

# NCP5111

## High Voltage, High and Low Side Driver

The NCP5111 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 ensure a proper drive of the high-side power switch.

### 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
- One Input with Internal Fixed Dead Time (650 ns)
- Under  $V_{CC}$  LockOut (UVLO) for Both Channels
- Pin-to-Pin Compatible with Industry Standards
- These are Pb-Free Devices

### Typical Applications

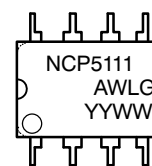
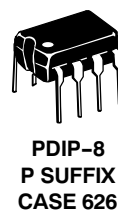
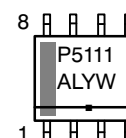
- Half-bridge Power Converters



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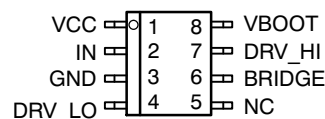
### MARKING DIAGRAMS



NCP5111 = 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

(Note: Microdot may be in either location)

### PINOUT INFORMATION



### ORDERING INFORMATION

| Device      | Package          | Shipping†          |
|-------------|------------------|--------------------|
| NCP5111PG   | PDIP-8 (Pb-Free) | 50 Units / Rail    |
| NCP5111DR2G | 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.

## NCP5111

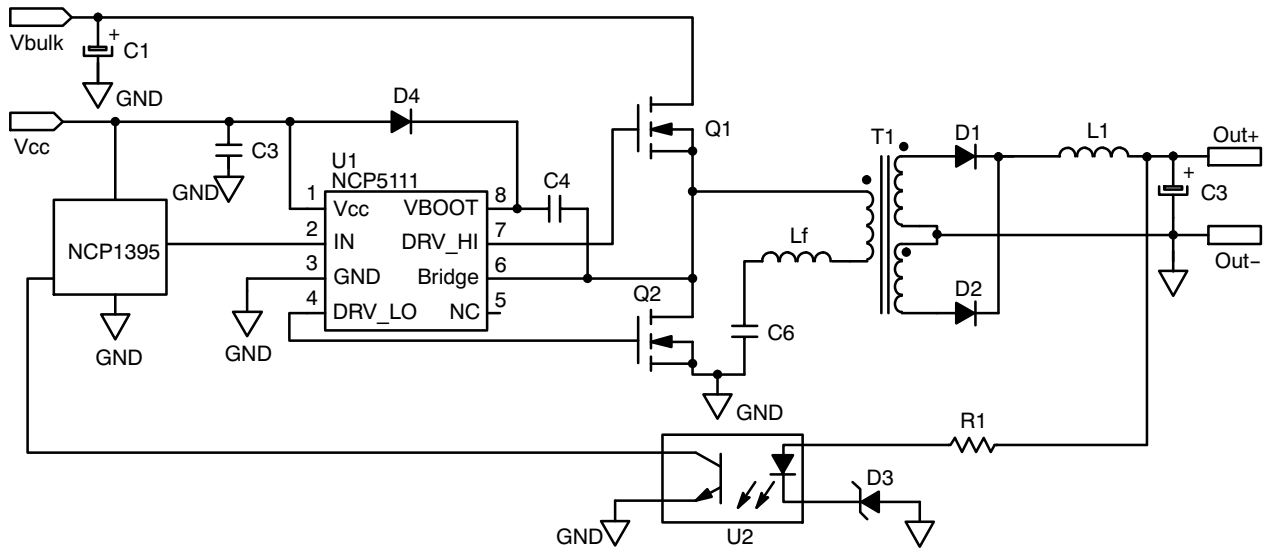


Figure 1. Typical Application Resonant Converter (LLC type)

