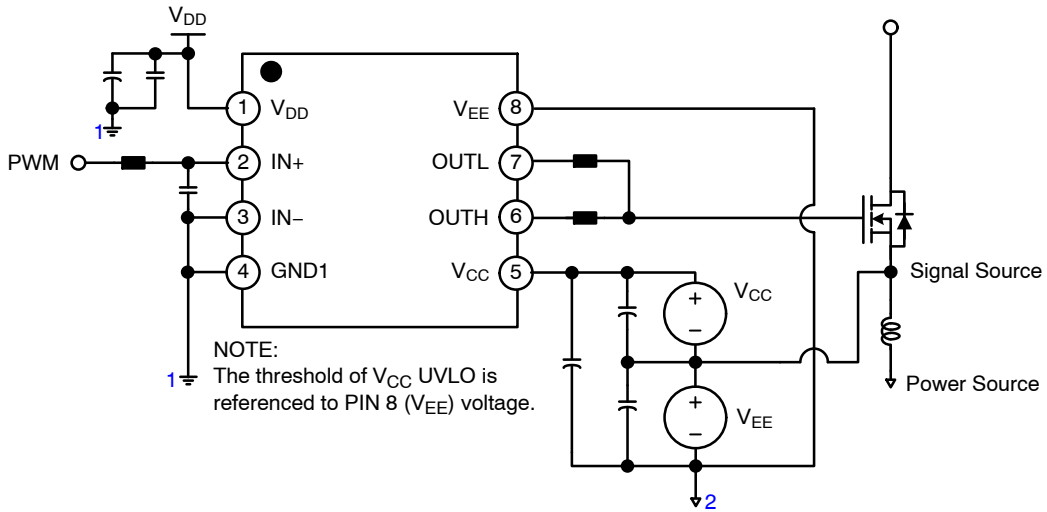
See detailed ordering and shipping information on page 22 of this data sheet.

# NCV51152

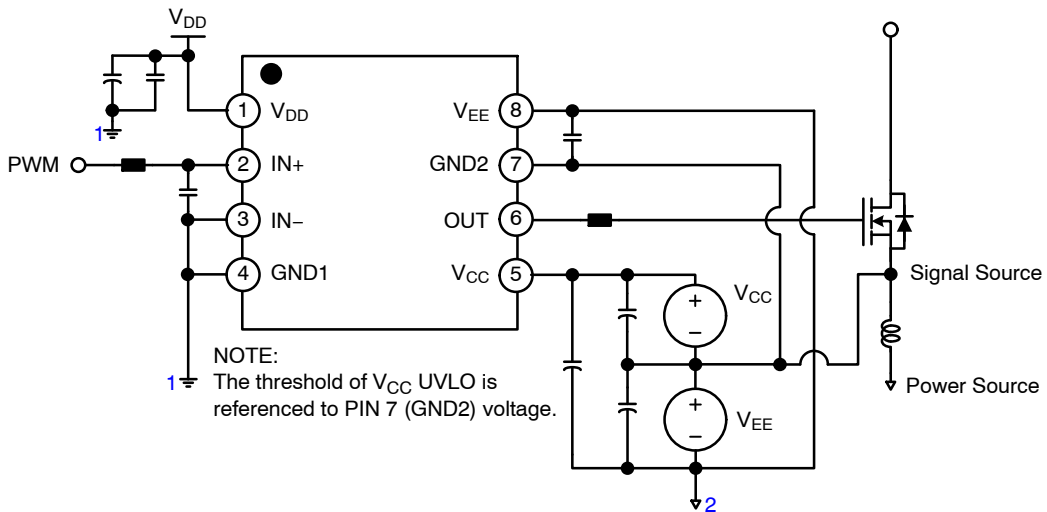
## TYPICAL APPLICATION CIRCUIT



(a) Split Output for variant A



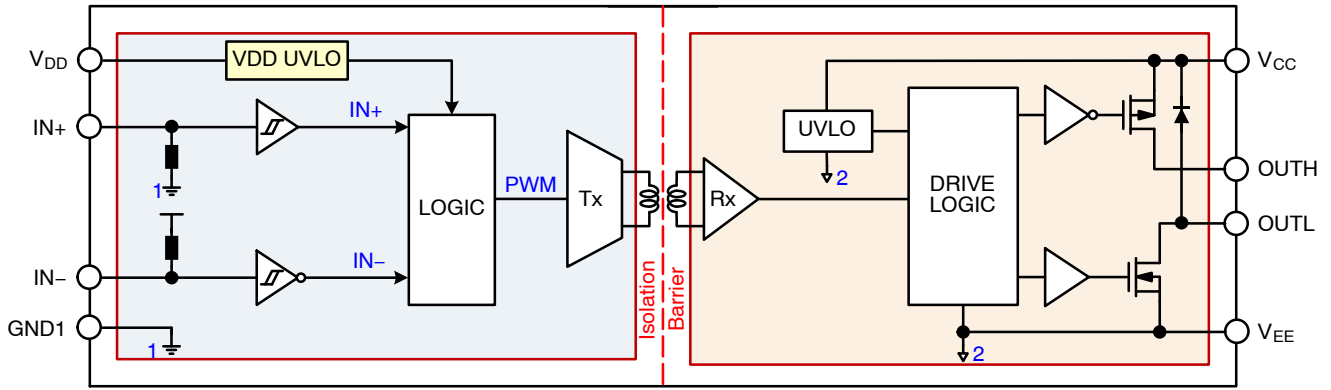
(b) Split Output and external negative bias for variant A



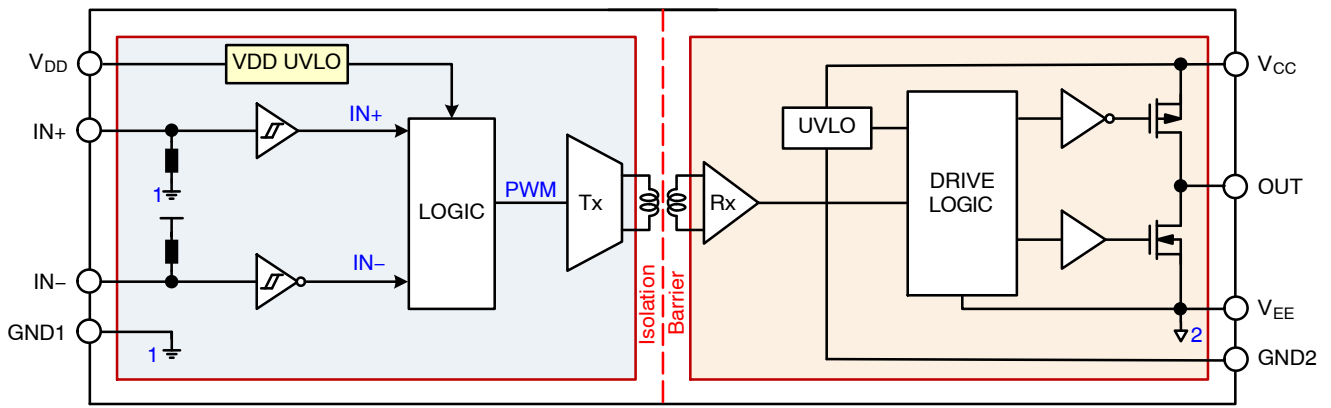
(c) External negative bias for variant B

Figure 1. Typical Application Schematic

FUNCTIONAL BLOCK DIAGRAM



(a) Separated Output (Variant A)



(b) V<sub>CC</sub> UVLO Referenced to GND2 and external negative bias (Variant B)

Figure 2. Simplified Block Diagram

# NCV51152

## PIN CONNECTIONS

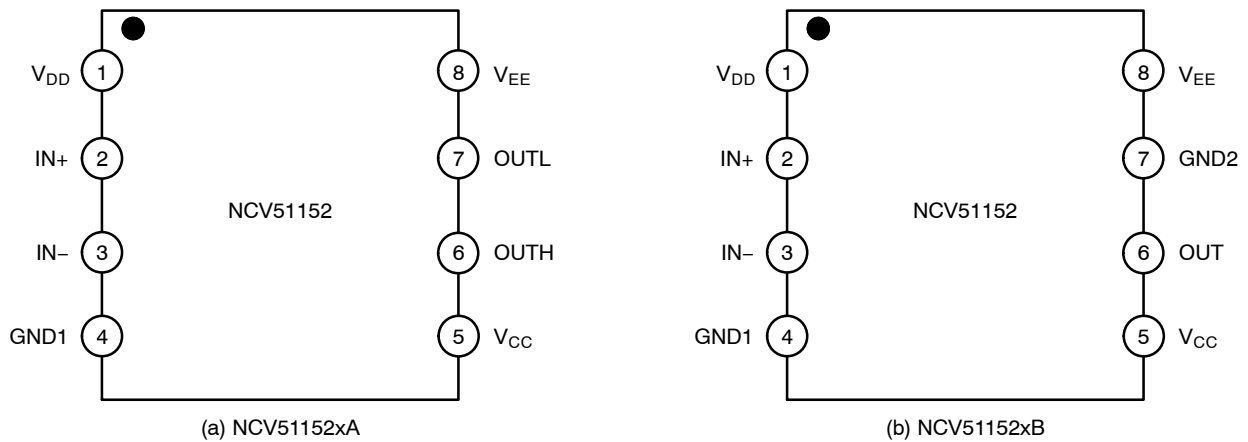


Figure 3. Pin Connections – SOIC-8 NB (Top View)

### PIN DESCRIPTION

Pin Name	Pin No.		I/O	Description
	NCV51152xA	NCV51152xB		
V <sub>DD</sub>	1	1	Power	Input-side Supply Voltage. It is recommended to place a bypass capacitor from V <sub>DD</sub> to GND1.
IN+	2	2	Input	Non-inverting Logic Input with internal pull-down resistor to GND1.
IN-	3	3	Input	Inverting Logic Input with internal pull-up resistor to V <sub>DD</sub> .
GND1	4	4	Power	Ground Input-side. (all signals on input-side are referenced to this ground)
V <sub>CC</sub>	5	5	Power	Positive Output Supply Rail.
OUTH	6	6	Output	Gate Drive Pull-up Output.
OUTL	7	-	Output	Gate Drive Pull-down Output.
GND2	-	7	Power	Gate-drive common pin. Connect this pin to the MOSFET source. V <sub>CC</sub> UVLO with respect to GND2 for variant B.
V <sub>EE</sub>	8	8	Power	Negative output supply rail for variant B, and ground for variant A.

**INSULATION RATINGS**

Symbol	Parameter	Value	Unit
	Installation Classifications per DIN VDE 0110/1.89 Table 1 Rated Mains Voltage	<150 V <sub>RMS</sub>	I-IV
		<300 V <sub>RMS</sub>	I-IV
		<450 V <sub>RMS</sub>	I-IV
		<600 V <sub>RMS</sub>	I-IV
		<1000 V <sub>RMS</sub>	I-III
CTI	Comparative Tracking Index (DIN IEC 112/VDE 0303 Part 1)	600	
	Climatic Classification	40/125/21	
	Pollution Degree (DIN VDE 0110/1.89)	2	
V <sub>PR</sub>	Input-to-Output Test Voltage, Method b, V <sub>IORM</sub> × 1.875 = V <sub>PR</sub> , 100% Production Test with t <sub>m</sub> = 1 s, Partial Discharge < 5 pC	2250	V <sub>PK</sub>
V <sub>IORM</sub>	Maximum Repetitive Peak Isolation Voltage	1200	V <sub>PK</sub>
V <sub>IOWM</sub>	Maximum Working Voltage	870	V <sub>RMS</sub>
V <sub>IOTM</sub>	Maximum Transient Isolation Voltage	6300	V <sub>PK</sub>
E <sub>CR</sub>	External Creepage	4.0	mm
E <sub>CL</sub>	External Clearance	4.0	mm
DTI	Insulation Thickness	17.3	μm
R <sub>IO</sub>	Insulation Resistance at T <sub>S</sub> , V <sub>IO</sub> = 500 V	10 <sup>9</sup>	Ω

**SAFETY LIMITING VALUE**

Symbol	Parameter	Test Condition	Side	Value	Unit
P <sub>S</sub>	Safety Supply Power	R <sub>θJA</sub> = 100°C/W, T <sub>A</sub> = 25°C, T <sub>J</sub> = 150°C	INPUT	0.21	W
			OUTPUT	1.04	W
			TOTAL	1.25	W
T <sub>S</sub>	Safety Temperature			150	°C

**MAXIMUM RATINGS**

Symbol	Parameter	Min	Max	Unit	
V <sub>DD</sub> to GND1	Power Supply Voltage – Input Side (Note 2)	-0.3	25	V	
V <sub>CC</sub> – GND2	Positive Supply Voltage – Driver Side	-0.3	33	V	
VEE – GND2	Negative Supply Voltage for Only B Version	-18	0.3	V	
V <sub>CC</sub> – VEE	Differential Supply Voltage – Driver Side (Note 3)	-0.3	33	V	
OUT to VEE	Driver Output Voltage (Note 3)	V <sub>EE</sub> – 0.3	V <sub>CC</sub> + 0.3	V	
OUT to VEE, Transient for 200 ns (Note 4)		V <sub>EE</sub> – 2	V <sub>CC</sub> + 0.3	V	
IN+, and IN-	Input Signal Voltages (Note 2)	-5	V <sub>DD</sub> + 0.3	V	
T <sub>J</sub>	Junction Temperature	-40	+150	°C	
T <sub>S</sub>	Storage Temperature	-65	+150	°C	
Electrostatic Discharge Capability	HBM (Note 5)	Human Body Model	-	2	kV
	CDM (Note 5)	Charged Device Model	-	1	kV

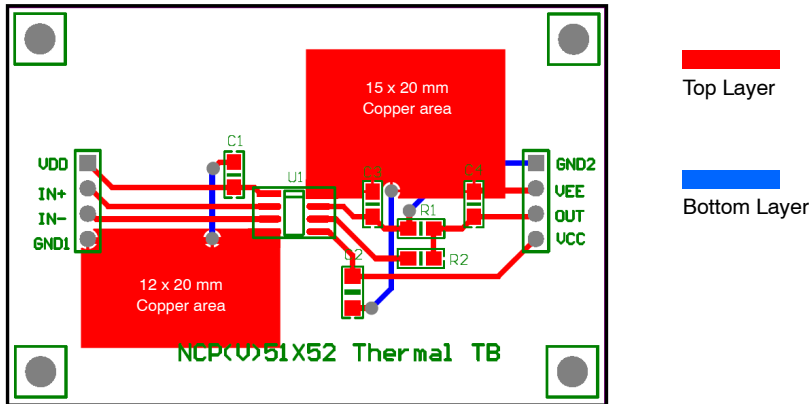
Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for Safe Operating parameters.
2. All voltage values are given with respect to GND1 pin.
3. All voltage values are given with respect to VEE pin.
4. This parameter verified by design and bench test, 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 (EIA/JESD22-A114)  
 ESD Charged Device Model tested per AEC-Q100-011 (EIA/JESD22-C101)  
 Latch up Current Maximum Rating: ≤100 mA per JEDEC standard: JESD78F.

