

# NCP5304

## High Voltage, High and Low Side Driver

The NCP5304 is a High Voltage Power gate Driver providing two outputs for direct drive of 2 N-channel power MOSFETs or IGBTs arranged in a half-bridge configuration.

It uses the bootstrap technique to insure a proper drive of the High-side power switch. The driver works with 2 independent inputs with cross conduction protection.

### Features

- High Voltage Range: up to 600 V
- $dV/dt$  Immunity  $\pm 50$  V/nsec
- Gate Drive Supply Range from 10 V to 20 V
- High and Low Drive Outputs
- Output Source / Sink Current Capability 250 mA / 500 mA
- 3.3 V and 5 V Input Logic Compatible
- Up to  $V_{CC}$  Swing on Input Pins
- Extended Allowable Negative Bridge Pin Voltage Swing to -10 V for Signal Propagation
- Matched Propagation Delays between Both Channels
- Outputs in Phase with the Inputs
- Cross Conduction Protection with 100 ns Internal Fixed Dead Time
- Under  $V_{CC}$  LockOut (UVLO) for Both Channels
- Pin-to-Pin Compatible with Industry Standards
- These are Pb-Free Devices

### Typical Applications

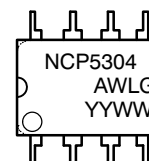
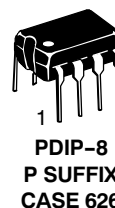
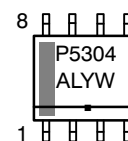
- Half-bridge Power Converters
- Full-bridge Converters



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### MARKING DIAGRAMS



NCP5304 = Specific Device Code  
A = Assembly Location  
L or WL = Wafer Lot  
Y or YY = Year  
W or WW = Work Week  
G or ■ = Pb-Free Package

### PINOUT INFORMATION

IN_LO	1	8	VBOOT
IN_HI	2	7	DRV_HI
VCC	3	6	BRIDGE
GND	4	5	DRV_LO

8 Pin Package

### ORDERING INFORMATION

Device	Package	Shipping†
NCP5304PG	PDIP-8 (Pb-Free)	50 Units / Rail
NCP5304DR2G	SOIC-8 (Pb-Free)	2500 / Tape & Reel

† For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# NCP5304

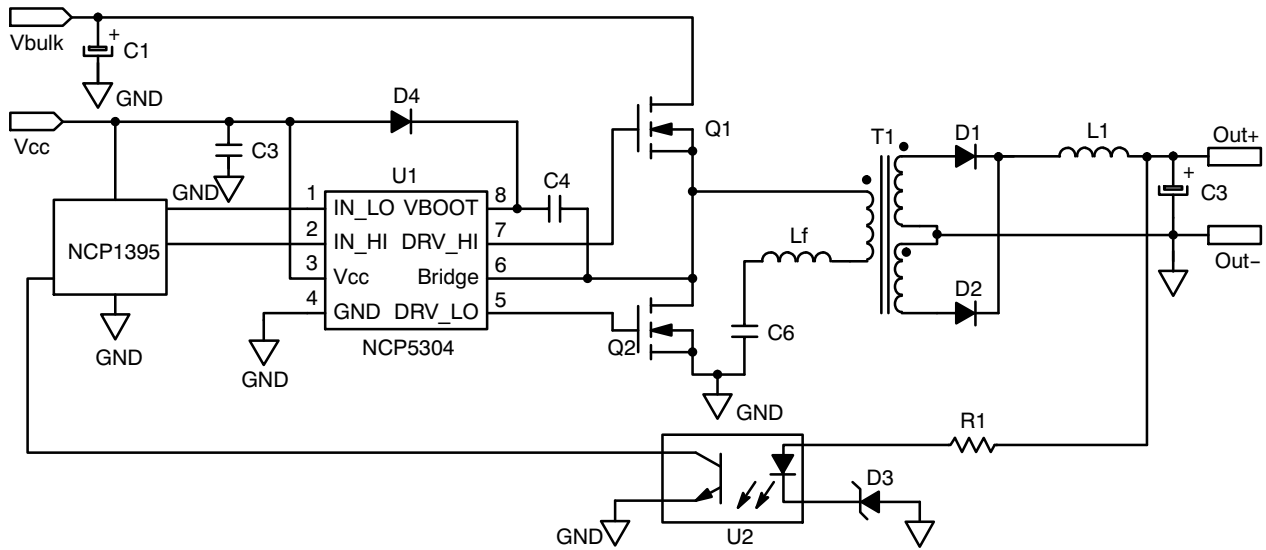


Figure 1. Typical Application Resonant Converter (LLC type)

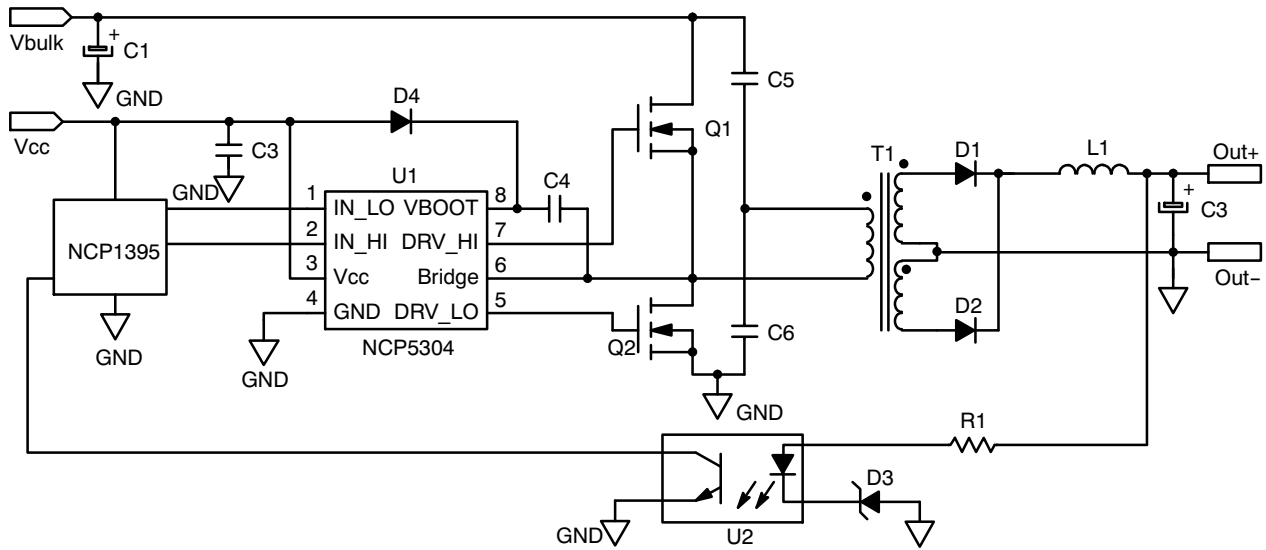


Figure 2. Typical Application Half Bridge Converter

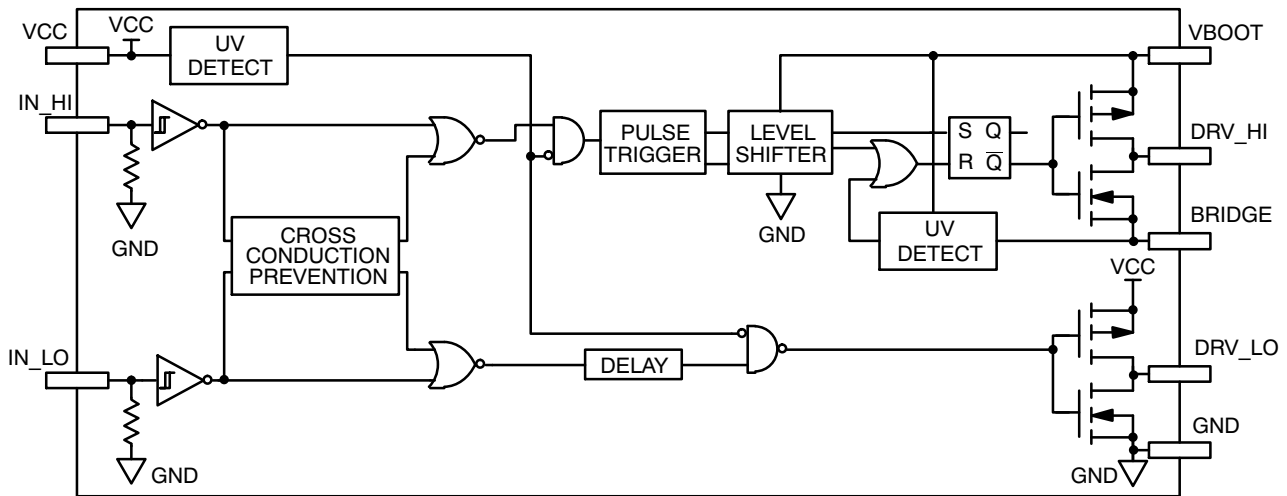


Figure 3. Detailed Block Diagram

# NCP5304

## PIN DESCRIPTIONS

Pin No.	Pin Name	Pin Function
1	IN_LO	Logic Input for Low side driver output in phase
2	IN_HI	Logic Input for High side driver output in phase
3	VCC	Low side and main power supply
4	GND	Ground
5	DRV_LO	Low side gate drive output
6	BRIDGE	Bootstrap return or High side floating supply return
7	DRV_HI	High side gate drive output
8	VBOOT	Bootstrap power supply