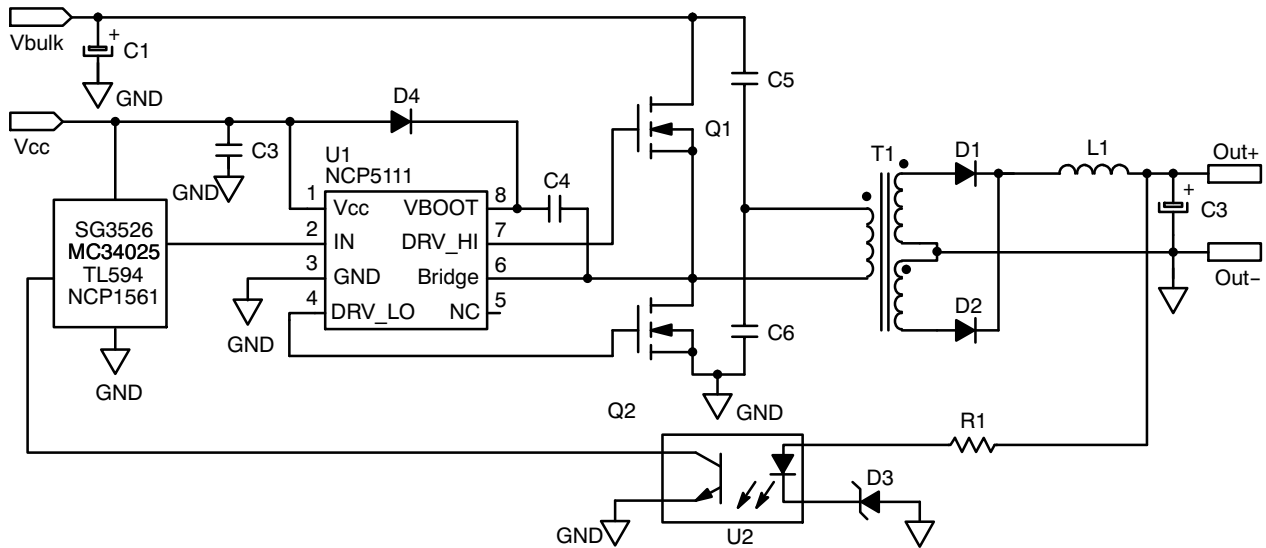


Figure 2. Typical Application Half Bridge Converter

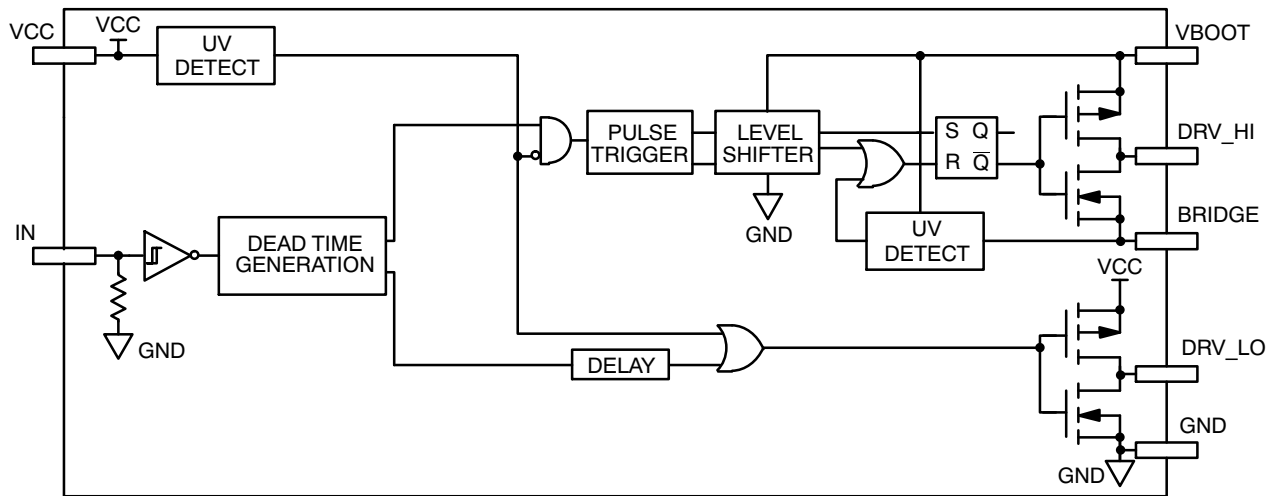


Figure 3. Detailed Block Diagram

# NCP5111

## PIN DESCRIPTIONS

| Pin No. | Pin Name | Pin Function                                         |
|---------|----------|------------------------------------------------------|
| 1       | VCC      | Low side and main power supply                       |
| 2       | IN       | Logic Input                                          |
| 3       | GND      | Ground                                               |
| 4       | DRV_LO   | Low side gate drive output                           |
| 5       | NC       | Not Connected                                        |
| 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:<br>$I_{VCC\_max} = 5\text{ mA}$ 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       |
| $V_{BOOT}-V_{BRIDGE}$ | 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    |
| $V_{IN}$              | Inputs IN                                                                                                                                 | -1.0 to $V_{CC} + 0.3$                 | V       |
|                       | ESD Capability:<br>- HBM model (all pins except pins 6-7-8)<br>- Machine model (all pins except pins 6-7-8)                               | 2<br>200                               | kV<br>V |
|                       | Latchup capability per JEDEC JESD78                                                                                                       |                                        |         |
| $R_{\theta JA}$       | Power dissipation and Thermal characteristics<br>PDIP-8: Thermal Resistance, Junction-to-Air<br>SO-8: Thermal Resistance, Junction-to-Air | 100<br>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.

# NCP5111

**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 <sub>J</sub> -40°C to 125°C |     |     | Units |
|--------|--------|-------------------------------|-----|-----|-------|