**THERMAL CHARACTERISTICS**

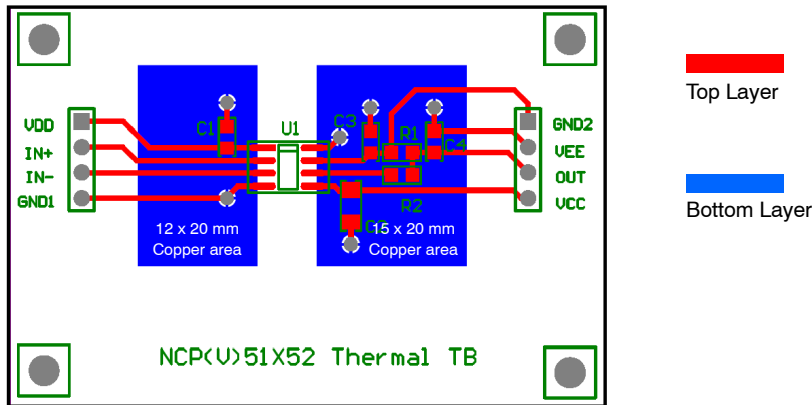
Symbol	Parameter	Min	Max	Unit
$\theta_{JA}$	Secondary Thermal Resistance of Junction–Air (Note 6)	Type–A (Note 7)	100	$^{\circ}\text{C}/\text{W}$
		Type–B (Note 8)	120	
$\Psi_{JT}$	Thermal Characterization Parameter Junction–Case Top	Type–A (Note 7)	8	
		Type–B (Note 8)	8	
$P_D$	Secondary Power Dissipation (Note 6)	Type–A (Note 7)	1.25	W
		Type–B (Note 8)	1.04	

6. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for Safe Operating parameters.
7. As specified for a reference layout shown in Figure 4. The DUT is mounted on a 60 x 40 x 1.6 mm FR4 substrate with an additional heat spreading copper of 240 mm<sup>2</sup>/300 mm<sup>2</sup> (Primary/Secondary). The copper thickness is 1 oz and test conditions is under natural convection or zero air flow.



**Figure 4. Reference Layout for the Type–A**

8. As specified for a reference layout shown in Figure 5. The DUT is mounted on a 60 x 40 x 1.6 mm FR4 substrate with an additional heat spreading copper of 240 mm<sup>2</sup>/300 mm<sup>2</sup> (Primary/Secondary). The copper thickness is 1oz and test conditions is under natural convection or zero air flow.



**Figure 5. Reference Layout for the Type–B**

# NCV51152

## RECOMMENDED OPERATING CONDITIONS

Symbol	Rating	Min	Max	Unit	
V <sub>DD</sub>	Power Supply Voltage – Input Side	3.0	20	V	
V <sub>CC</sub>	Power Supply Voltage – Driver Side (Note 9)	5-V UVLO Version	6.5	30	V
		8-V UVLO Version	9.5	30	V
		12-V UVLO Version	13.5	30	V
		17-V UVLO Version	18.5	30	V
VEE – GND2	Negative Supply Voltage for only Variant B (NCV51152xB)	-15	0	V	
V <sub>IN</sub>	Logic Input Voltage at Pins IN+, and IN-	0	V <sub>DD</sub>	V	
T <sub>A</sub>	Ambient Temperature	-40	+125	°C	
T <sub>J</sub>	Junction Temperature	-40	+125	°C	
CMTI	Common Mode Transient Immunity	200	-	kV/μs	

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

9. All V<sub>CC</sub> UVLO threshold voltages of the variant A and B are given with respect to V<sub>EE</sub> and GND2 pins respectively.

## ISOLATION CHARACTERISTICS

Symbol	Parameter	Condition	Value	Unit
V <sub>ISO, INPUT TO OUTPUT</sub>	Input to Output Isolation Voltage	T <sub>A</sub> = 25°C, Relative Humidity < 50%, t = 1.0 minute, I <sub>I-O</sub> < 30 μA, 50 Hz (Note 10,11,12)	3750	V <sub>RMS</sub>
R <sub>ISO</sub>	Isolation Resistance	V <sub>I-O</sub> = 500 V (Note 10)	10 <sup>11</sup>	Ω

10. Device is considered a two-terminal device; pins 1 to 4 are shorted together and pins 5 to 8 are shorted together.

11. 3,750 V<sub>RMS</sub> for 1-minute duration is equivalent to 4,500 V<sub>RMS</sub> for 1-second duration for input to output isolation test, and Impulse Test > 10 ms; sample tested for between channel isolation test.

12. The input-output isolation voltage is a dielectric voltage rating per UL1577. It should not be regarded as an input-output continuous voltage rating. For the continuous working voltage rating, refer to equipment-level safety specification or DIN VDE V 0884-11 Safety and Insulation Ratings Table.

# NCV51152

**ELECTRICAL CHARACTERISTICS** ( $V_{DD} = 5\text{ V}$ ,  $V_{CC} = 15\text{ V}$ , or  $20\text{ V}$  ( $V_{EE} = 0\text{ V}$  for NCV51151xB) (Note 15) for typical values  $T_J = T_A = 25^\circ\text{C}$ , for min/max values  $T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise specified. (Note 15))

Symbol	Parameter	Condition	Min	Typ	Max	Unit
<b>PRIMARY POWER SUPPLY SECTION (VDD)</b>						
$I_{QVDD}$	V <sub>DD</sub> Quiescent Current	$V_{IN+} = V_{IN-} = 0\text{ V}$ , $V_{DD} = 5\text{ V}$	500	715	1000	$\mu\text{A}$
		$V_{IN+} = V_{IN-} = 0\text{ V}$ , $V_{DD} = 15\text{ V}$	600	870	1100	$\mu\text{A}$
		$V_{IN+} = V_{IN-} = V_{DD}$ , $V_{DD} = 5\text{ V}$	500	720	1000	$\mu\text{A}$
		$V_{IN+} = V_{IN-} = V_{DD}$ , $V_{DD} = 15\text{ V}$	600	870	1100	$\mu\text{A}$
$I_{VDD}$	V <sub>DD</sub> Operating Current	$V_{IN+} = V_{DD}$ , $V_{IN-} = 0\text{ V}$ , $V_{DD} = 5\text{ V}$	4.5	6.4	8.0	mA
		$V_{IN+} = V_{DD}$ , $V_{IN-} = 0\text{ V}$ , $V_{DD} = 15\text{ V}$	5.0	6.6	8.4	mA
		$f_{IN+} = 500\text{ kHz}$ , $C_{OUT} = 200\text{ pF}$ , $V_{DD} = 5\text{ V}$	2.9	3.9	5.0	mA
		$f_{IN+} = 500\text{ kHz}$ , $C_{OUT} = 200\text{ pF}$ , $V_{DD} = 15\text{ V}$	3.0	4.1	5.2	mA
$V_{DDUV+}$	V <sub>DD</sub> Supply Under-Voltage Positive-Going Threshold	$V_{DD} = \text{Sweep}$	2.7	2.8	2.9	V
$V_{DDUV-}$	V <sub>DD</sub> Supply Under-Voltage Negative-Going Threshold	$V_{DD} = \text{Sweep}$	2.6	2.7	2.8	V
$V_{DDHYS}$	V <sub>DD</sub> Supply Under-Voltage Lockout Hysteresis	$V_{DD} = \text{Sweep}$	-	0.1	-	V
$t_{VDDUV}$	Debounce Time (Note 16)		-	-	10	$\mu\text{s}$

## SECONDARY POWER SUPPLY SECTION

$I_{QVCC}$	V <sub>CC</sub> Quiescent Current	$V_{IN+} = V_{IN-} = 0\text{ V}$ or $5\text{ V}$ , No Load	200	385	700	$\mu\text{A}$
		$V_{IN+} = 5\text{ V}$ , $V_{IN-} = 0\text{ V}$ , No Load	200	507	800	$\mu\text{A}$
$I_{VCC}$	V <sub>CC</sub> Operating Current	$f_{IN+} = 500\text{ kHz}$ , $C_{OUT} = 200\text{ pF}$ , $V_{CC} = 15\text{ V}$	3.0	4.2	5.0	mA
		$f_{IN+} = 500\text{ kHz}$ , $C_{OUT} = 200\text{ pF}$ , $V_{CC} = 20\text{ V}$	3.7	5.2	6.2	mA

## VCC UVLO THRESHOLD (6-V UVLO VERSION)

$V_{CCUV+}$	V <sub>CC</sub> Supply Under-Voltage Positive-Going Threshold (Note 13)		5.7	6.0	6.4	V
$V_{CCUV-}$	V <sub>CC</sub> Supply Under-Voltage Negative-Going Threshold		5.3	5.7	6.0	V
$V_{CCHYS}$	Under-Voltage Lockout Hysteresis		-	0.3	-	V
$t_{VCCUV}$	UVLO Filter Debounce Time (Note 16)		-	-	10	$\mu\text{s}$

## VCC UVLO THRESHOLD (8-V UVLO VERSION)

$V_{CCUV+}$	V <sub>CC</sub> Supply Under-Voltage Positive-Going Threshold (Note 13)		8.2	8.7	9.2	V
$V_{CCUV-}$	V <sub>CC</sub> Supply Under-Voltage Negative-Going Threshold		7.7	8.2	8.7	V
$V_{CCHYS}$	Under-Voltage Lockout Hysteresis		-	0.5	-	V
$t_{VCCUV}$	UVLO Filter Debounce Time (Note 16)		-	-	10	$\mu\text{s}$

## VCC UVLO THRESHOLD (12-V UVLO VERSION)

$V_{CCUV+}$	V <sub>CC</sub> Supply Under-Voltage Positive-Going Threshold (Note 13)		11	12	13	V
$V_{CCUV-}$	V <sub>CC</sub> Supply Under-Voltage Negative-Going Threshold		10	11	12	V
$V_{CCHYS}$	Under-Voltage Lockout Hysteresis		-	1.0	-	V
$t_{VCCUV}$	UVLO Filter Debounce Time (Note 16)		-	-	10	$\mu\text{s}$



# NCV51152

**ELECTRICAL CHARACTERISTICS** ( $V_{DD} = 5\text{ V}$ ,  $V_{CC} = 15\text{ V}$ , or  $20\text{ V}$  ( $V_{EE} = 0\text{ V}$  for NCV51151xB) (Note 15) for typical values  $T_J = T_A = 25^\circ\text{C}$ , for min/max values  $T_J = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ , unless otherwise specified. (Note 15)) (continued)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
<b>VCC UVLO THRESHOLD (17-V UVLO VERSION)</b>						
$V_{CCUV+}$	$V_{CC}$ Supply Under-Voltage Positive-Going Threshold (Note 13)		16	17	18	V
$V_{CCUV-}$	$V_{CC}$ Supply Under-Voltage Negative-Going Threshold		15	16	17	V
$V_{CCHYS}$	Under-Voltage Lockout Hysteresis		–	1.0	–	V
$t_{VCCUV}$	UVLO Filter Debounce Time (Note 16)		–	–	10	$\mu\text{s}$