## MAXIMUM RATINGS

Rating	Symbol	Value	Unit
$V_{CC}$	Main power supply voltage	-0.3 to 20	V
$V_{CC\_transient}$	Main transient power supply voltage: $I_{VCC\_max} = 5\text{ mA}$ during 10 ms	23	V
$V_{BRIDGE}$	VHV: High Voltage BRIDGE pin	-1 to 600	V
$V_{BRIDGE}$	Allowable Negative Bridge Pin Voltage for IN_LO Signal Propagation to DRV_LO	-10	V
$V_{BOOT-VBRIDGE}$	VHV: Floating supply voltage	-0.3 to 20	V
$V_{DRV\_HI}$	VHV: High side output voltage	$V_{BRIDGE} - 0.3$ to $V_{BOOT} + 0.3$	V
$V_{DRV\_LO}$	Low side output voltage	-0.3 to $V_{CC} + 0.3$	V
$dV_{BRIDGE}/dt$	Allowable output slew rate	50	V/ns
$V_{IN\_XX}$	Inputs IN_HI, IN_LO	-1.0 to $V_{CC} + 0.3$	V
	ESD Capability:		
	- HBM model (all pins except pins 6-7-8 in 8 pins package or 11-12-13 in 14 pins package)	2	kV
	- Machine model (all pins except pins 6-7-8 in 8 pins package or 11-12-13 in 14 pins package)	200	V
	Latch up capability per Jedec JESD78		
$R_{\theta JA}$	Power dissipation and Thermal characteristics PDIP-8: Thermal Resistance, Junction-to-Air SO-8: Thermal Resistance, Junction-to-Air	100 178	°C/W
$T_{J\_max}$	Maximum Operating Junction Temperature	+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.

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**ELECTRICAL CHARACTERISTIC** ( $V_{CC} = V_{boot} = 15\text{ V}$ ,  $V_{GND} = V_{bridge}$ ,  $-40^{\circ}\text{C} < T_J < 125^{\circ}\text{C}$ , Outputs loaded with 1 nF)

Rating	Symbol	$T_J -40^{\circ}\text{C to }125^{\circ}\text{C}$			Units
		Min	Typ	Max	

## OUTPUT SECTION

Output high short circuit pulsed current $V_{DRV} = 0\text{ V}$ , $PW \leq 10\ \mu\text{s}$ (Note 1)	$I_{DRVsource}$	-	250	-	mA
Output low short circuit pulsed current $V_{DRV} = V_{CC}$ , $PW \leq 10\ \mu\text{s}$ (Note 1)	$I_{DRVsink}$	-	500	-	mA
Output resistor (Typical value @ $25^{\circ}\text{C}$ ) Source	$R_{OH}$	-	30	60	$\Omega$
Output resistor (Typical value @ $25^{\circ}\text{C}$ ) Sink	$R_{OL}$	-	10	20	$\Omega$
High level output voltage, $V_{BIAS} - V_{DRV\_XX}$ @ $I_{DRV\_XX} = 20\text{ mA}$	$V_{DRV\_H}$	-	0.7	1.6	V
Low level output voltage $V_{DRV\_XX}$ @ $I_{DRV\_XX} = 20\text{ mA}$	$V_{DRV\_L}$	-	0.2	0.6	V

## DYNAMIC OUTPUT SECTION

Turn-on propagation delay ( $V_{bridge} = 0\text{ V}$ )	$t_{ON}$	-	100	170	ns
Turn-off propagation delay ( $V_{bridge} = 0\text{ V}$ or $50\text{ V}$ ) (Note 2)	$t_{OFF}$	-	100	170	ns
Output voltage rise time (from 10% to 90% @ $V_{CC} = 15\text{ V}$ ) with 1 nF load	$t_r$	-	85	160	ns
Output voltage fall time (from 90% to 10% @ $V_{CC} = 15\text{ V}$ ) with 1 nF load	$t_f$	-	35	75	ns
Propagation delay matching between the High side and the Low side @ $25^{\circ}\text{C}$ (Note 3)	$\Delta t$	-	20	35	ns
Internal fixed dead time (Note 4)	$DT$	65	100	190	ns
Minimum input width that changes the output	$t_{PW1}$	-	-	50	ns
Maximum input width that does not change the output	$t_{PW2}$	20	-	-	ns

## INPUT SECTION

Low level input voltage threshold	$V_{IN}$	-	-	0.8	V
Input pull-down resistor ( $V_{IN} < 0.5\text{ V}$ )	$R_{IN}$	-	200	-	k $\Omega$
High level input voltage threshold	$V_{IN}$	2.3	-	-	V
Logic "1" input bias current @ $V_{IN\_XX} = 5\text{ V}$ @ $25^{\circ}\text{C}$	$I_{IN+}$	-	5	25	$\mu\text{A}$
Logic "0" input bias current @ $V_{IN\_XX} = 0\text{ V}$ @ $25^{\circ}\text{C}$	$I_{IN-}$	-	-	2.0	$\mu\text{A}$

## SUPPLY SECTION

Vcc UV Start-up voltage threshold	$V_{cc\_stup}$	8.0	8.9	9.9	V
Vcc UV Shut-down voltage threshold	$V_{cc\_shtdwn}$	7.3	8.2	9.1	V
Hysteresis on Vcc	$V_{cc\_hyst}$	0.3	0.7	-	V
Vboot Start-up voltage threshold reference to bridge pin ( $V_{boot\_stup} = V_{boot} - V_{bridge}$ )	$V_{boot\_stup}$	8.0	8.9	9.9	V
Vboot UV Shut-down voltage threshold	$V_{boot\_shtdwn}$	7.3	8.2	9.1	V
Hysteresis on Vboot	$V_{boot\_shtdwn}$	0.3	0.7	-	V
Leakage current on high voltage pins to GND ( $V_{BOOT} = V_{BRIDGE} = DRV\_HI = 600\text{ V}$ )	$I_{HV\_LEAK}$	-	5	40	$\mu\text{A}$
Consumption in active mode ( $V_{CC} = V_{boot}$ , $f_{sw} = 100\text{ kHz}$ and 1 nF load on both driver outputs)	$ICC1$	-	4	5	mA
Consumption in inhibition mode ( $V_{CC} = V_{boot}$ )	$ICC2$	-	250	400	$\mu\text{A}$
Vcc current consumption in inhibition mode	$ICC3$	-	200	-	$\mu\text{A}$
Vboot current consumption in inhibition mode	$ICC4$	-	50	-	$\mu\text{A}$

1. Parameter guaranteed by design
2. Turn-off propagation delay @  $V_{bridge} = 600\text{ V}$  is guaranteed by design
3. See characterization curve for  $\Delta t$  parameters variation on the full range temperature.
4. Timing diagram definition see Figure 7.
5. Timing diagram definition see Figure 5 and Figure 6.

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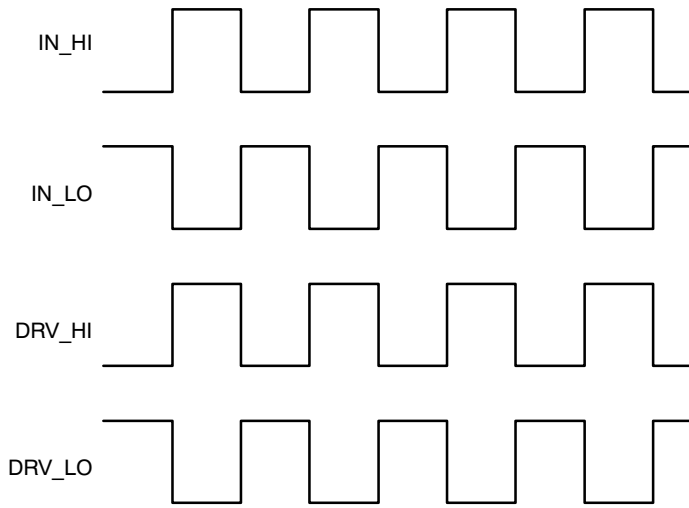