|        |        | Min                           | Typ | Max |       |

## OUTPUT SECTION

|                                                                                                            |                 |   |     |     |          |
|------------------------------------------------------------------------------------------------------------|-----------------|---|-----|-----|----------|
| Output high short circuit pulsed current $V_{DRV} = 0\text{ V}$ , $PW \leq 10\text{ }\mu\text{s}$ (Note 1) | $I_{DRVsource}$ | - | 250 | -   | mA       |
| Output low short circuit pulsed current $V_{DRV} = V_{CC}$ , $PW \leq 10\text{ }\mu\text{s}$ (Note 1)      | $I_{DRVsink}$   | - | 500 | -   | mA       |
| Output resistor (Typical value @ 25°C) Source                                                              | $R_{OH}$        | - | 30  | 60  | $\Omega$ |
| Output resistor (Typical value @ 25°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 ( $V_{bridge} = 0\text{ V}$ ) (Note 2)                          | $t_{ON}$   | -   | 750 | 1170 | ns |
| Turn-off propagation delay ( $V_{bridge} = 0\text{ V}$ or $50\text{ V}$ ) (Notes 2 and 3) | $t_{OFF}$  | -   | 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°C (Note 4)         | $\Delta t$ | -   | 30  | 60   | ns |
| Internal fixed dead time (Note 5)                                                         | $DT$       | 400 | 650 | 1000 | ns |

## INPUT SECTION

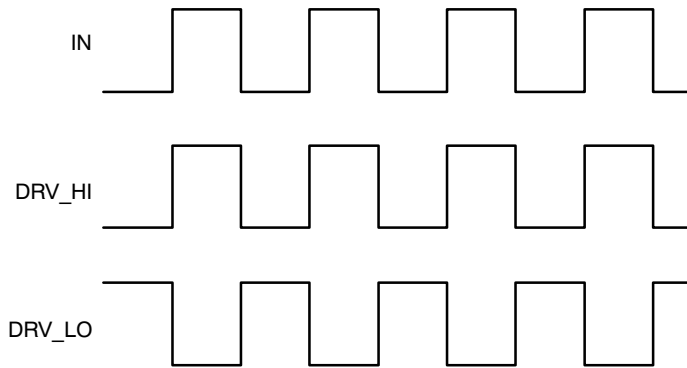
|                                                             |           |     |     |     |               |
|-------------------------------------------------------------|-----------|-----|-----|-----|---------------|
| Low level input voltage threshold                           | $V_{IN}$  | -   | -   | 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 @ $V_{IN} = 5\text{ V}$ @ 25°C | $I_{IN+}$ | -   | 5   | 25  | $\mu\text{A}$ |
| Logic "0" input bias current @ $V_{IN} = 0\text{ V}$ @ 25°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  | -   | $\mu\text{A}$ |