## LOGIC INPUT SECTION (IN+, AND IN-)

$V_{INH}$	High Level Input Voltage		1.4	1.63	2.0	V
$V_{INL}$	Low Level Input Voltage		0.8	1.08	1.4	V
$V_{INHYS}$	Input Logic Hysteresis		–	0.55	–	V
$I_{IN+H}$	High Level Logic Input Bias Current at IN+	$V_{IN+} = 5\text{ V}$	33	40	52	$\mu\text{A}$
$I_{IN+L}$	Low Level Logic Input Bias Current at IN+	$V_{IN+} = \text{GND1}$	–	–	1.0	$\mu\text{A}$
$I_{IN-H}$	High Level Logic Input Bias Current at IN-	$V_{IN-} = 5\text{ V}$	-1.0	–	–	$\mu\text{A}$
$I_{IN-L}$	Low Level Logic Input Bias Current at IN-	$V_{IN-} = \text{GND1}$	-52	-40	-33	$\mu\text{A}$
$R_{IN}$	Logic Input Pull-Up/Down Resistance		95	125	155	k $\Omega$

## SHORT CIRCUIT SECTION

$V_{CLP-OUT}$	Clamping Voltage, Sourcing ( $V_{OUTH} - V_{CC}$ or $V_{OUT} - V_{CC}$ )	$I_{N+} = \text{High}$ , $I_{N-} = \text{Low}$ , $t_{CLAMP} = 10\ \mu\text{s}$ $I_{OUTH}$ or $I_{OUT} = 500\ \text{mA}$	–	0.7	1.75	V
	Clamping Voltage, Sinking ( $V_{EE} - V_{OUTL}$ or $V_{EE} - V_{OUT}$ )	$I_{N+} = \text{Low}$ , $I_{N-} = \text{High}$ , $t_{CLAMP} = 10\ \mu\text{s}$ $I_{OUTH}$ or $I_{OUT} = -500\ \text{mA}$	–	0.24	0.5	V

## GATE DRIVE SECTION

$I_{OUT+}$	Source Peak Current (Note 16)	$V_{IN+} = 5\text{ V}$ , $PW \leq 5\ \mu\text{s}$	2.6	4.5	–	A
$I_{OUT-}$	Sink Peak Current (Note 16)	$V_{IN+} = 0\text{ V}$ , $PW \leq 5\ \mu\text{s}$	7.0	9.0	–	A
$R_{OH}$	Output Resistance at High State	$I_{OUTH} = 100\ \text{mA}$	–	1.4	2.8	$\Omega$
$R_{OL}$	Output Resistance at Low State	$I_{OUTL} = 100\ \text{mA}$	–	0.5	1.0	$\Omega$
$V_{OH}$	High Level Output Voltage ( $V_{CC} - V_{OUT}$ )	$I_{OUTH} = 100\ \text{mA}$	–	140	280	mV
$V_{OL}$	Low Level Output Voltage ( $V_{OUT} - V_{EE}$ )	$I_{OUTL} = 100\ \text{mA}$	–	50	100	mV

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.

13. All  $V_{CC}$  UVLO threshold voltages are given with respect to GND2 pin.

14. Performance guaranteed over the indicated operating temperature range by design and/or characterization tested at  $T_J = T_A = 25^\circ\text{C}$ .

15.  $V_{CC} = 15\text{ V}$  is used for the test condition of 5-V, and 8-V UVLO,  $V_{CC} = 20\text{ V}$  is used for 12-V and 17-V UVLO.

16. These parameters verified by bench test only and not tested in production

## DYNAMIC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Condition	Min	Typ	Max	Unit
$t_{PDON}$	Turn-On Propagation Delay from IN to OUT	$C_{LOAD} = 0\ \text{nF}$	20	36	55	ns
$t_{PDOFF}$	Turn-Off Propagation Delay from IN to OUT		20	36	55	ns
$t_{PWD}$	Pulse Width Distortion ( $t_{PDON} - t_{PDOFF}$ )		-5	–	5	ns
$t_{SK(PP)}$	Propagation Part-to-part Skew (Note 17)		-20	–	20	ns
$t_{VPOR\ to\ OUT}$	Power-up Delay from the $V_{POR}$ to Output (Note 17)	See the Figure 47	–	18	–	$\mu\text{s}$
$t_R$	Turn-On Rise Time	$C_{LOAD} = 1.8\ \text{nF}$	–	12	22	ns
$t_F$	Turn-Off Fall Time	$C_{LOAD} = 1.8\ \text{nF}$	–	8.3	22	ns
$t_{PW}$	Minimum Input Pulse Width that Change Output State	$C_{LOAD} = 0\ \text{nF}$	–	15	35	ns

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.

17. These parameters verified by bench test only and not tested in production

INSULATION CHARACTERISTICS CURVES

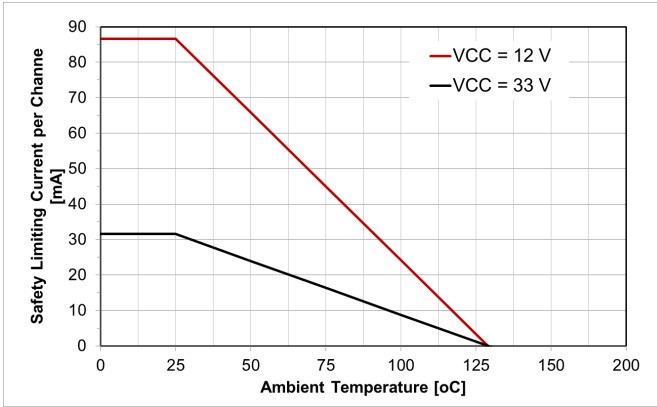


Figure 6. Thermal Derating Curve for Safety-related Limiting Current ( $\theta_{JA} = 100^{\circ}\text{C/W}$ ) (Note 7)

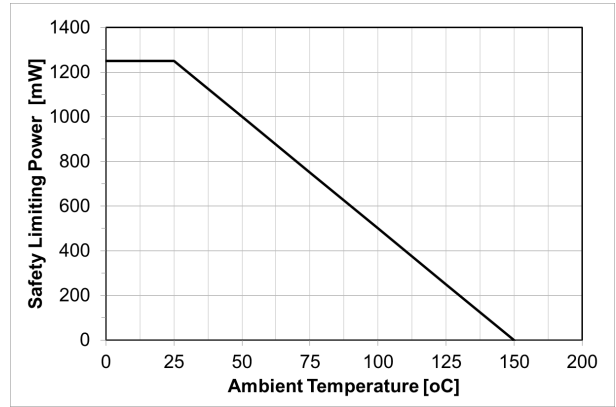


Figure 7. Thermal Derating Curve for Safety-related Limiting Power ( $\theta_{JA} = 100^{\circ}\text{C/W}$ ) (Note 7)

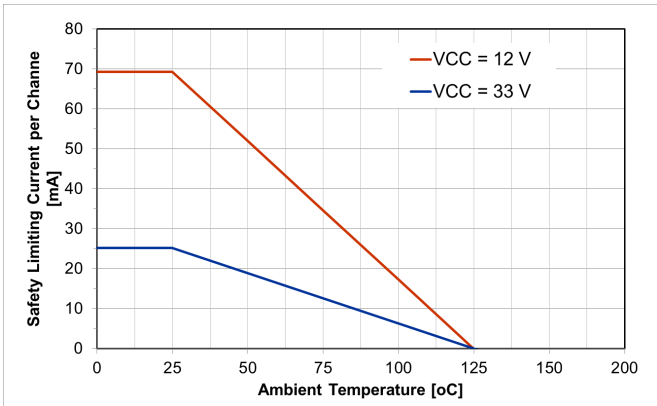


Figure 8. Thermal Derating Curve for Safety-related Limiting Current ( $\theta_{JA} = 120^{\circ}\text{C/W}$ ) (Note 8)

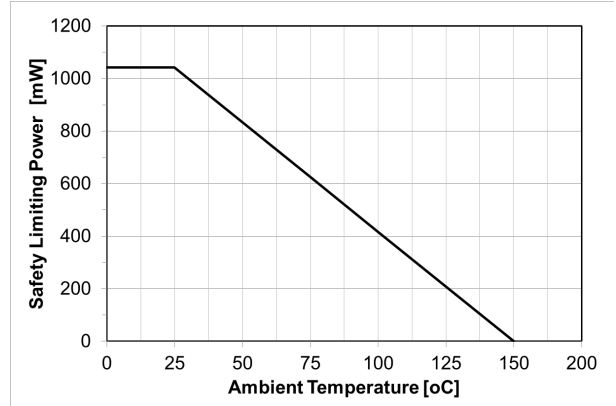


Figure 9. Thermal Derating Curve for Safety-related Limiting Power ( $\theta_{JA} = 120^{\circ}\text{C/W}$ ) (Note 8)

TYPICAL CHARACTERISTICS

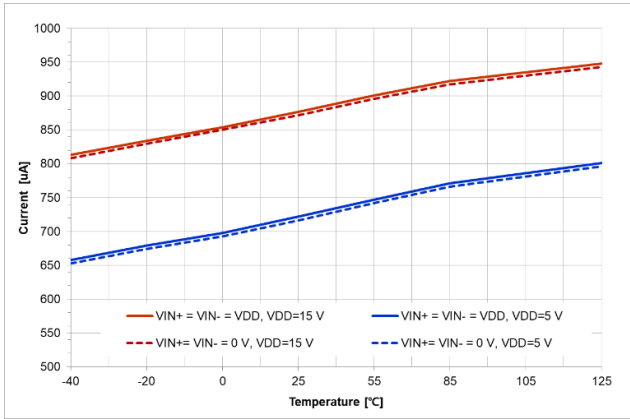


Figure 10.  $V_{DD}$  Quiescent Current vs. Temperature

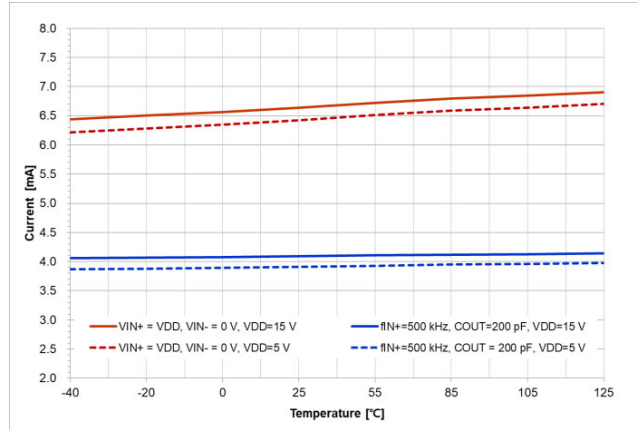


Figure 11.  $V_{DD}$  Quiescent Current vs. Temperature

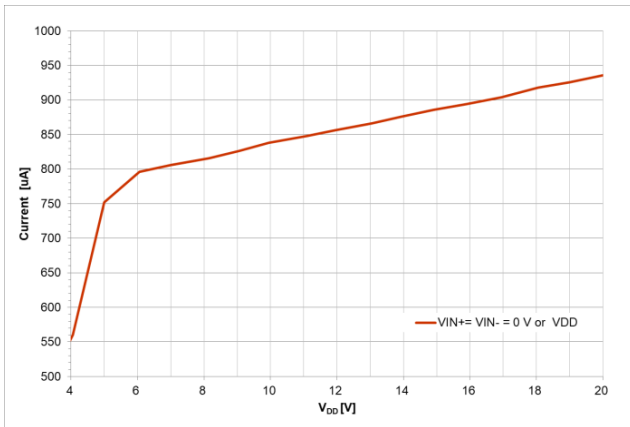


Figure 12.  $V_{DD}$  Quiescent Current vs.  $V_{DD}$

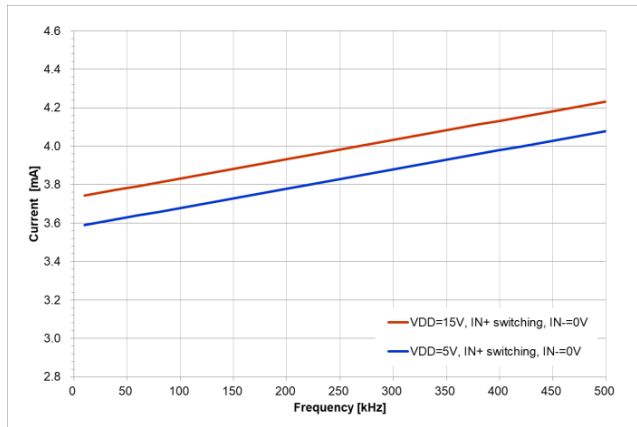


Figure 13.  $V_{DD}$  Operating Current vs. Switching Frequency

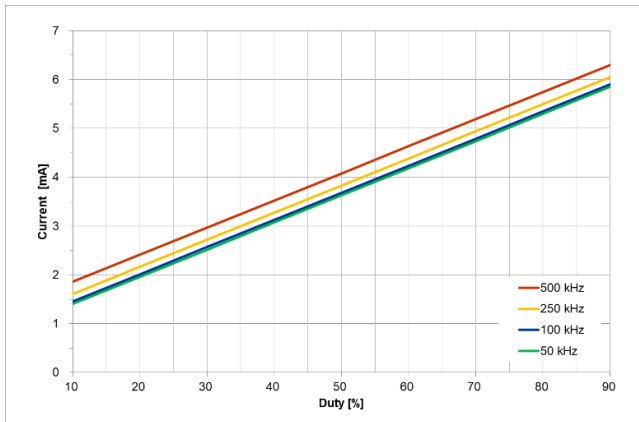


Figure 14.  $V_{DD}$  Operating Current vs. Duty ( $V_{DD} = 5\text{ V}$ ,  $IN+$  Switching with Different Frequency,  $IN- = 0\text{ V}$ )