Figure 4. Input/Output Timing Diagram

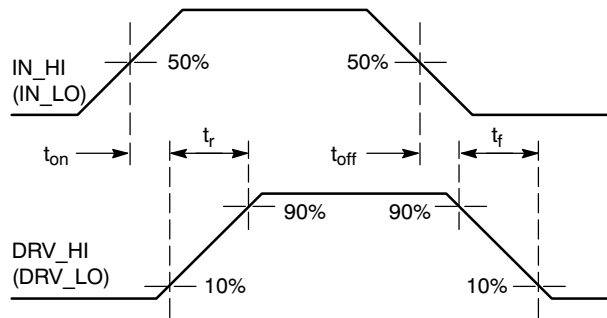


Figure 5. Propagation Delay and Rise / Fall Time Definition

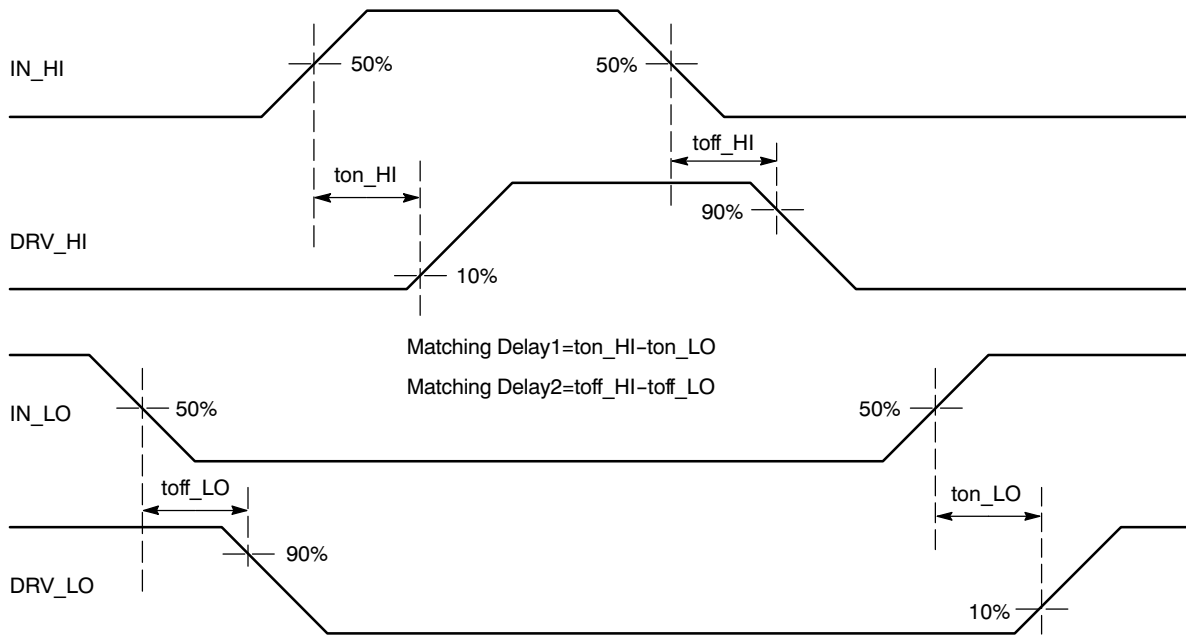
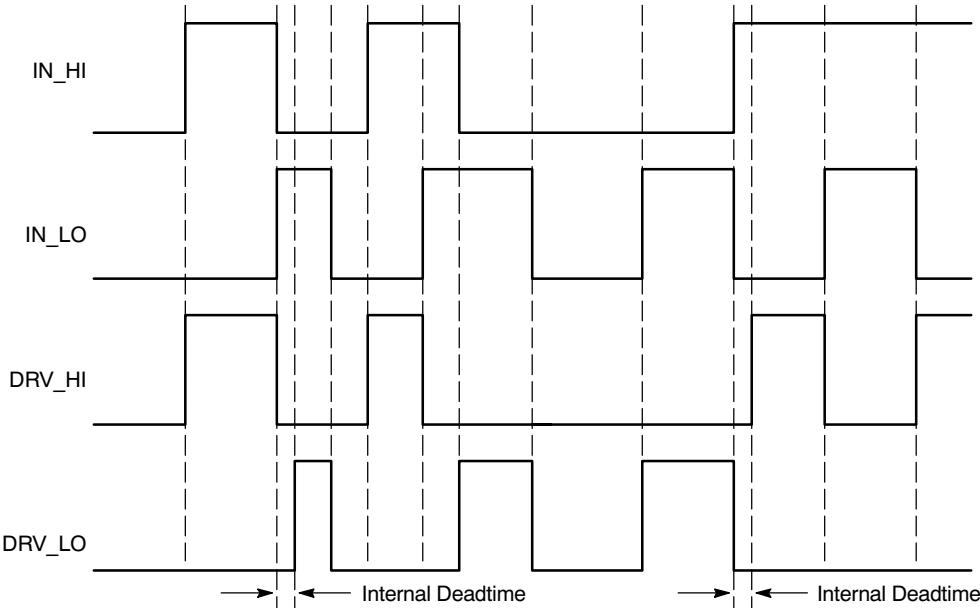


Figure 6. Matching Propagation Delay

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**Figure 7. Input/Output Cross Conduction Output Protection Timing Diagram**

CHARACTERIZATION CURVES

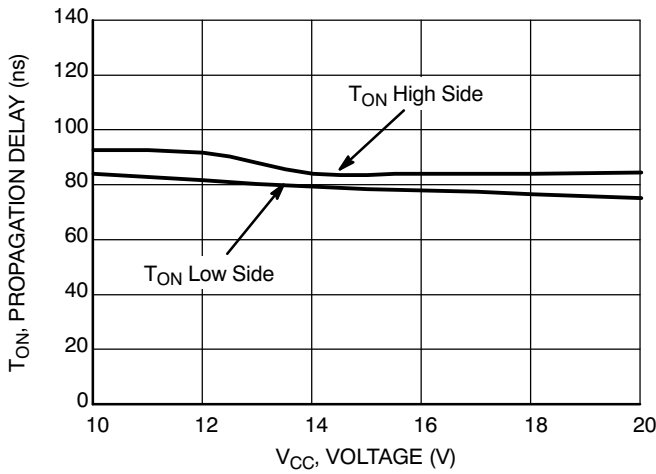


Figure 8. Turn ON Propagation Delay vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

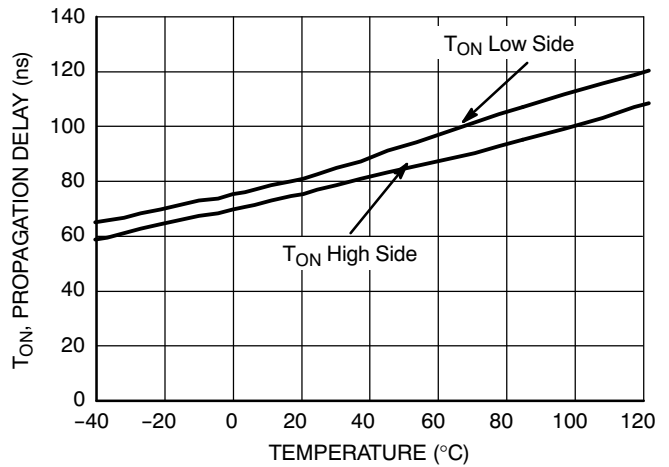


Figure 9. Turn ON Propagation Delay vs. Temperature

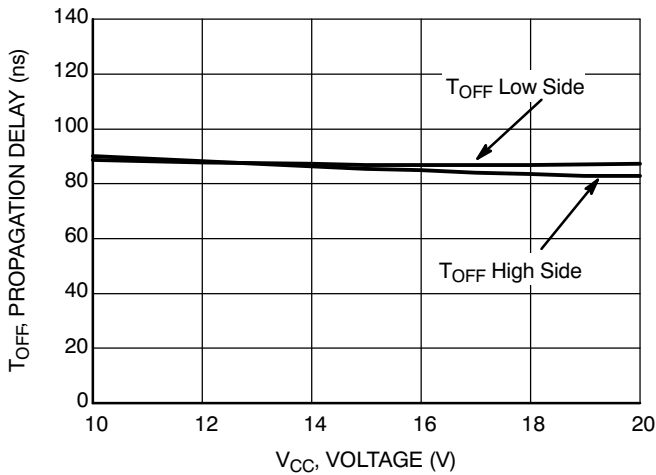


Figure 10. Turn OFF Propagation Delay vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