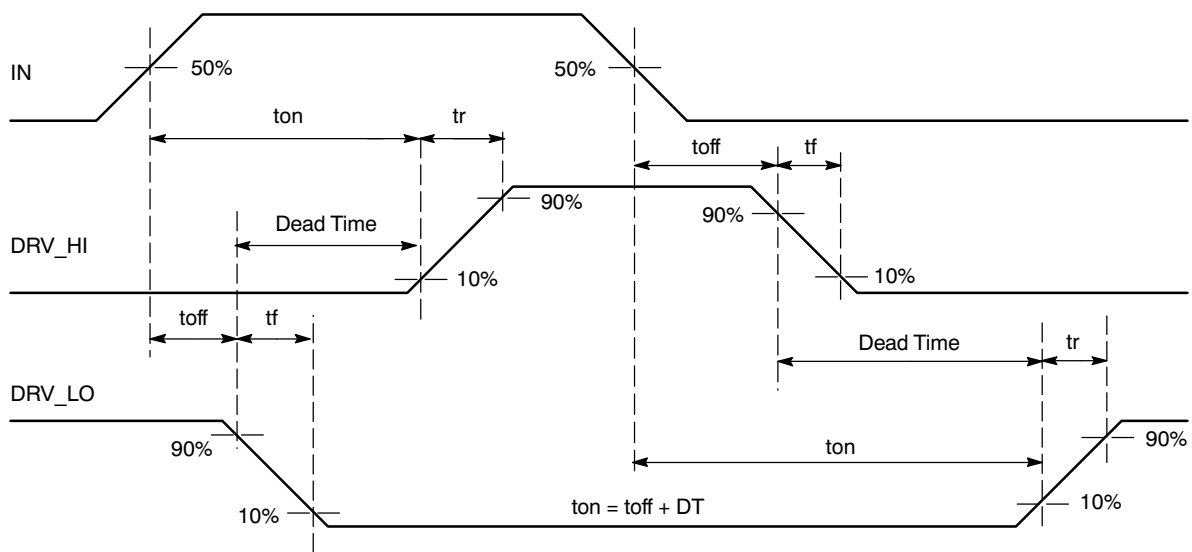
1. Parameter guaranteed by design.
2.  $T_{ON} = T_{OFF} + DT$ .
3. Turn-off propagation delay @  $V_{bridge} = 600\text{ V}$  is guaranteed by design.
4. See characterization curve for  $\Delta t$  parameters variation on the full range temperature.
5. Timing diagram definition see: Figure 5 and Figure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

# NCP5111

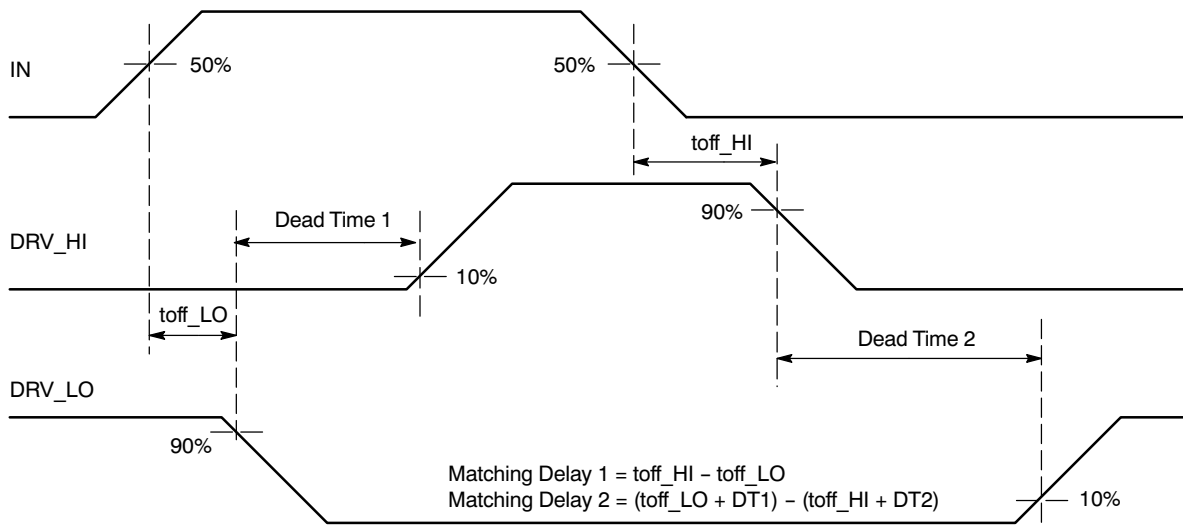


Note: DRV\_HI output is in phase with the input.