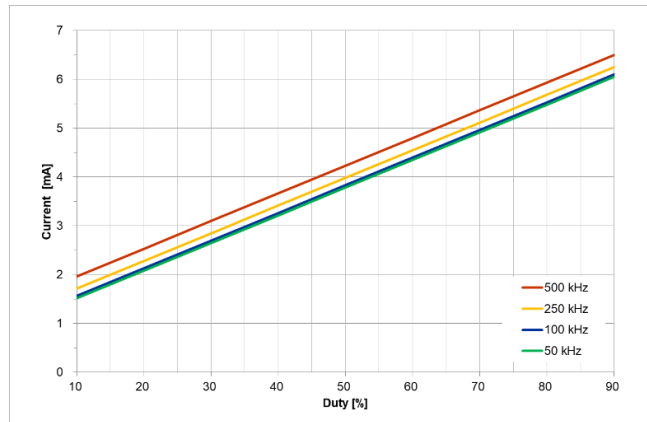


Figure 15.  $V_{DD}$  Operating Current vs. Duty ( $V_{DD} = 15\text{ V}$ ,  $IN+$  Switching with Different Frequency,  $IN- = 0\text{ V}$ )

TYPICAL CHARACTERISTICS (CONTINUED)

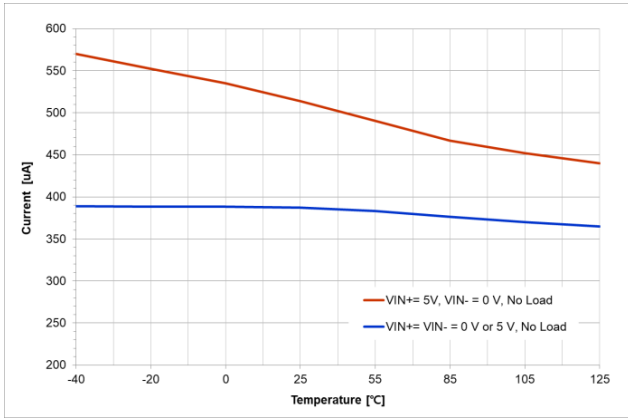


Figure 16. Quiescent  $V_{CC}$  Supply Current vs. Temperature

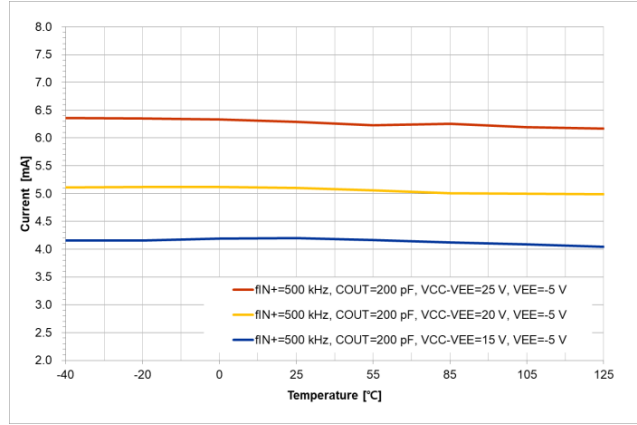


Figure 17.  $V_{CC}$  Operating Current vs. Temperature

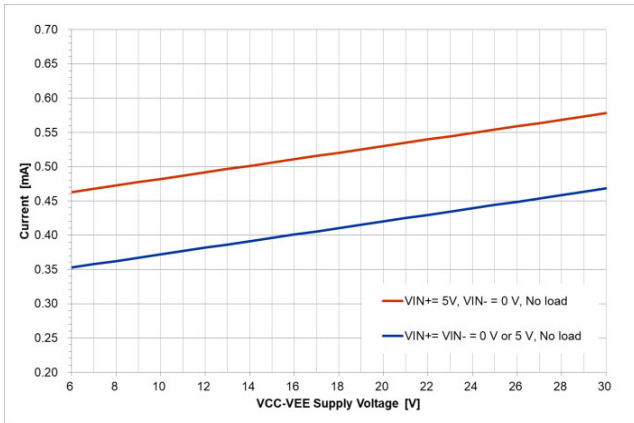


Figure 18. Quiescent  $V_{CC}$  Supply Current vs.  $V_{CC}$  Supply Voltage

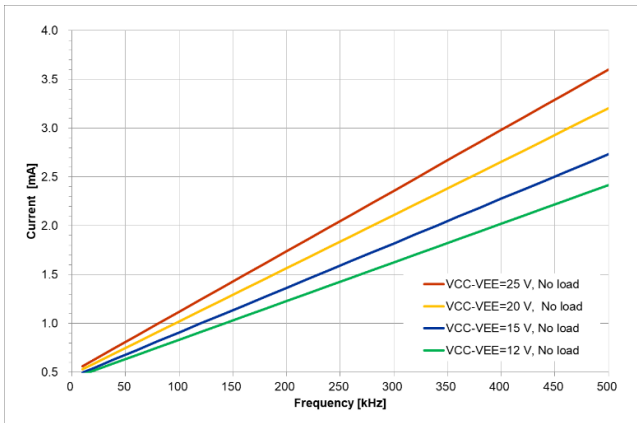


Figure 19.  $V_{CC}$  Operating Current vs. Switching Frequency ( $V_{CC} - V_{EE} = 12/15/20/25$  V and No Load)

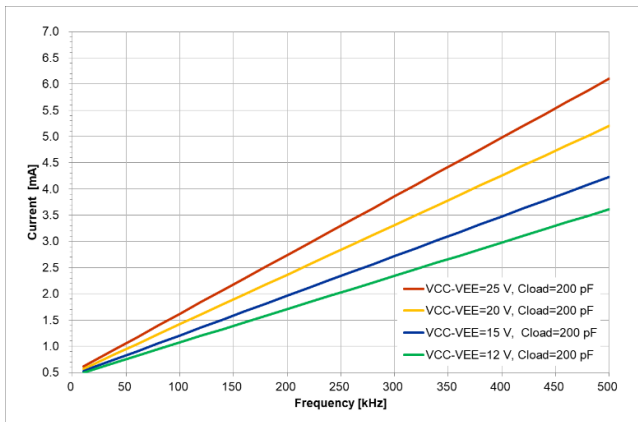


Figure 20.  $V_{CC}$  Operating Current vs. Switching Frequency ( $V_{CC} - V_{EE} = 12/15/20/25$  V and  $C_{LOAD} = 200$  pF)

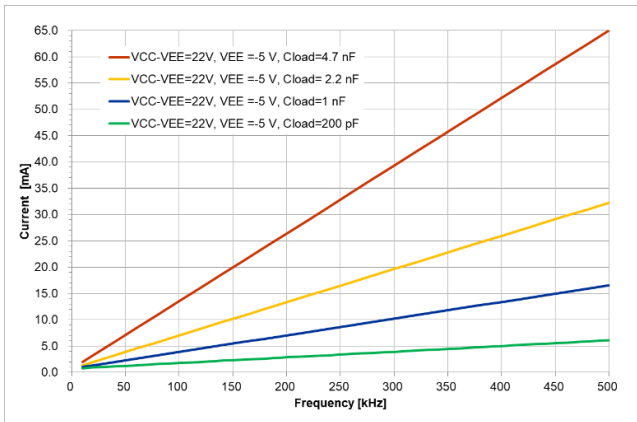


Figure 21.  $V_{CC}$  Operating Current vs. Switching Frequency ( $V_{CC} - V_{EE} = 20$  V and Different  $C_{LOAD}$ )

TYPICAL CHARACTERISTICS (CONTINUED)

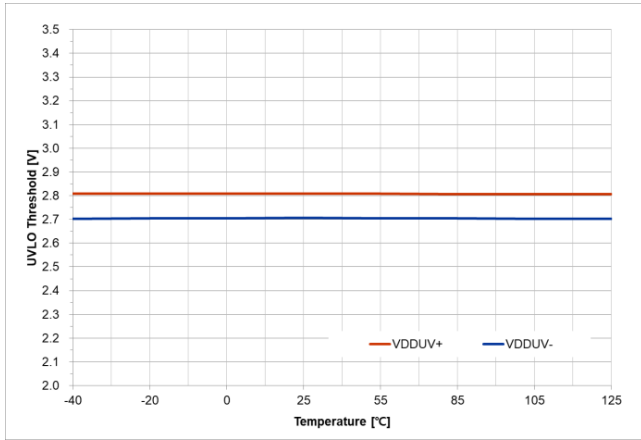


Figure 22.  $V_{DD}$  UVLO vs. Temperature

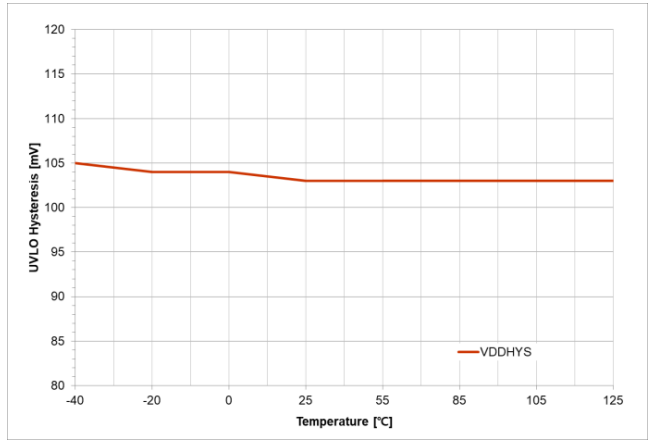


Figure 23.  $V_{DD}$  UVLO Hysteresis vs. Temperature

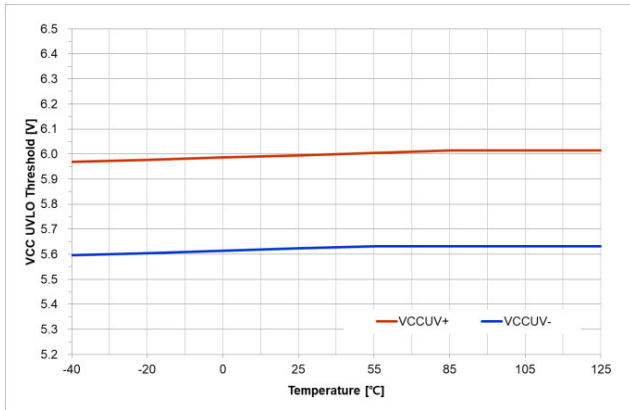


Figure 24.  $V_{CC}$  6-V UVLO Threshold vs. Temperature

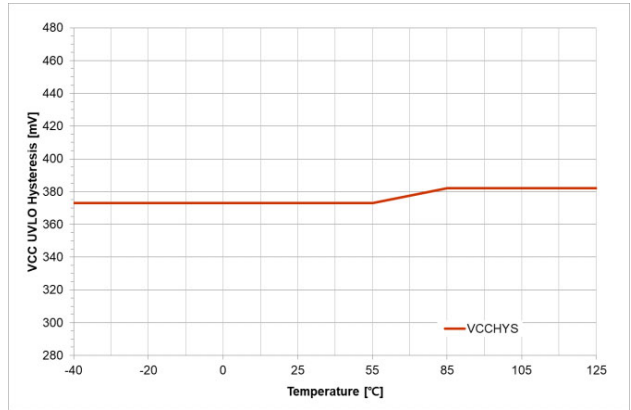


Figure 25.  $V_{DD}$  6-V UVLO Hysteresis vs. Temperature

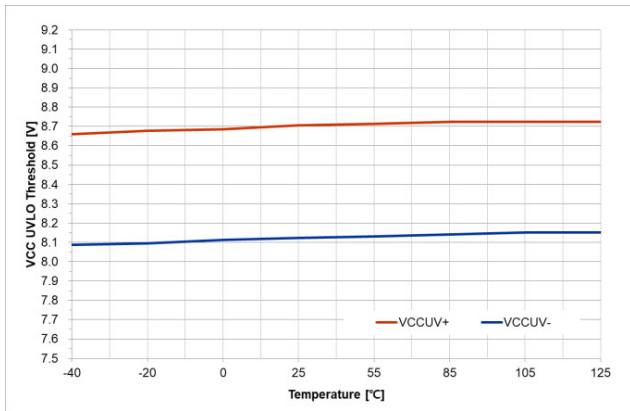


Figure 26.  $V_{CC}$  8-V UVLO Threshold vs. Temperature

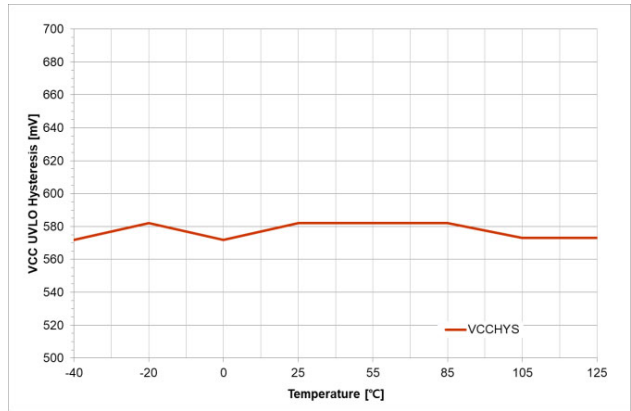


Figure 27.  $V_{DD}$  8-V UVLO Hysteresis vs. Temperature

TYPICAL CHARACTERISTICS (CONTINUED)