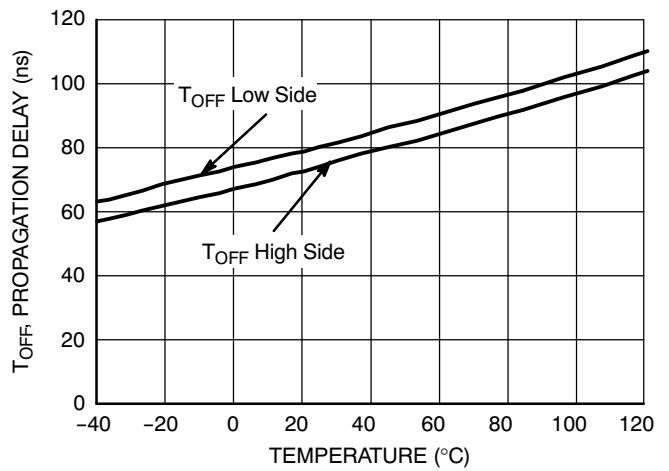


Figure 11. Turn OFF Propagation Delay vs. Temperature

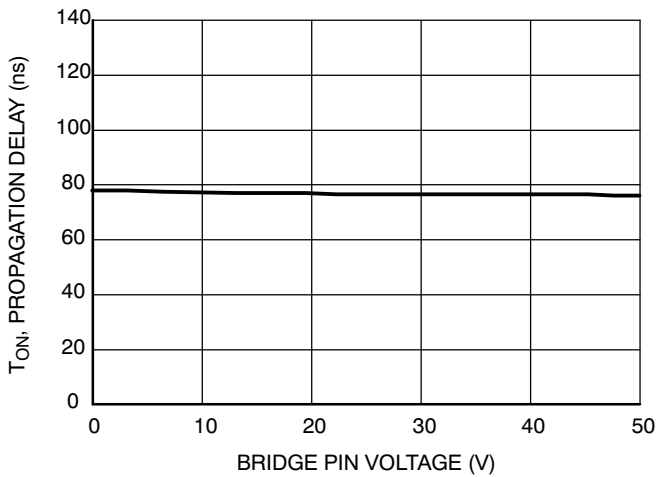


Figure 12. High Side Turn ON Propagation Delay vs.  $V_{BRIDGE}$  Voltage

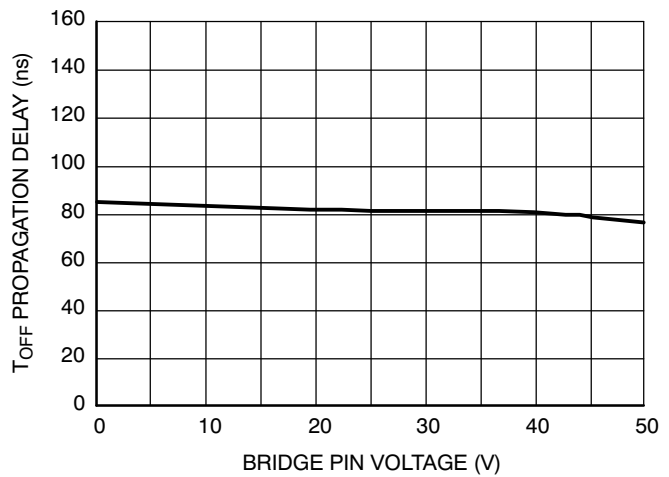
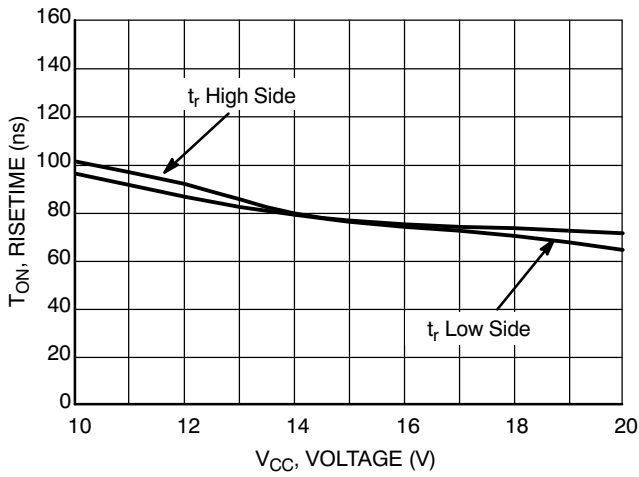
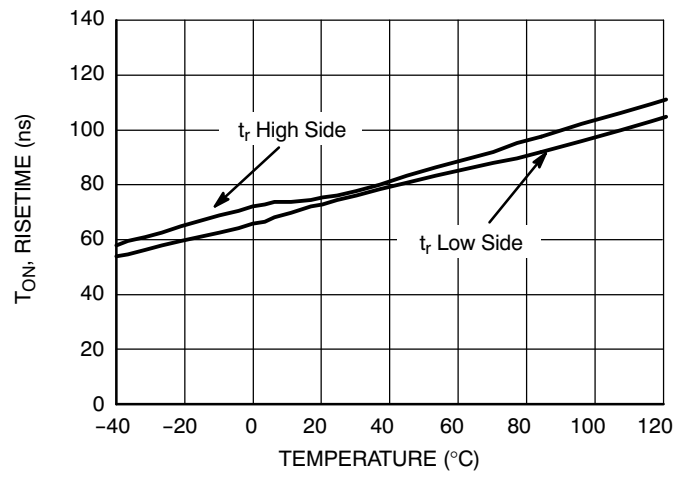


Figure 13. High Side Turn OFF Propagation Delay vs.  $V_{BRIDGE}$  Voltage

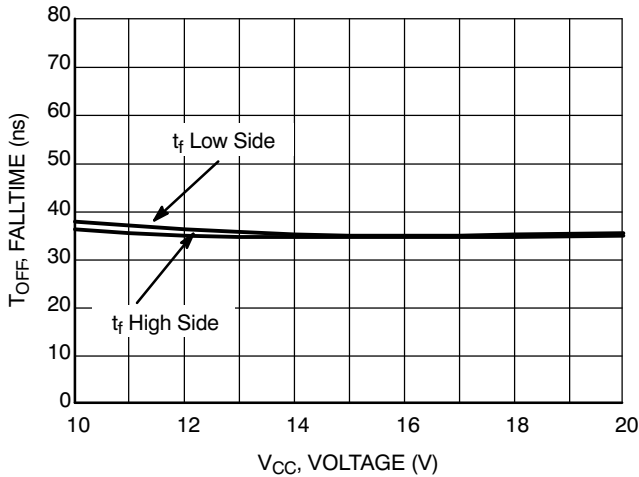
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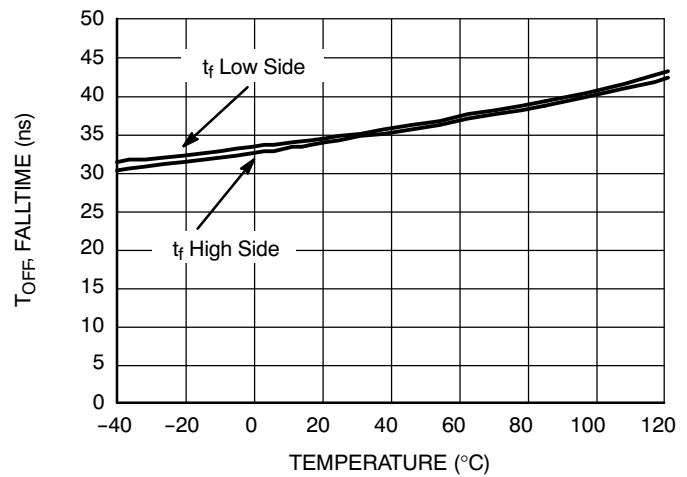
**Figure 14. Turn ON Risetime vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )**



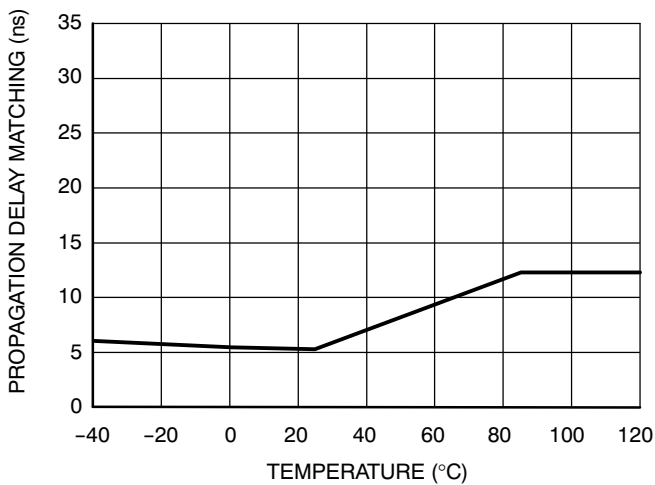
**Figure 15. Turn ON Risetime vs. Temperature**



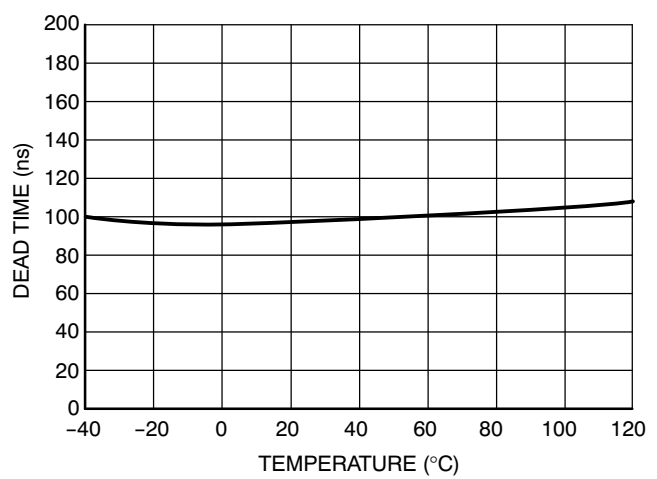
**Figure 16. Turn OFF Falltime vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )**