**Figure 4. Input/Output Timing Diagram**

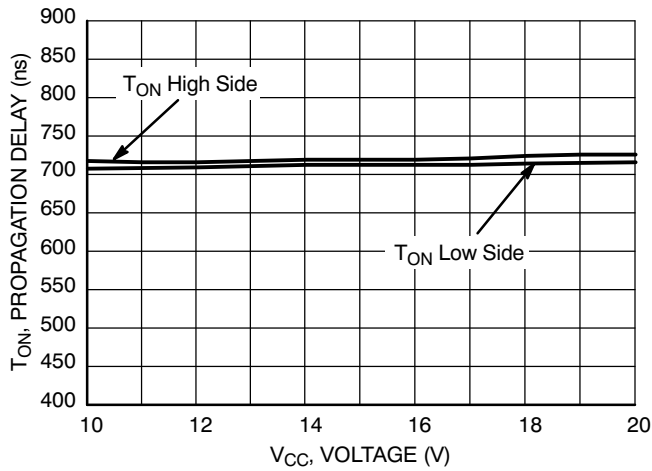


**Figure 5. Timing Definitions**

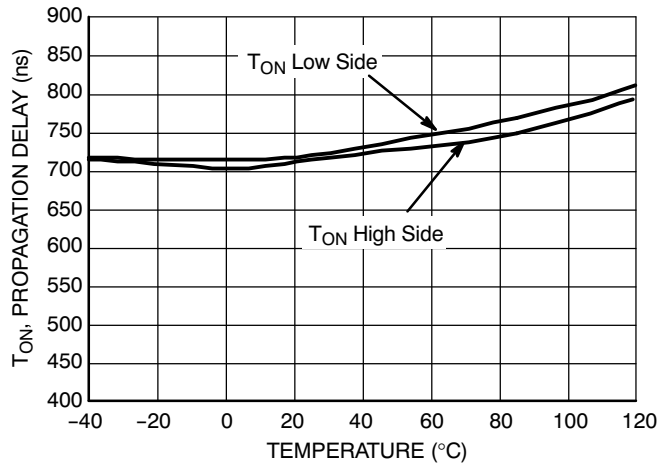


**Figure 6. Matching Propagation Delay**

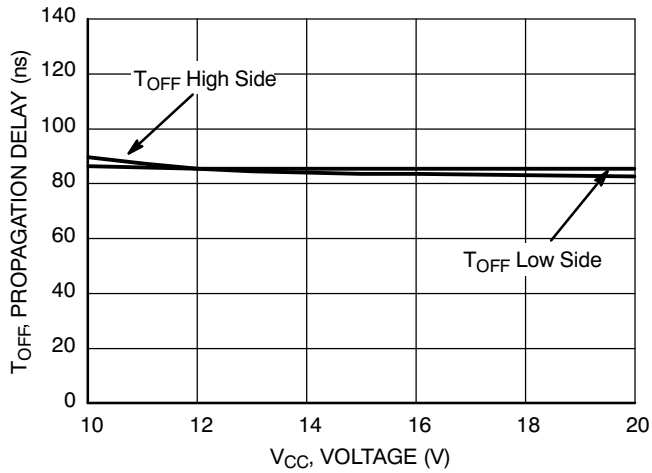
# CHARACTERIZATION CURVES



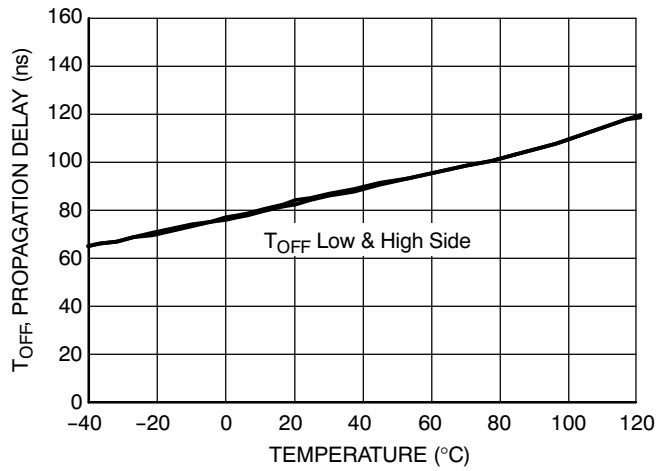
**Figure 7. Turn ON Propagation Delay vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )**