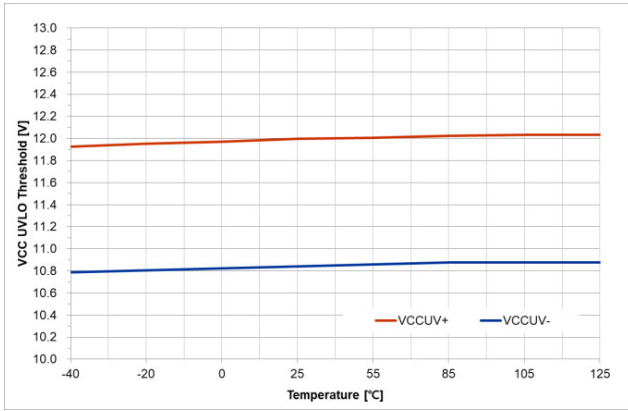


Figure 28. V<sub>CC</sub> 12-V UVLO Threshold vs. Temperature

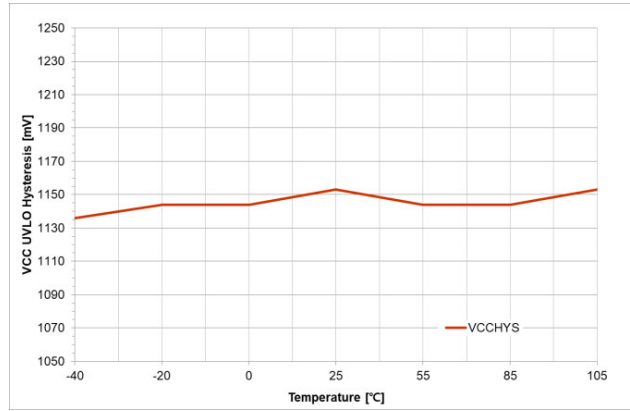


Figure 29. V<sub>CC</sub> 12-V UVLO Hysteresis vs. Temperature

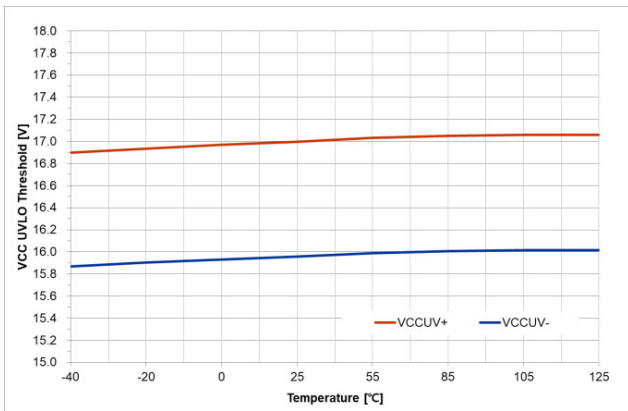


Figure 30. V<sub>CC</sub> 17-V UVLO Threshold vs. Temperature

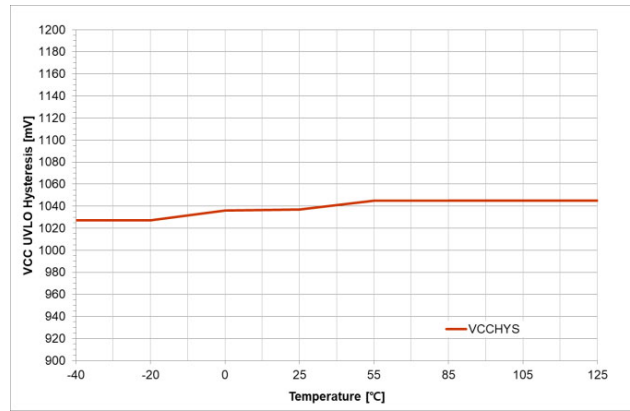


Figure 31. V<sub>CC</sub> 17-V UVLO Hysteresis vs. Temperature

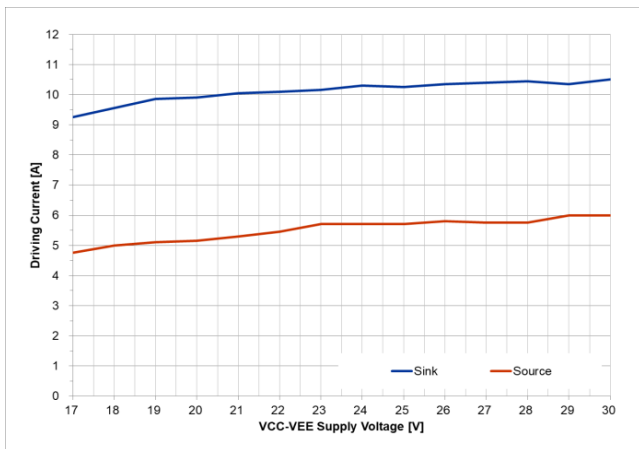


Figure 32. Figure 32. Output Current vs. V<sub>CC</sub> Supply Voltage

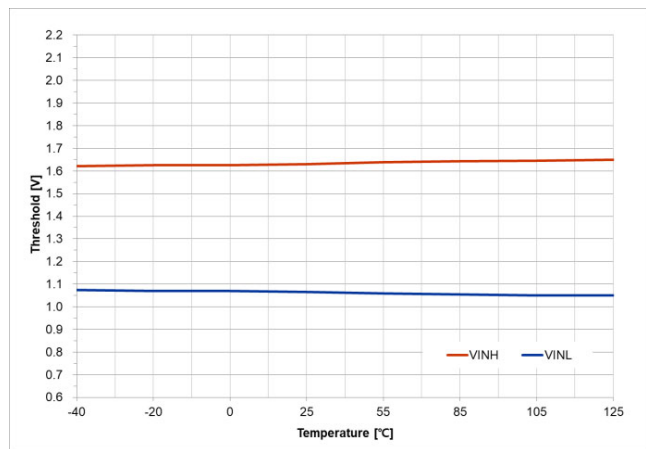


Figure 33. Input Logic Threshold vs. Temperature

TYPICAL CHARACTERISTICS (CONTINUED)

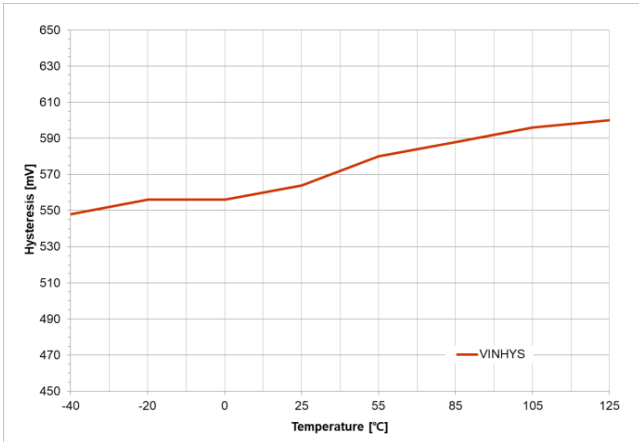


Figure 34. Input Logic Hysteresis vs. Temperature

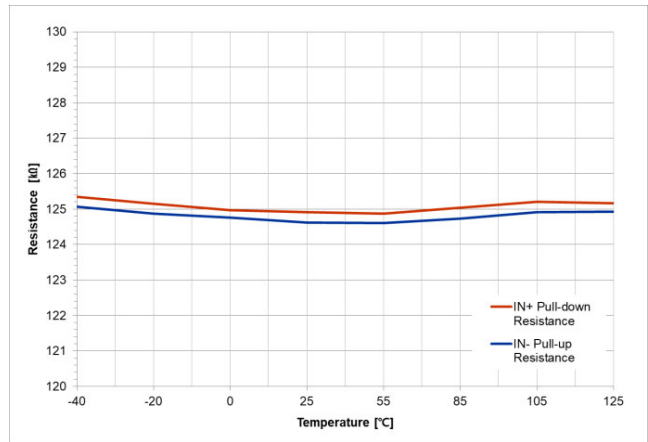


Figure 35. Logic Input Pull-Up/Down Resistance vs. Temperature

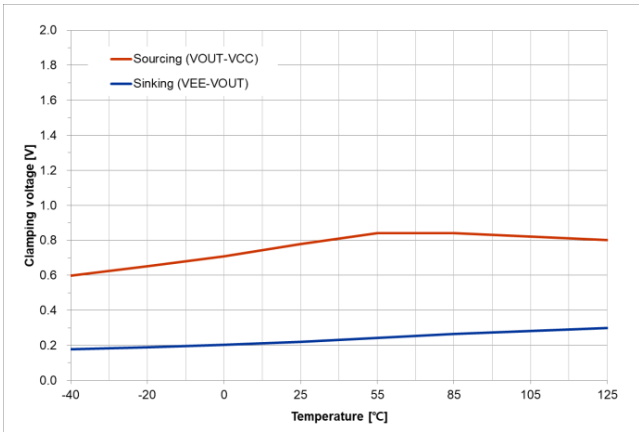


Figure 36. Clamping Voltage vs. Temperature

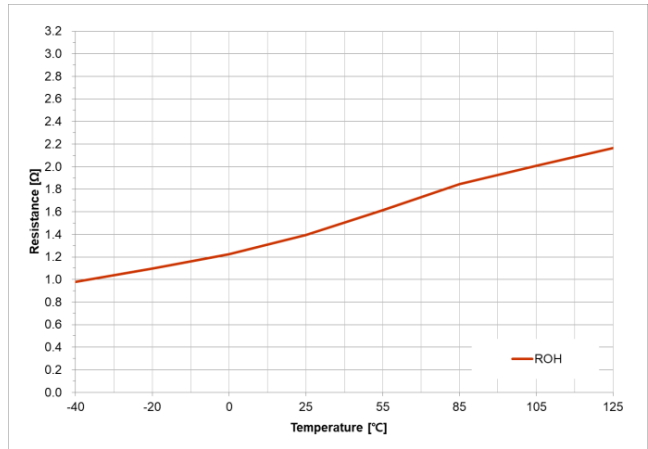


Figure 37. Output Resistance at High State vs. Temperature

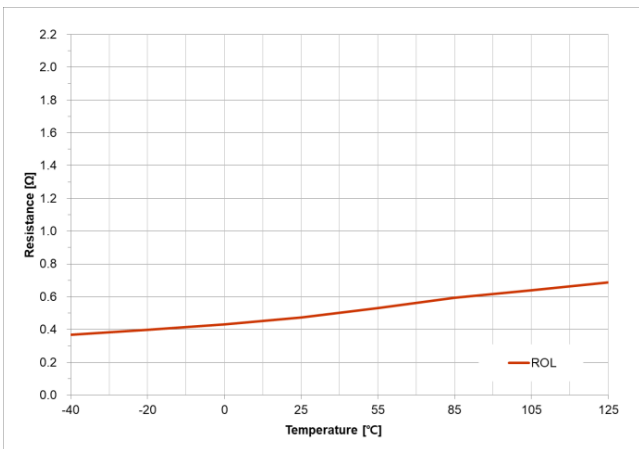


Figure 38. Output Resistance at Low State vs. Temperature

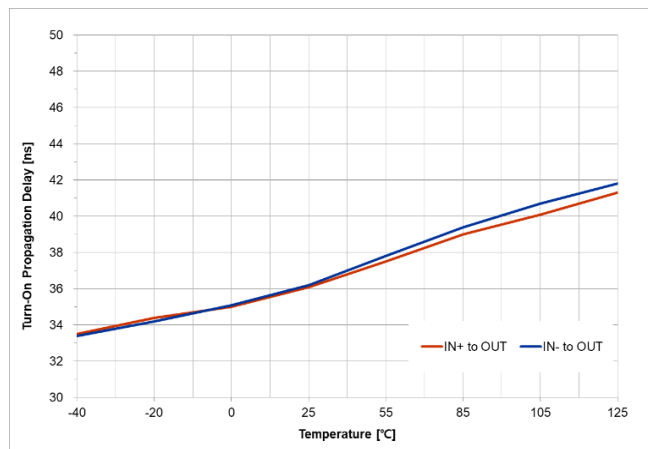


Figure 39. Turn-on Propagation Delay vs. Temperature ( $C_{LOAD} = 0 \text{ nF}$ )

TYPICAL CHARACTERISTICS (CONTINUED)

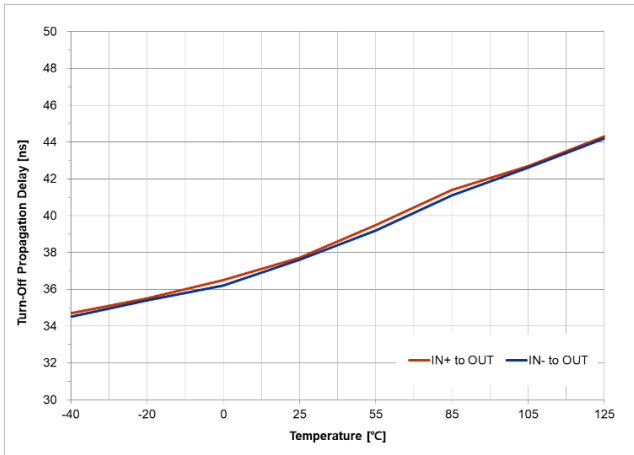


Figure 40. Turn-off Propagation Delay vs. Temperature ( $C_{LOAD} = 0$  nF)