**Figure 17. Turn OFF Falltime vs. Temperature**



**Figure 18. Propagation Delay Matching Between High Side and Low Side Driver vs. Temperature**



**Figure 19. Dead Time vs. Temperature**



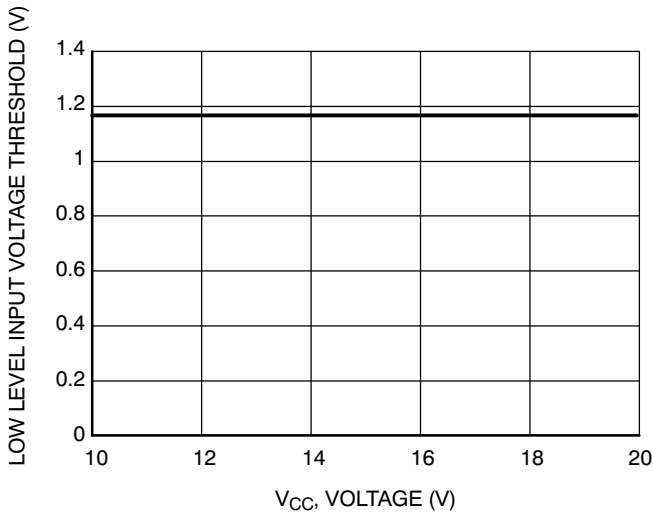


Figure 20. Low Level Input Voltage Threshold vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

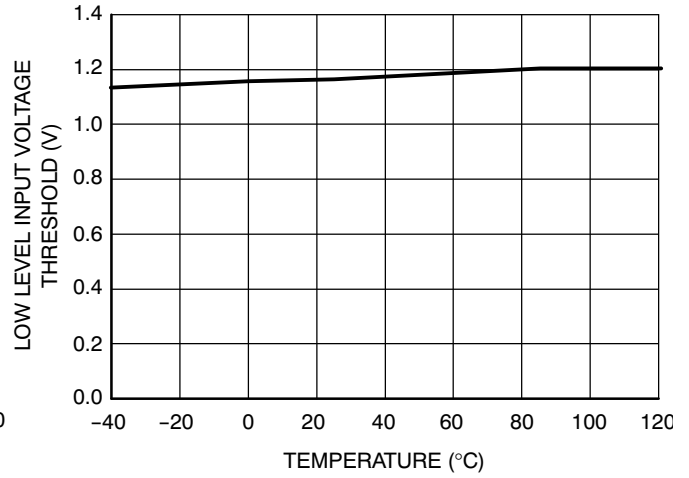


Figure 21. Low Level Input Voltage Threshold vs. Temperature

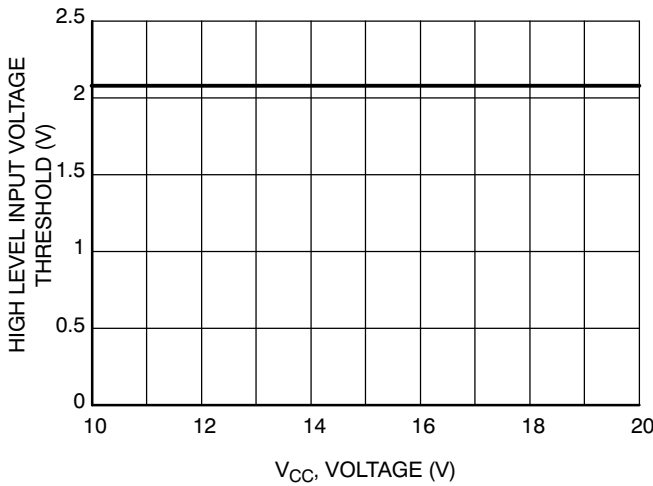


Figure 22. High Level Input Voltage Threshold vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

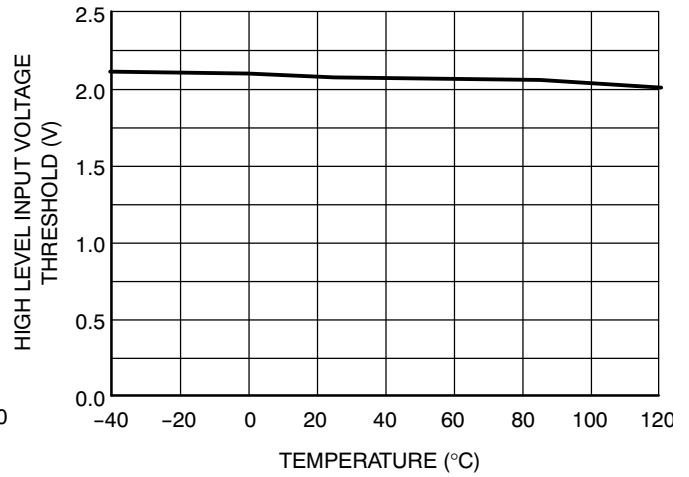


Figure 23. High Level Input Voltage Threshold vs. Temperature

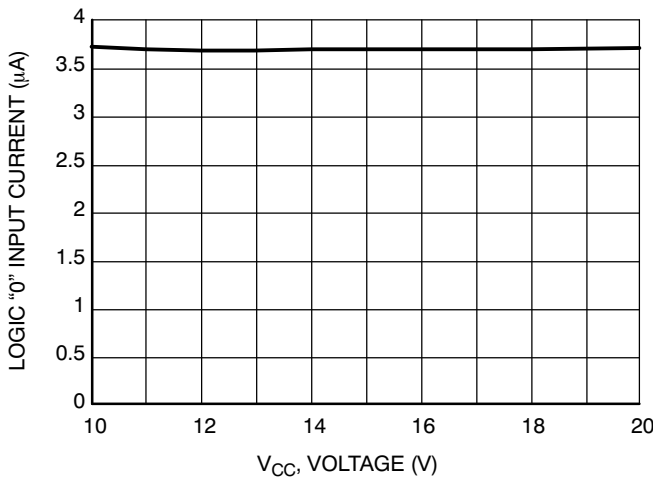


Figure 24. Logic "0" Input Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

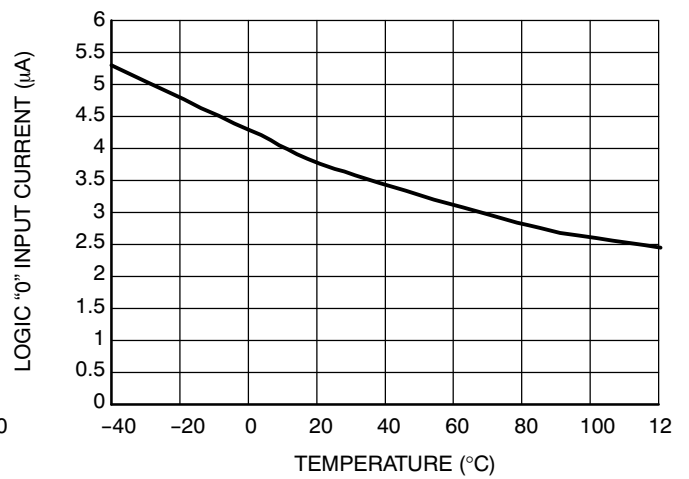
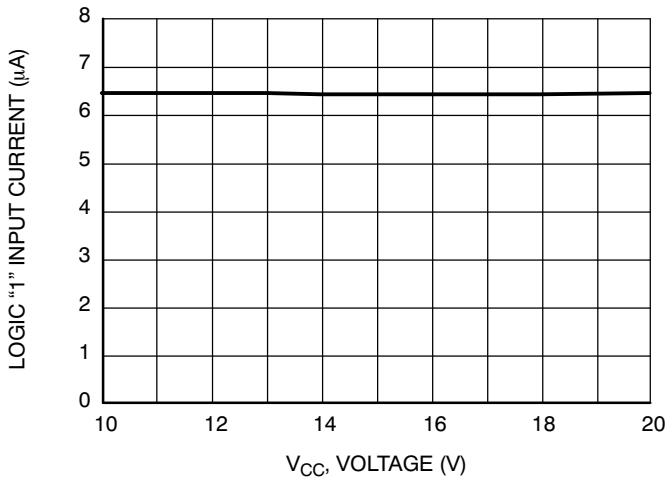
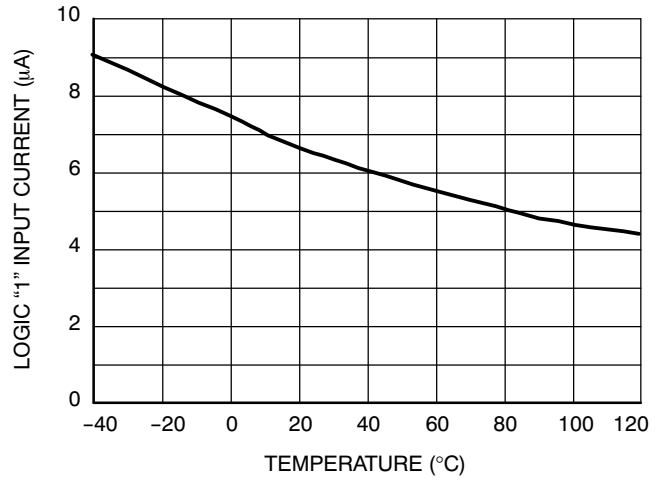