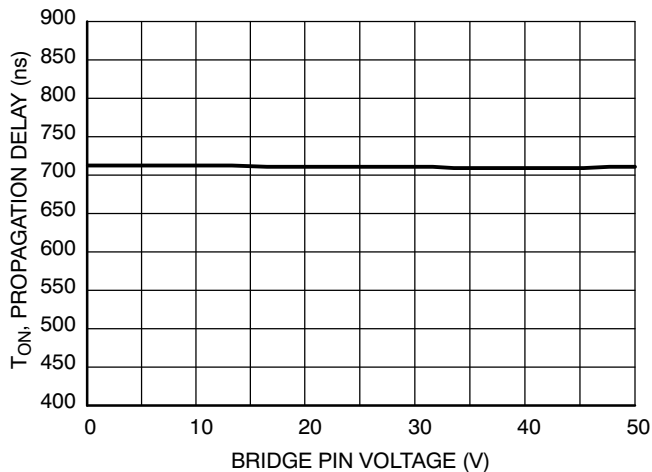
**Figure 8. Turn ON Propagation Delay vs. Temperature**



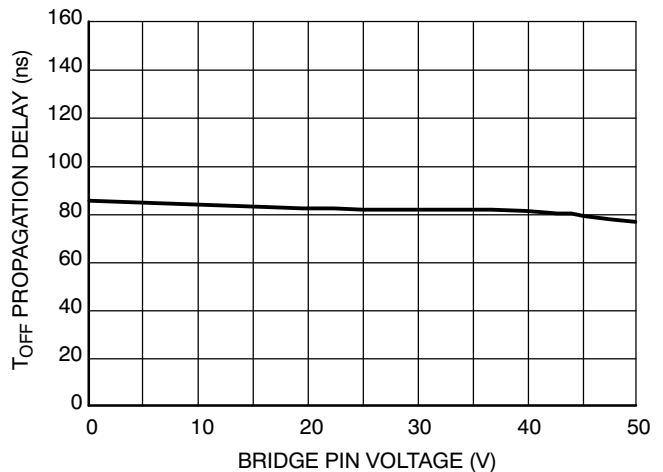
**Figure 9. Turn OFF Propagation Delay vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )**



**Figure 10. Turn OFF Propagation Delay vs. Temperature**



**Figure 11. High Side Turn ON Propagation Delay vs.  $V_{BRIDGE}$  Voltage**



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

CHARACTERIZATION CURVES

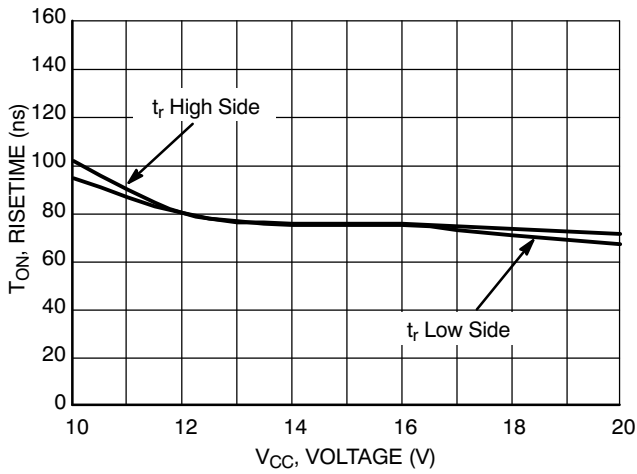


Figure 13. Turn ON Risettime vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