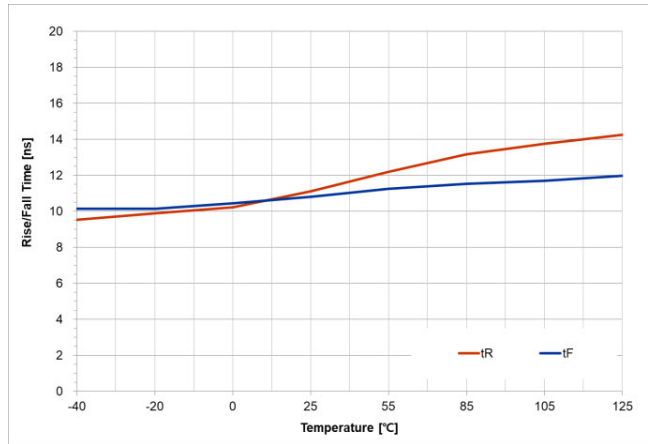


Figure 41. Rise/Fall Time vs. Temperature ( $C_{LOAD} = 1.8$  nF)

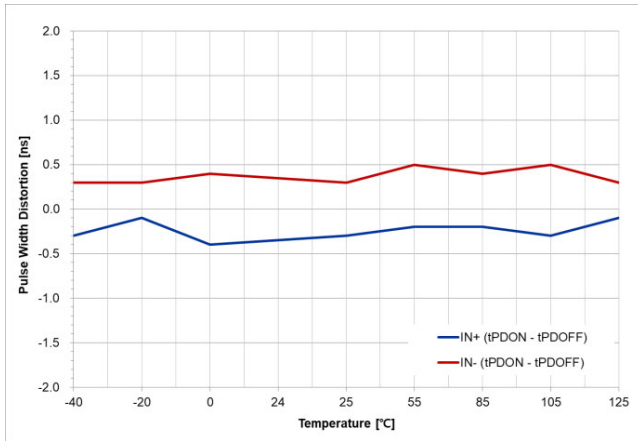


Figure 42. Pulse Width Distortion vs. Temperature ( $C_{LOAD} = 0$  nF)

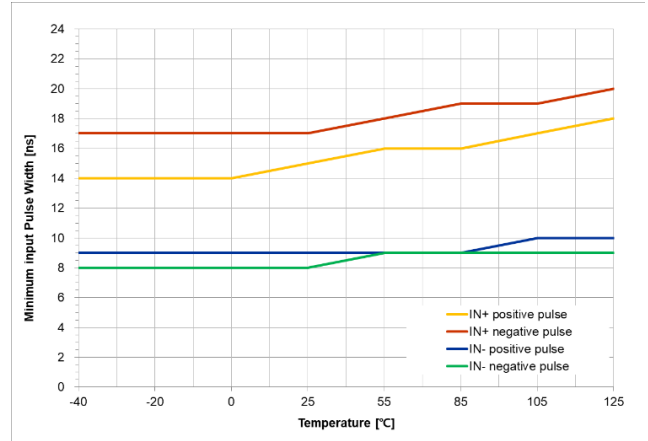


Figure 43. Minimum Input Pulse Width vs. Temperature

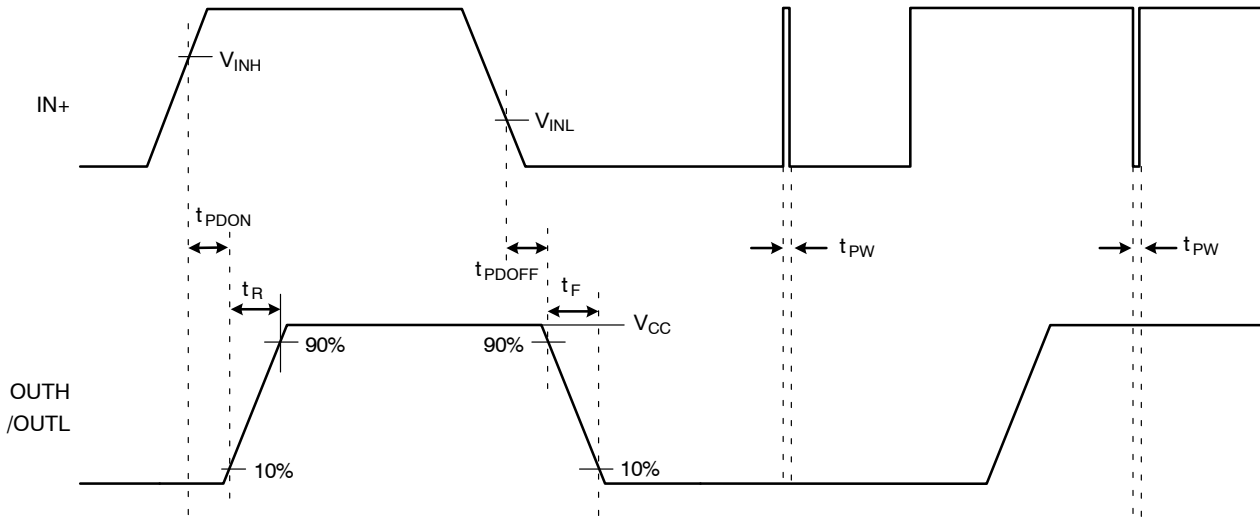


**PARAMETER MEASUREMENT DEFINITION**

**Switching Time Definitions**

Figure 44 shows the switching time waveforms definitions of the turn-on ( $t_{PDON}$ ) and turn-off ( $t_{PDOFF}$ )

propagation delay times among the driver's input signal IN+ and output signal OUT. The typical values of the propagation delay ( $t_{PDON}$ ,  $t_{PDOFF}$ ), pulse width distortion ( $t_{PWD}$ ) and delay matching between channels times are specified in the electrical characteristics table.

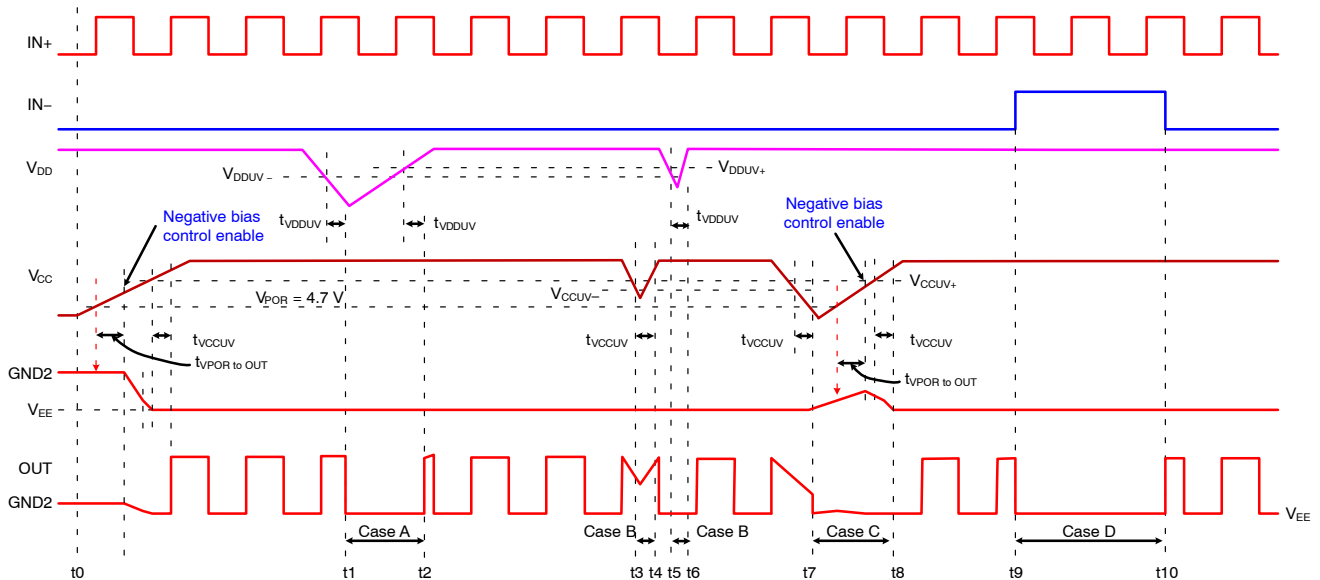


**Figure 44. Switching Time Definition**

**Input to Output Operation Definitions**

The NCV51152 provides important protection functions such as independent under-voltage lockout for gate driver. Figure 45 shows an overall input to output timing diagram. Under-Voltage Lockout protection on the primary- and

secondary-sides power supplies events in the *CASE-A, B and C* and the gate driver output (OUT) is immediately turn-off when two input signal (IN+ and IN-) are HIGH at same time in the *CASE-D*.



**Figure 45. Overall Operating Waveforms Definitions**

**PROTECTION FUNCTION**

The NCV51152 provides the protection features include Under-Voltage Lockout (UVLO) of power supplies on primary-side ( $V_{DD}$ ), and secondary-side ( $V_{CC}$ ).

**Under-Voltage Lockout Protection  $V_{DD}$  and  $V_{CC}$**

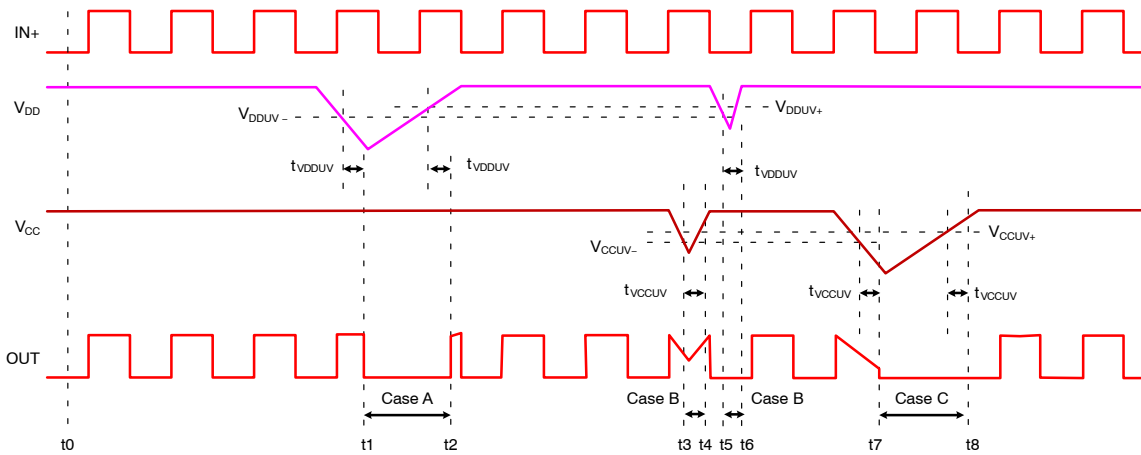
The NCV51152 provides the Under-Voltage Lockout (UVLO) protection function for  $V_{DD}$  in primary-side and gate drive output for  $V_{CC}$  in secondary-side as shown in Figure 46. The gate driver is running when the  $V_{DD}$  supply voltage is greater than the specified under-voltage lockout threshold voltage (e.g. typically 2.8 V).

In addition, gate output driver has an under-voltage lockout protection (UVLO) function in secondary-side. (e.g.  $V_{CC}$ ).

The variant A and B need to be greater than specified UVLO threshold level with respect to  $V_{EE}$  and GND2 respectively to let the output operate per input signal. The typical  $V_{CC}$  UVLO threshold voltage levels for each option respectively as are per Table 1.

**Table 1.  $V_{CC}$  UVLO OPTION TABLE**

Option	$V_{CC}$ UVLO Threshold	$V_{CC}$ UVLO Referenced		Unit
		Variant A	Variant B	
5-V	6.0	$V_{EE}$	GND2	V
8-V	8.7	$V_{EE}$	GND2	V
12-V	12	$V_{EE}$	GND2	V
17-V	17	$V_{EE}$	GND2	V

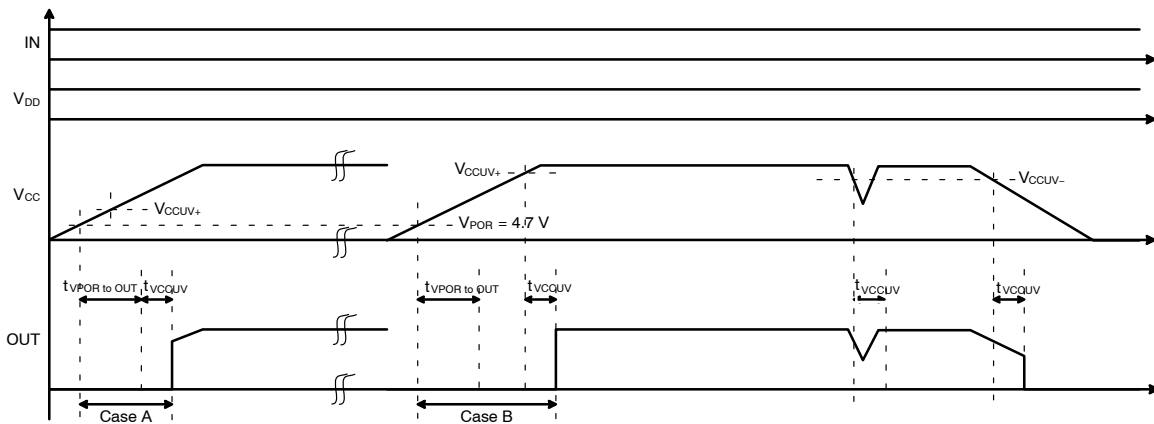


**Figure 46. Timing Chart Under-Voltage Lockout Protection**

**Power-up  $V_{CC}$  UVLO Delay to OUTPUT**

To provide a variety of Under-Voltage Lockout (UVLO) thresholds NCV51152 has a power-up delay time during initial  $V_{CC}$  start-up or after POR event.