Figure 25. Logic "0" Input Current vs. Temperature

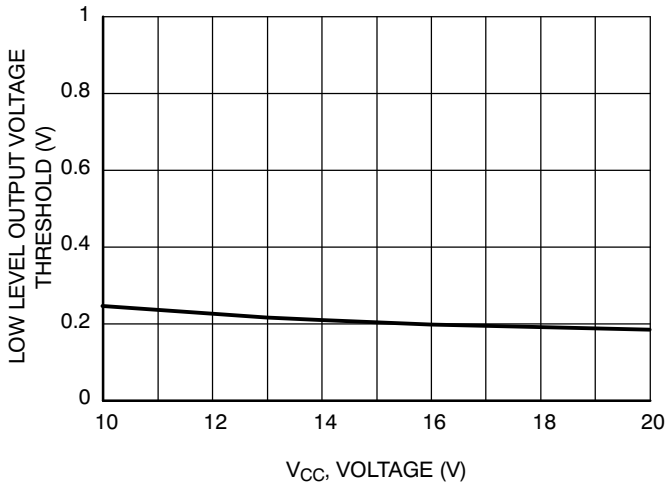
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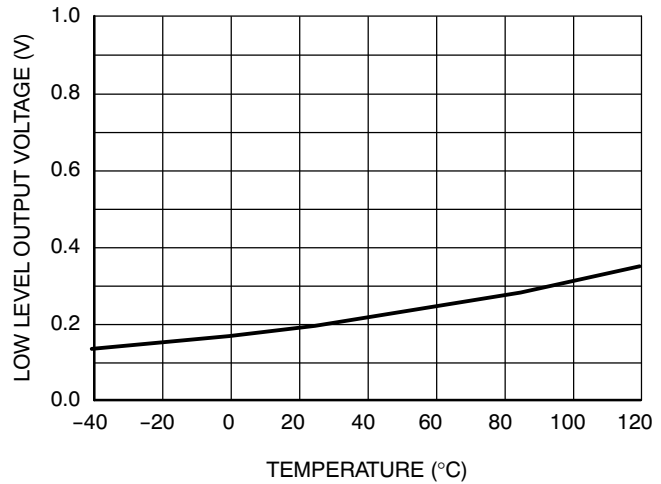
**Figure 26. Logic "1" Input Current vs. Supply Voltage (V<sub>CC</sub> = V<sub>BOOT</sub>)**



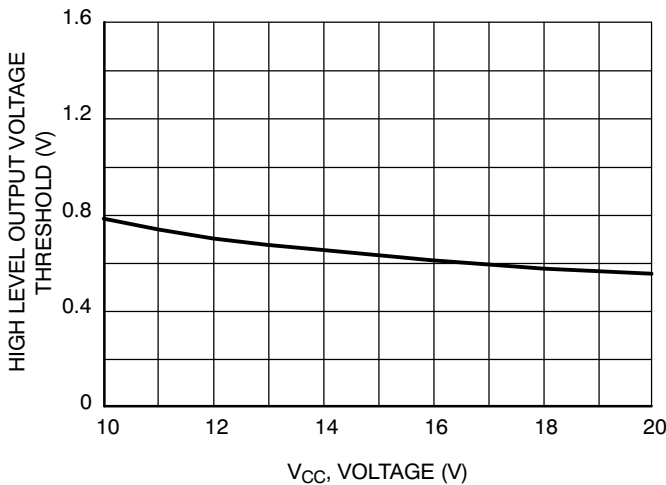
**Figure 27. Logic "1" Input Current vs. Temperature**



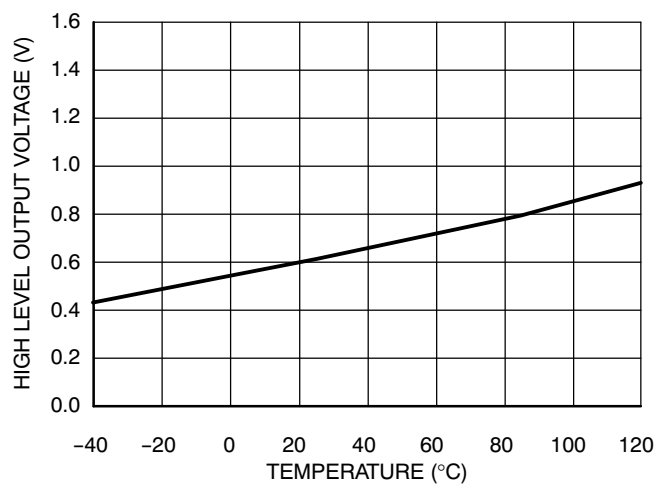
**Figure 28. Low Level Output Voltage vs. Supply Voltage (V<sub>CC</sub> = V<sub>BOOT</sub>)**



**Figure 29. Low Level Output Voltage vs. Temperature**



**Figure 30. High Level Output Voltage vs. Supply Voltage (V<sub>CC</sub> = V<sub>BOOT</sub>)**



**Figure 31. High Level Output Voltage vs. Temperature**

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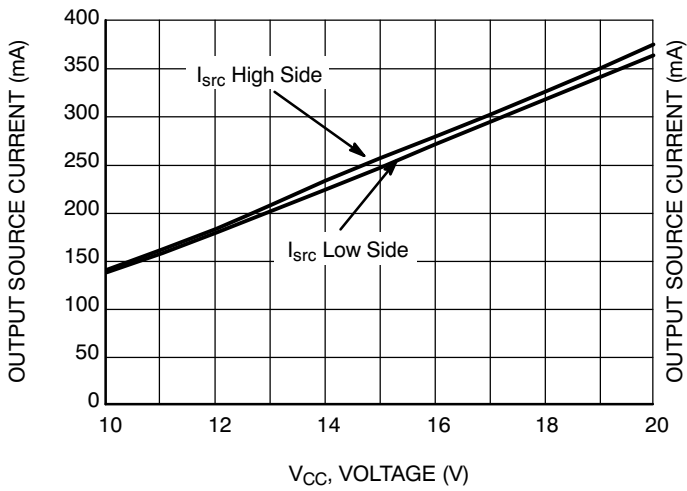