Before the gate driver is ready to deliver a proper output state, there is a power-up delay time from the  $V_{CC}$  power-on reset (POR) threshold to output and it is defined as  $t_{VPOR\ to\ OUT}$ . (e.g. typically 18  $\mu$ s). Figure 47 shows the  $V_{CC}$  power-up UVLO delay time diagram.



**Figure 47.  $V_{CC}$  Power-up UVLO Delay Time**

**FUNCTIONAL MODES TABLE**

Table 2 and Table 3 shows the functional modes for the NCV51152 variant A and B assuming  $V_{DD}$  and  $V_{CC}$  are in the recommended range.

**Table 2. FUNCTIONAL MODES FOR THE VARIANT A**

Input		Gate Drive Output	
IN+	IN-	OUTH	OUTL
LOW	X (Note 18)	Hi-Z	LOW
X (Note 18)	HIGH	Hi-Z	LOW
HIGH	LOW	HIGH	Hi-Z

**Table 3. FUNCTIONAL MODES FOR THE VARIANT B**

Input		Gate Drive Output
IN+	IN-	OUT
LOW	X (Note 18)	LOW
X (Note 18)	HIGH	LOW
HIGH	LOW	HIGH

18.X: Don't care

**APPLICATION INFORMATION**

This section provides application guidelines when using the NCV51152.

**Power Supply Recommendations**

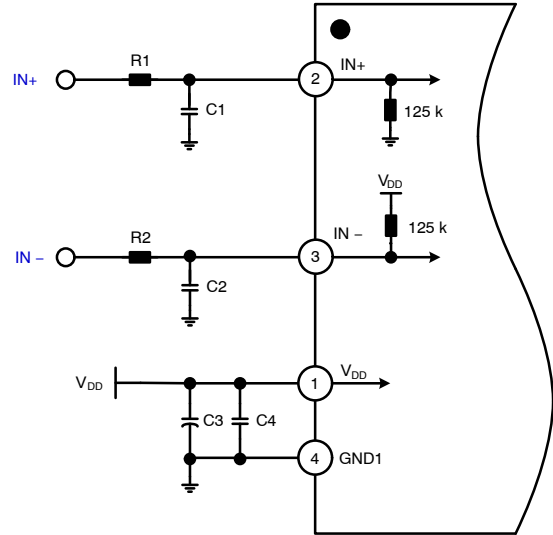
The NCV51152 variant A and B are designed to support unipolar or bipolar power supply respectively.

The  $V_{DD}$  input power supply supports a wide voltage range from 3 V to 20 V and the  $V_{CC}$  output supply supports a voltage range from 6.5 V to 30 V. The  $V_{CC}$  local bypass capacitor should be placed between the  $V_{CC}$  and  $V_{EE}$  pins with a value of at least ten times the gate capacitance, and an additional capacitor 100-nF in parallel for device biasing and both capacitors located as close to the device as possible. A low ESR, ceramic surface mount capacitors are recommended. In addition, for the negative bias supply capacitor should be placed between  $GND2$  and  $V_{EE}$  pins with a value of at least few hundred nanofarads. (variant B). Similarly, the  $V_{DD}$  bypass capacitor should also be placed between the  $V_{DD}$  and  $GND1$  pins for input logic power supply. We recommend using 2 capacitors; at least 100 nF ceramic surface-mount capacitor with few microfarads added in parallel and both capacitors also located as close to the pins of the device as shown in Figure 48.

- In Unipolar power supply the driver is typically supplied with a positive voltage at  $V_{CC}$ . For operation with unipolar supply, the  $V_{CC}$  supply is connected to 15 V with respect to  $V_{EE}$  pin for IGBTs and MOSFET, and 20 V for SiC MOSFETs. (variant A)

- In bipolar power supply the driver is typically supplied of the  $V_{CC}$  and  $V_{EE}$  output supplies for bipolar operation are 15 V and -8 V with respect to  $GND2$  for IGBTs and 20 V and -5 V for SiC MOSFETs. Negative power supply prevents the power device from unintentionally turning on because of current induced from the Miller effect. (variant B)

**Input Stage**



**Figure 48. Schematic of Input Stage**

The input signal pins (IN+, and IN-) of the NCV51152 are based on the TTL compatible input-threshold logic that is independent of the  $V_{DD}$  supply voltage.

The logic level compatible input provides a typically HIGH and LOW threshold of 1.6 V and 1.1 V respectively. The input signal pins impedance is 125 k $\Omega$  typically and the IN+ pin is pulled to  $GND1$  pin and IN- pin is pulled to  $V_{DD}$  pin as shown in Figure 48. For non-inverting input logic input signal is applied to IN+ while the IN- input can be used as an enable function. If IN- is pulled HIGH, the driver output remains LOW state, regardless of the state of IN+. To enable the driver output, IN- should be tied to  $GND1$  through a few ten k $\Omega$  resistor (e.g.10 k $\Omega$ ) or can be used as an active LOW enable pull down.

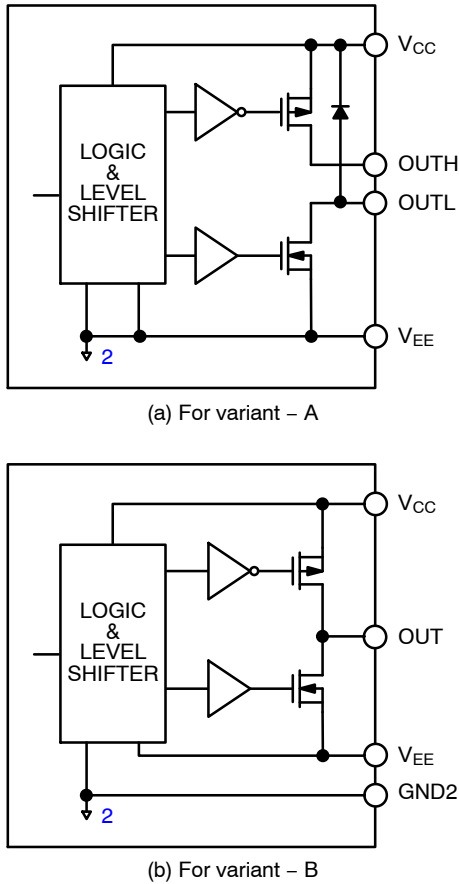
- Non-inverting input IN+ controls the driver output while inverting input IN- is set to LOW
- Inverting input IN- controls the driver output while non-inverting input IN+ is set to HIGH

An RC filter is recommended to be added on the input signal pins to reduce the impact of system noise and ground bounce, the time constant of the RC filter as shown in Figure 48. Such a filter should use an  $R_{IN}$  in the range of 0  $\Omega$  to 100  $\Omega$  and a  $C_{IN}$  between 10 pF and 100 pF.

**Output Stage**

The NCV51152 have different output stages of the variant A and B as shown in Figure 49.

For the variant A is designed to support separate source (OUTH) and sink (OUTL) outputs. This scheme allows a single resistor between each pin and the MOSFET gate to independently control gate ringing as well as fine tuning  $dV_{DS}/dT$  turn-on and turn-off transitions present on the MOSFET drain-source voltage.

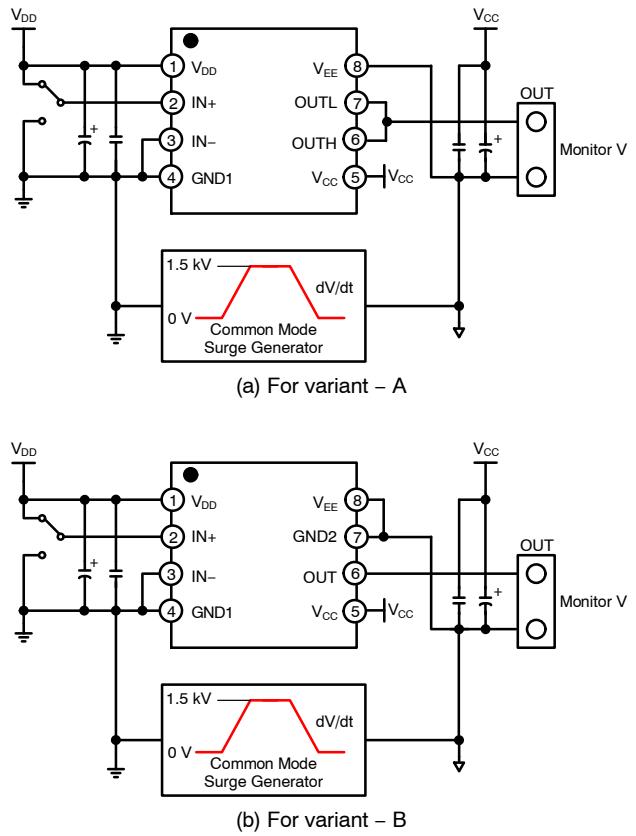


**Figure 49. Schematic of Output Stage**

The output impedance of the pull up and pull down switches shall be able to provide about +4.5 A and -9 A peak currents typical at 25°C and the minimum sink and source peak currents are -7 A sink and +2.6 A source at 125°C.

**Common Mode Transient Immunity Testing**

Figure 50 shows a simplified diagram of the Common Mode Transient Immunity (CMTI) testing configuration for each the variant A and B. CMTI is the maximum sustainable common-mode voltage slew rate while maintaining the correct output. CMTI applies to both rising and falling common-mode voltage edges. CMTI is tested with the transient generator connected between GND1 and VEE. ( $V_{CM} = 1500$  V).



**Figure 50. Common Mode Transient Immunity Test Circuit**

**PCB Layout Guideline**

To improve the switching characteristics and efficiency of design, the following should be considered before beginning a PCB layout.

*Component Placement*

- Keep the input/output traces as short as possible. Minimize influence of the parasitic inductance and capacitance on the layout. (To maintain low signal-path inductance, avoid using via.)
- Placement and routing for supply bypass capacitors for  $V_{DD}$ ,  $V_{CC}$  and  $V_{EE}$ , and gate resistors need to be located as close as possible to the gate driver.
- The gate driver should be located switching device as close as possible to decrease the trace inductance and avoid output ringing.

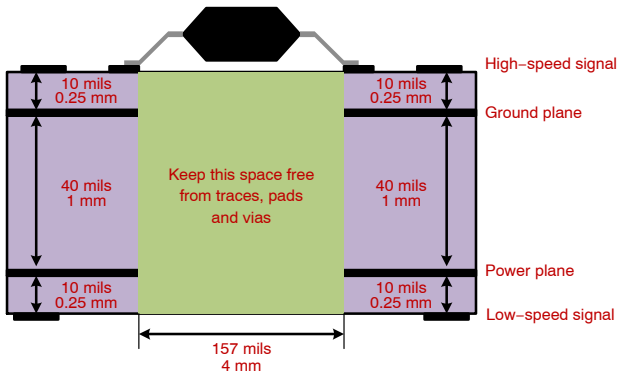
*Grounding Consideration*

- Have a solid ground plane underneath the high-speed signal layer.

*High-Voltage (VISO) Consideration*

- To ensure isolation performance between the primary and secondary side, any PCB traces or copper should be not placed under the driver device as shown in Figure 51. A PCB cutout is recommended to avoid contamination that may impair the isolation performance of NCV51152.

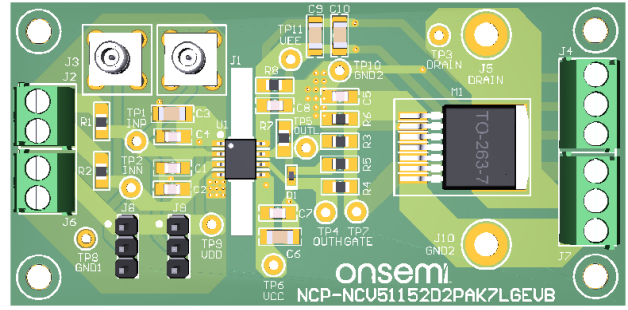
# NCV51152



**Figure 51. Recommended Layer Stack**

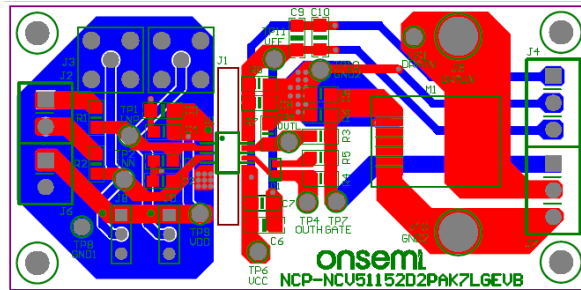
Figure 52 shows the 3D layout of the top view of an evaluation board. The component's location of the PCB

cutout between primary and secondary sides ensures isolation performance.