Figure 32. Output Source Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

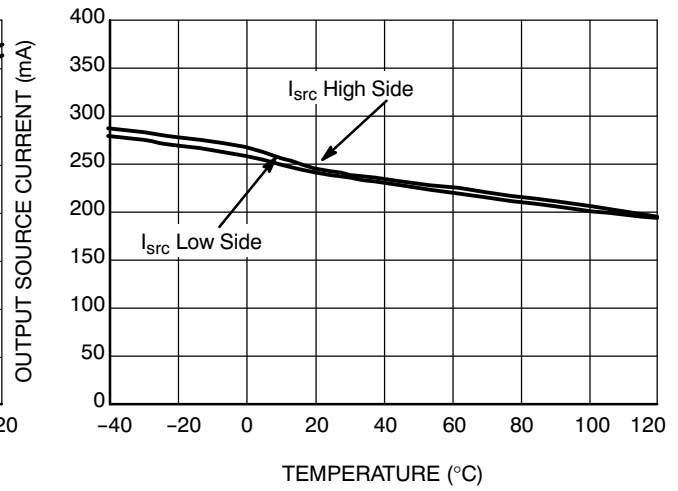


Figure 33. Output Source Current vs. Temperature

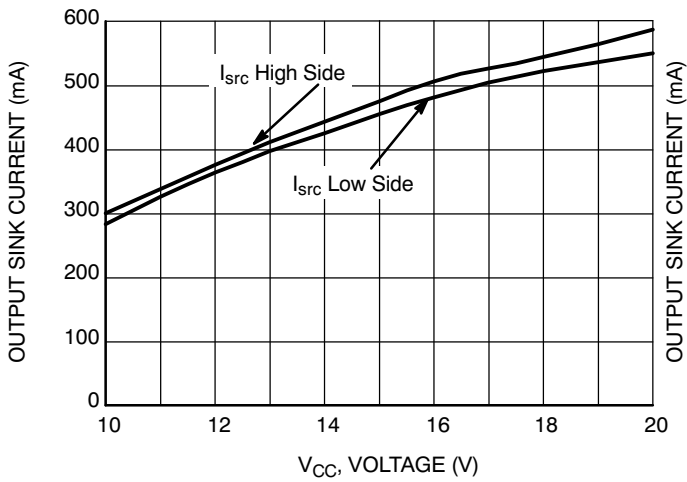


Figure 34. Output Sink Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

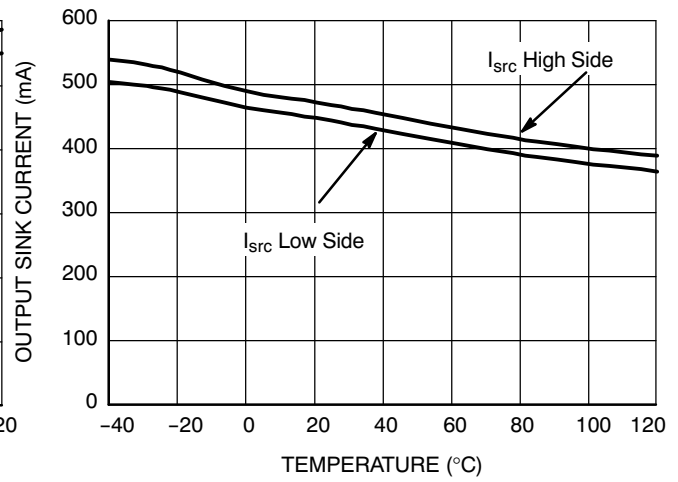


Figure 35. Output Sink Current vs. Temperature

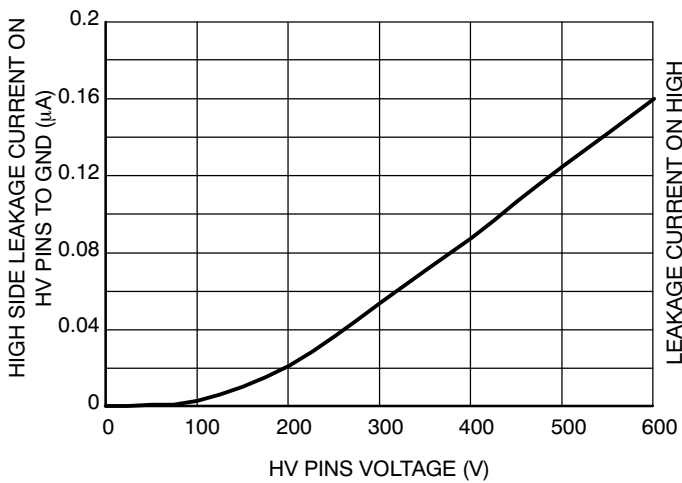


Figure 36. Leakage Current on High Voltage Pins (600 V) to Ground vs.  $V_{BRIDGE}$  Voltage ( $V_{BRIDGE} = V_{BOOT} = V_{DRV\_HI}$ )

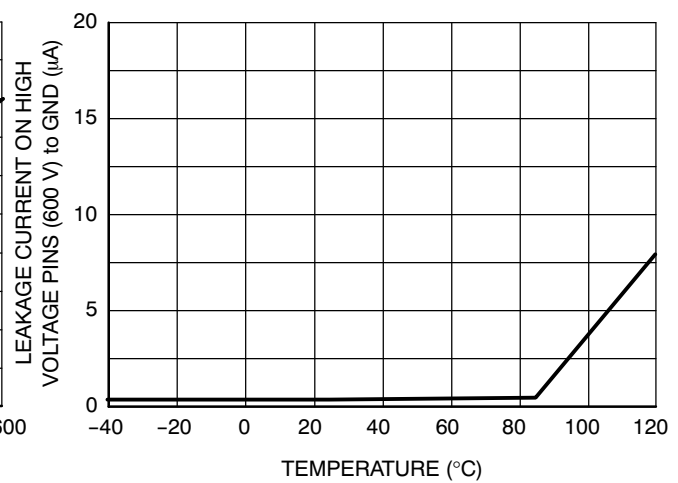


Figure 37. Leakage Current on High Voltage Pins (600 V) to Ground vs. Temperature ( $V_{BRIDGE} = V_{BOOT} = V_{DRV\_HI} = 600$  V)