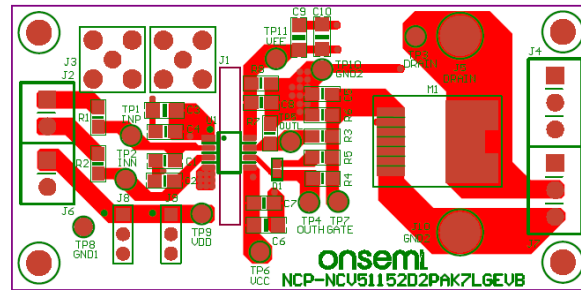


**Figure 52. 3-D PCB View**

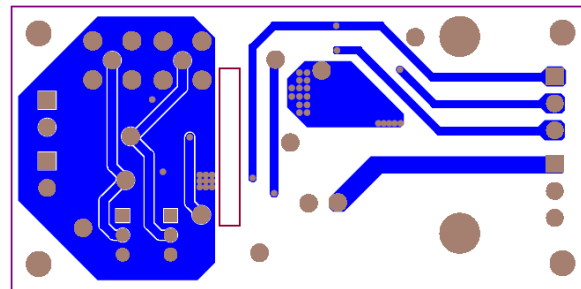
Figure 53 shows the top and bottom layer traces and copper of printed circuit board layout.



(A) Top & Bottom View



(B) Top View



(C) Bottom View

**Figure 53. Printed Circuit Board**

# NCV51152

## ORDERING INFORMATION

Device	Description	Package	UVLO	OUTPUT/UVLO/NEG	Shipping <sup>†</sup>
NCV51152AADR2G*	High current single isolated MOS driver	SOIC-8 NB (Pb-Free)	6 V	Split OUTPUT	2500 / Tape & Reel
NCV51152BADR2G		SOIC-8 NB (Pb-Free)	8 V		2500 / Tape & Reel
NCV51152CADR2G		SOIC-8 NB (Pb-Free)	12 V		2500 / Tape & Reel
NCV51152DADR2G*		SOIC-8 NB (Pb-Free)	17 V		2500 / Tape & Reel
NCV51152ABDR2G*	High current single isolated MOS driver with true VCC UVLO	SOIC-8 NB (Pb-Free)	6 V	TRUE VCC UVLO	2500 / Tape & Reel
NCV51152BBDR2G*		SOIC-8 NB (Pb-Free)	8 V		2500 / Tape & Reel
NCV51152CBDR2G*		SOIC-8 NB (Pb-Free)	12 V		2500 / Tape & Reel
NCV51152DBDR2G*		SOIC-8 NB (Pb-Free)	17 V		2500 / Tape & Reel

†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.

\*Option on demand

# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



SCALE 1:1

SOIC-8 NB  
CASE 751-07  
ISSUE AK

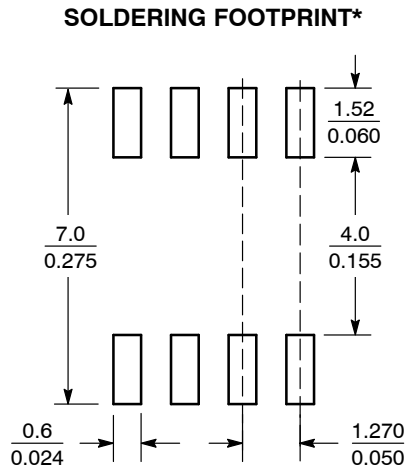
DATE 16 FEB 2011



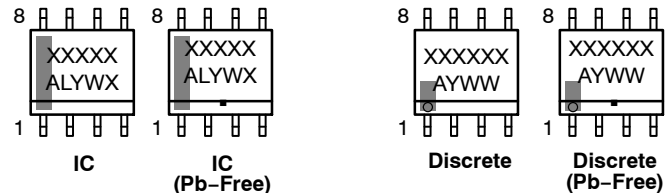
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
  6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0°	8°	0°	8°
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

## GENERIC MARKING DIAGRAM\*



SCALE 6:1 ( $\frac{\text{mm}}{\text{inches}}$ )



XXXXXX = Specific Device Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
W = Work Week  
▪ = Pb-Free Package

XXXXXX = Specific Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
▪ = 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.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

## STYLES ON PAGE 2

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**SOIC-8 NB**  
**CASE 751-07**  
**ISSUE AK**

DATE 16 FEB 2011

- |   |  |  |  |
|---|--|--|--|
| <p>STYLE 1:<br/>         PIN 1. EMITTER<br/>         2. COLLECTOR<br/>         3. COLLECTOR<br/>         4. EMITTER<br/>         5. EMITTER<br/>         6. BASE<br/>         7. BASE<br/>         8. EMITTER</p>   | <p>STYLE 2:<br/>         PIN 1. COLLECTOR, DIE, #1<br/>         2. COLLECTOR, #1<br/>         3. COLLECTOR, #2<br/>         4. COLLECTOR, #2<br/>         5. BASE, #2<br/>         6. EMITTER, #2<br/>         7. BASE, #1<br/>         8. EMITTER, #1</p>               | <p>STYLE 3:<br/>         PIN 1. DRAIN, DIE #1<br/>         2. DRAIN, #1<br/>         3. DRAIN, #2<br/>         4. DRAIN, #2<br/>         5. GATE, #2<br/>         6. SOURCE, #2<br/>         7. GATE, #1<br/>         8. SOURCE, #1</p>                            | <p>STYLE 4:<br/>         PIN 1. ANODE<br/>         2. ANODE<br/>         3. ANODE<br/>         4. ANODE<br/>         5. ANODE<br/>         6. ANODE<br/>         7. ANODE<br/>         8. COMMON CATHODE</p>   |
| <p>STYLE 5:<br/>         PIN 1. DRAIN<br/>         2. DRAIN<br/>         3. DRAIN<br/>         4. DRAIN<br/>         5. GATE<br/>         6. GATE<br/>         7. SOURCE<br/>         8. SOURCE</p>   | <p>STYLE 6:<br/>         PIN 1. SOURCE<br/>         2. DRAIN<br/>         3. DRAIN<br/>         4. SOURCE<br/>         5. SOURCE<br/>         6. GATE<br/>         7. GATE<br/>         8. SOURCE</p>  | <p>STYLE 7:<br/>         PIN 1. INPUT<br/>         2. EXTERNAL BYPASS<br/>         3. THIRD STAGE SOURCE<br/>         4. GROUND<br/>         5. DRAIN<br/>         6. GATE 3<br/>         7. SECOND STAGE Vd<br/>         8. FIRST STAGE Vd</p>                    | <p>STYLE 8:<br/>         PIN 1. COLLECTOR, DIE #1<br/>         2. BASE, #1<br/>         3. BASE, #2<br/>         4. COLLECTOR, #2<br/>         5. COLLECTOR, #2<br/>         6. EMITTER, #2<br/>         7. EMITTER, #1<br/>         8. COLLECTOR, #1</p>                              |
| <p>STYLE 9:<br/>         PIN 1. EMITTER, COMMON<br/>         2. COLLECTOR, DIE #1<br/>         3. COLLECTOR, DIE #2<br/>         4. EMITTER, COMMON<br/>         5. EMITTER, COMMON<br/>         6. BASE, DIE #2<br/>         7. BASE, DIE #1<br/>         8. EMITTER, COMMON</p> | <p>STYLE 10:<br/>         PIN 1. GROUND<br/>         2. BIAS 1<br/>         3. OUTPUT<br/>         4. GROUND<br/>         5. GROUND<br/>         6. BIAS 2<br/>         7. INPUT<br/>         8. GROUND</p>  | <p>STYLE 11:<br/>         PIN 1. SOURCE 1<br/>         2. GATE 1<br/>         3. SOURCE 2<br/>         4. GATE 2<br/>         5. DRAIN 2<br/>         6. DRAIN 2<br/>         7. DRAIN 1<br/>         8. DRAIN 1</p>   | <p>STYLE 12:<br/>         PIN 1. SOURCE<br/>         2. SOURCE<br/>         3. SOURCE<br/>         4. GATE<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. DRAIN<br/>         8. DRAIN</p>   |
| <p>STYLE 13:<br/>         PIN 1. N.C.<br/>         2. SOURCE<br/>         3. SOURCE<br/>         4. GATE<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. DRAIN<br/>         8. DRAIN</p>  | <p>STYLE 14:<br/>         PIN 1. N-SOURCE<br/>         2. N-GATE<br/>         3. P-SOURCE<br/>         4. P-GATE<br/>         5. P-DRAIN<br/>         6. P-DRAIN<br/>         7. N-DRAIN<br/>         8. N-DRAIN</p>   | <p>STYLE 15:<br/>         PIN 1. ANODE 1<br/>         2. ANODE 1<br/>         3. ANODE 1<br/>         4. ANODE 1<br/>         5. CATHODE, COMMON<br/>         6. CATHODE, COMMON<br/>         7. CATHODE, COMMON<br/>         8. CATHODE, COMMON</p>               | <p>STYLE 16:<br/>         PIN 1. EMITTER, DIE #1<br/>         2. BASE, DIE #1<br/>         3. EMITTER, DIE #2<br/>         4. BASE, DIE #2<br/>         5. COLLECTOR, DIE #2<br/>         6. COLLECTOR, DIE #2<br/>         7. COLLECTOR, DIE #1<br/>         8. COLLECTOR, DIE #1</p> |
| <p>STYLE 17:<br/>         PIN 1. VCC<br/>         2. V2OUT<br/>         3. V1OUT<br/>         4. TXE<br/>         5. RXE<br/>         6. VEE<br/>         7. GND<br/>         8. ACC</p>  | <p>STYLE 18:<br/>         PIN 1. ANODE<br/>         2. ANODE<br/>         3. SOURCE<br/>         4. GATE<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. CATHODE<br/>         8. CATHODE</p>   | <p>STYLE 19:<br/>         PIN 1. SOURCE 1<br/>         2. GATE 1<br/>         3. SOURCE 2<br/>         4. GATE 2<br/>         5. DRAIN 2<br/>         6. MIRROR 2<br/>         7. DRAIN 1<br/>         8. MIRROR 1</p>   | <p>STYLE 20:<br/>         PIN 1. SOURCE (N)<br/>         2. GATE (N)<br/>         3. SOURCE (P)<br/>         4. GATE (P)<br/>         5. DRAIN<br/>         6. DRAIN<br/>         7. DRAIN<br/>         8. DRAIN</p>   |
| <p>STYLE 21:<br/>         PIN 1. CATHODE 1<br/>         2. CATHODE 2<br/>         3. CATHODE 3<br/>         4. CATHODE 4<br/>         5. CATHODE 5<br/>         6. COMMON ANODE<br/>         7. COMMON ANODE<br/>         8. CATHODE 6</p>  | <p>STYLE 22:<br/>         PIN 1. I/O LINE 1<br/>         2. COMMON CATHODE/VCC<br/>         3. COMMON CATHODE/VCC<br/>         4. I/O LINE 3<br/>         5. COMMON ANODE/GND<br/>         6. I/O LINE 4<br/>         7. I/O LINE 5<br/>         8. COMMON ANODE/GND</p> | <p>STYLE 23:<br/>         PIN 1. LINE 1 IN<br/>         2. COMMON ANODE/GND<br/>         3. COMMON ANODE/GND<br/>         4. LINE 2 IN<br/>         5. LINE 2 OUT<br/>         6. COMMON ANODE/GND<br/>         7. COMMON ANODE/GND<br/>         8. LINE 1 OUT</p> | <p>STYLE 24:<br/>         PIN 1. BASE<br/>         2. EMITTER<br/>         3. COLLECTOR/ANODE<br/>         4. COLLECTOR/ANODE<br/>         5. CATHODE<br/>         6. CATHODE<br/>         7. COLLECTOR/ANODE<br/>         8. COLLECTOR/ANODE</p>                                      |
| <p>STYLE 25:<br/>         PIN 1. VIN<br/>         2. N/C<br/>         3. REXT<br/>         4. GND<br/>         5. IOUT<br/>         6. IOUT<br/>         7. IOUT<br/>         8. IOUT</p>   | <p>STYLE 26:<br/>         PIN 1. GND<br/>         2. dv/dt<br/>         3. ENABLE<br/>         4. ILIMIT<br/>         5. SOURCE<br/>         6. SOURCE<br/>         7. SOURCE<br/>         8. VCC</p>  | <p>STYLE 27:<br/>         PIN 1. ILIMIT<br/>         2. OVLO<br/>         3. UVLO<br/>         4. INPUT+<br/>         5. SOURCE<br/>         6. SOURCE<br/>         7. SOURCE<br/>         8. DRAIN</p>  | <p>STYLE 28:<br/>         PIN 1. SW_TO_GND<br/>         2. DASIC_OFF<br/>         3. DASIC_SW_DET<br/>         4. GND<br/>         5. V_MON<br/>         6. VBULK<br/>         7. VBULK<br/>         8. VIN</p>  |
| <p>STYLE 29:<br/>         PIN 1. BASE, DIE #1<br/>         2. EMITTER, #1<br/>         3. BASE, #2<br/>         4. EMITTER, #2<br/>         5. COLLECTOR, #2<br/>         6. COLLECTOR, #2<br/>         7. COLLECTOR, #1<br/>         8. COLLECTOR, #1</p>                        | <p>STYLE 30:<br/>         PIN 1. DRAIN 1<br/>         2. DRAIN 1<br/>         3. GATE 2<br/>         4. SOURCE 2<br/>         5. SOURCE 1/DRAIN 2<br/>         6. SOURCE 1/DRAIN 2<br/>         7. SOURCE 1/DRAIN 2<br/>         8. GATE 1</p>                           |  |  |

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