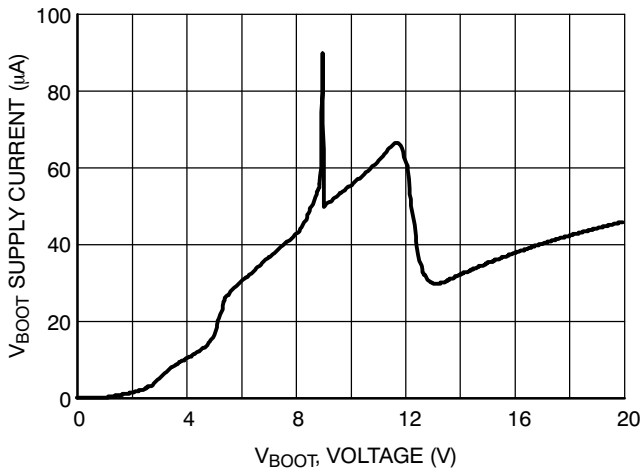


Figure 38.  $V_{BOOT}$  Supply Current vs. Bootstrap Supply Voltage

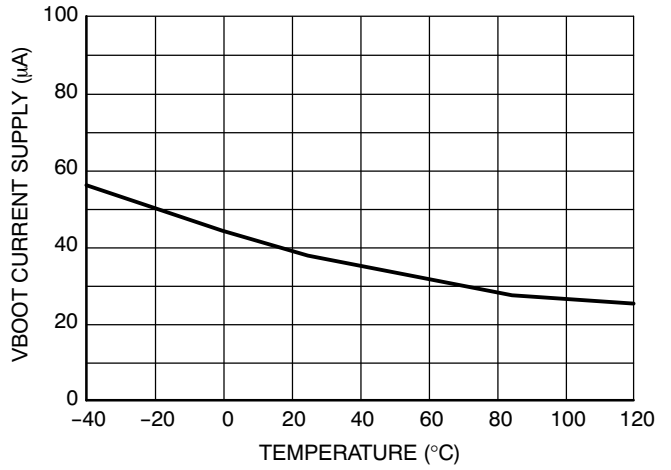


Figure 39.  $V_{BOOT}$  Supply Current vs. Temperature

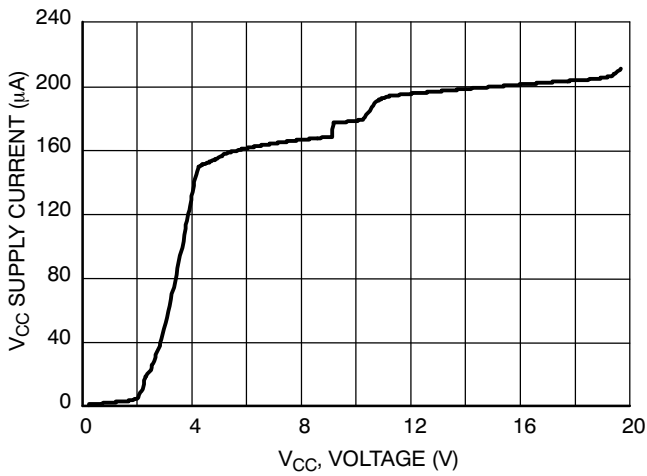


Figure 40.  $V_{CC}$  Supply Current vs.  $V_{CC}$  Supply Voltage

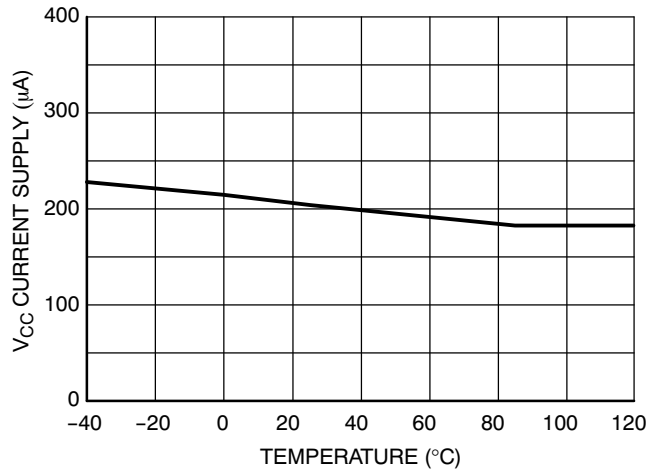


Figure 41.  $V_{CC}$  Supply Current vs. Temperature

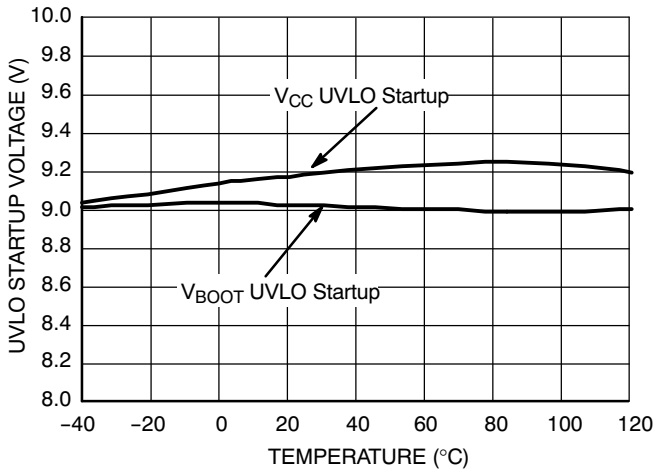


Figure 42. UVLO Startup Voltage vs. Temperature

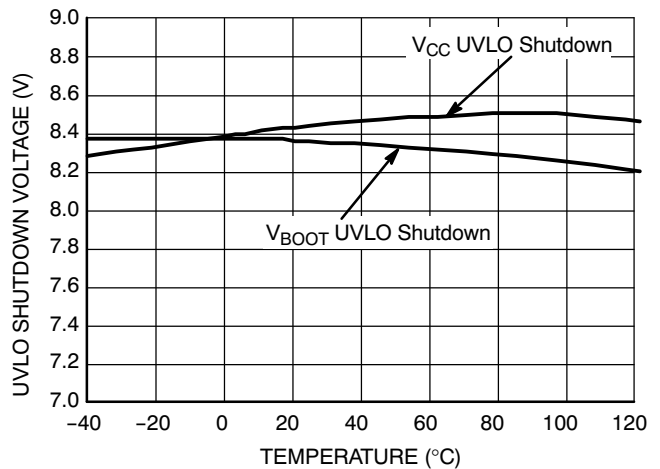
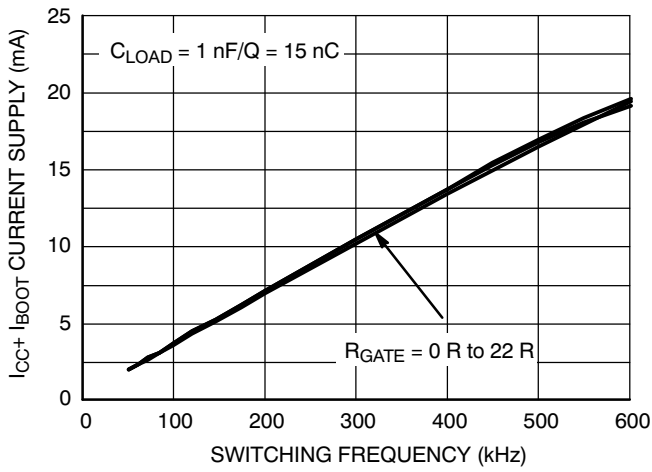
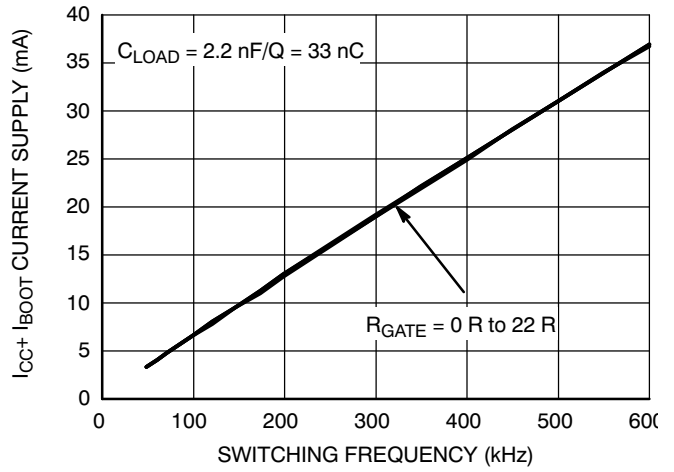


Figure 43. UVLO Shutdown Voltage vs. Temperature

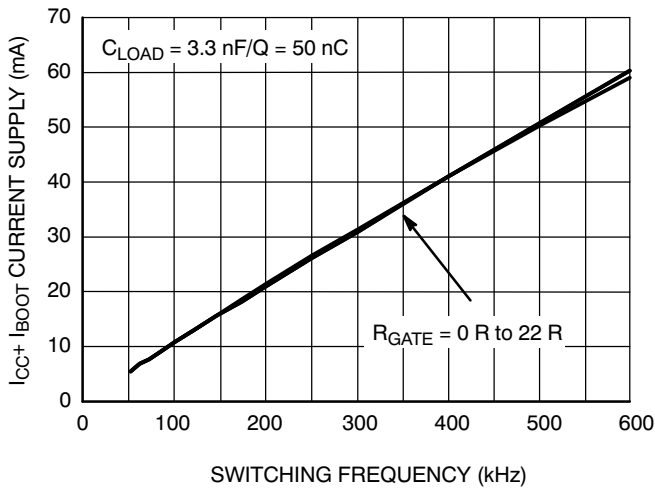
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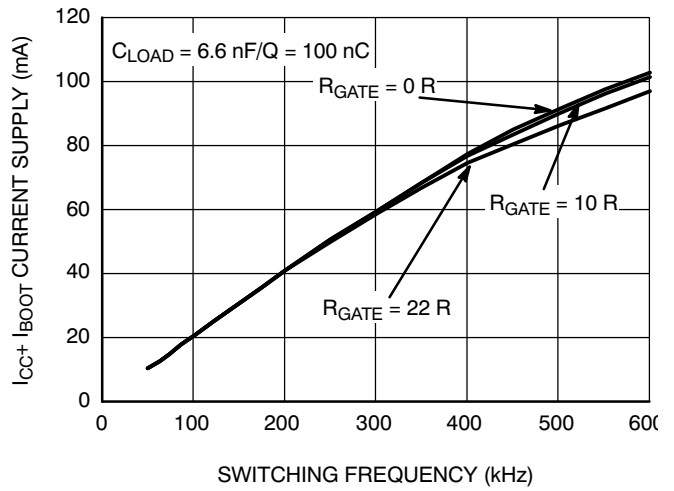
**Figure 44.  $I_{CC1}$  Consumption vs. Switching Frequency with 15 nC Load on Each Driver @  $V_{CC} = 15 V$**



**Figure 45.  $I_{CC1}$  Consumption vs. Switching Frequency with 33 nC Load on Each Driver @  $V_{CC} = 15 V$**



**Figure 46.  $I_{CC1}$  Consumption vs. Switching Frequency with 50 nC Load on Each Driver @  $V_{CC} = 15 V$**

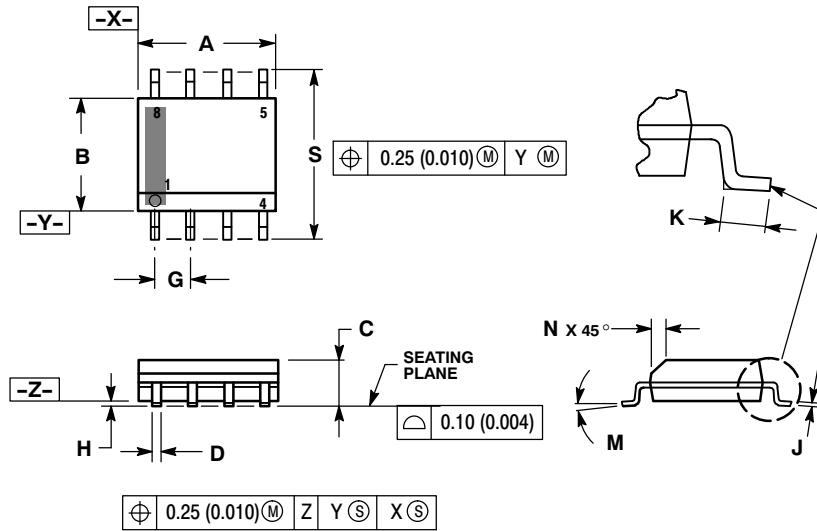


**Figure 47.  $I_{CC1}$  Consumption vs. Switching Frequency with 100 nC Load on Each Driver @  $V_{CC} = 15 V$**

# NCP5304

## PACKAGE DIMENSIONS

SOIC-8 NB  
CASE 751-07  
ISSUE AJ

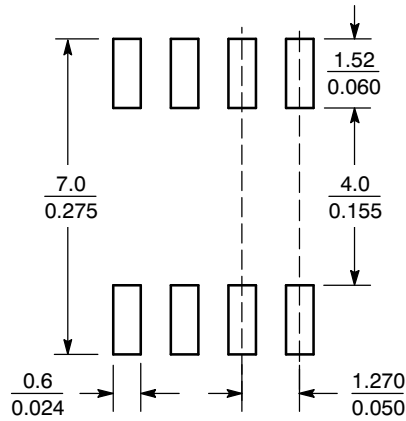


NOTES:

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

### SOLDERING FOOTPRINT\*



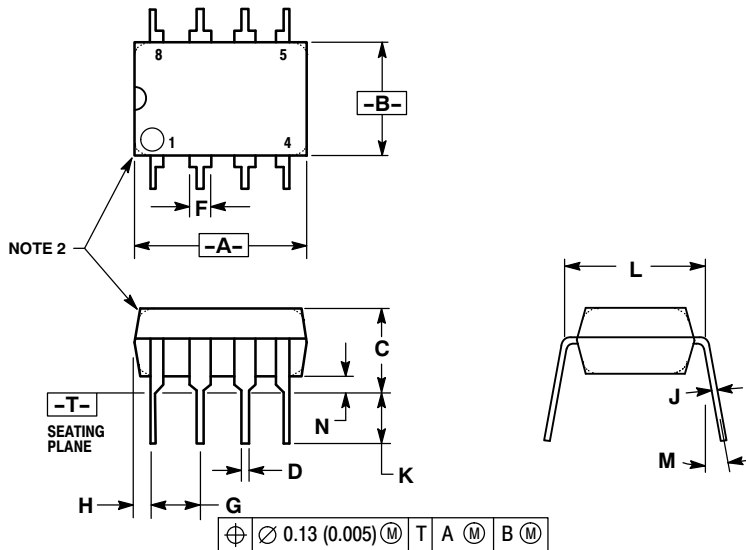
SCALE 6:1  $\left(\frac{\text{mm}}{\text{inches}}\right)$

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

# NCP5304

## PACKAGE DIMENSIONS

8 LEAD PDIP  
CASE 626-05  
ISSUE L



### NOTES:

1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	---	10°	---	10°
N	0.76	1.01	0.030	0.040

The product described herein is covered by U.S. patents: 6,097,075; 7,176,723; 6,362,067. There may be some other patents pending.

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