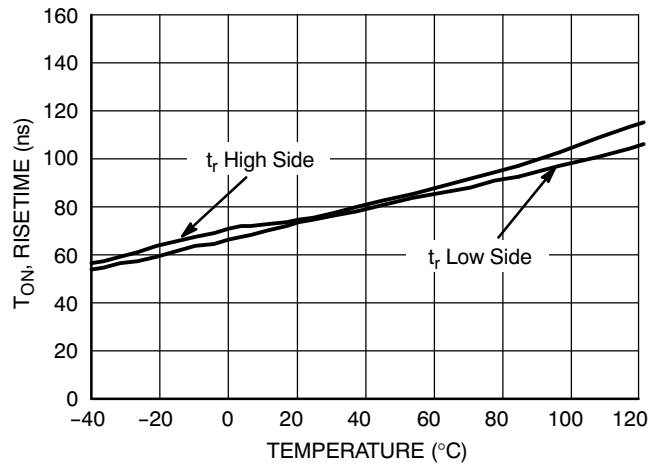


Figure 14. Turn ON Risettime vs. Temperature

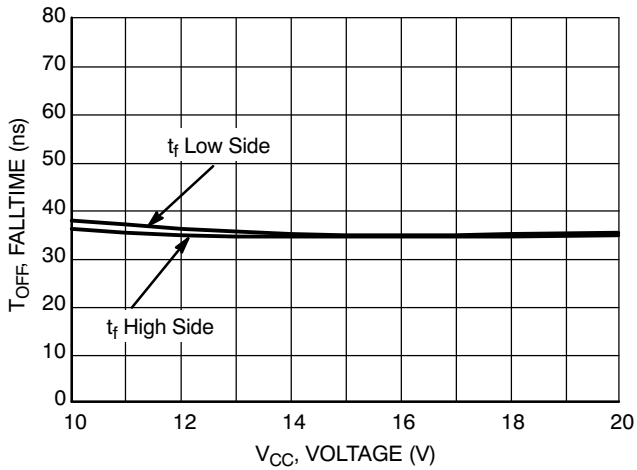


Figure 15. Turn OFF Falltime vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

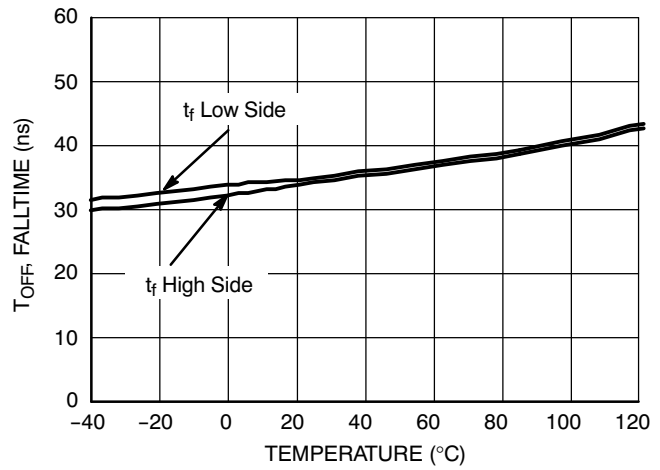


Figure 16. Turn OFF Falltime vs. Temperature

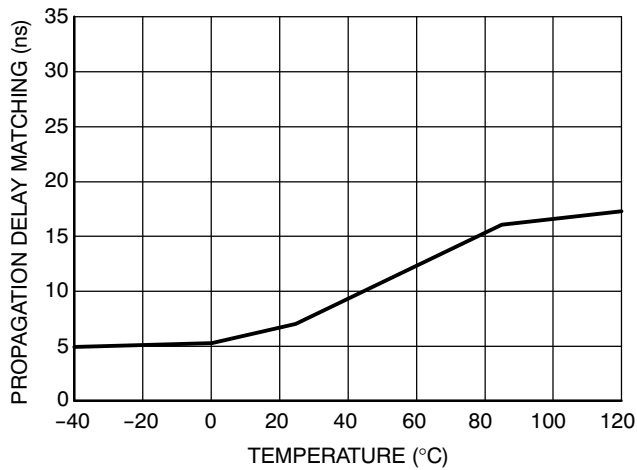


Figure 17. Propagation Delay Matching Between High Side and Low Side Driver vs. Temperature

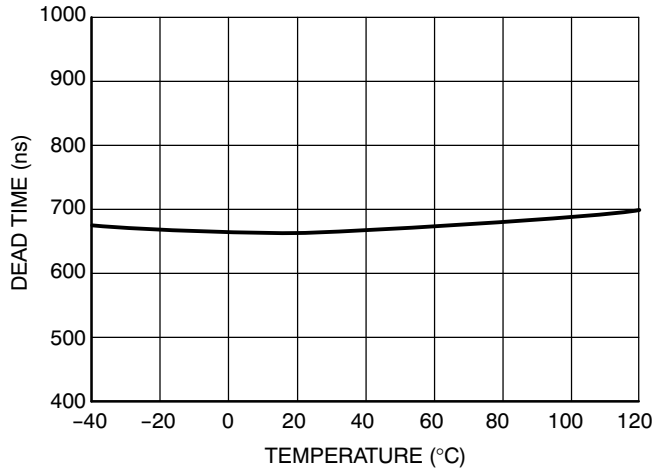


Figure 18. Dead Time vs. Temperature

CHARACTERIZATION CURVES

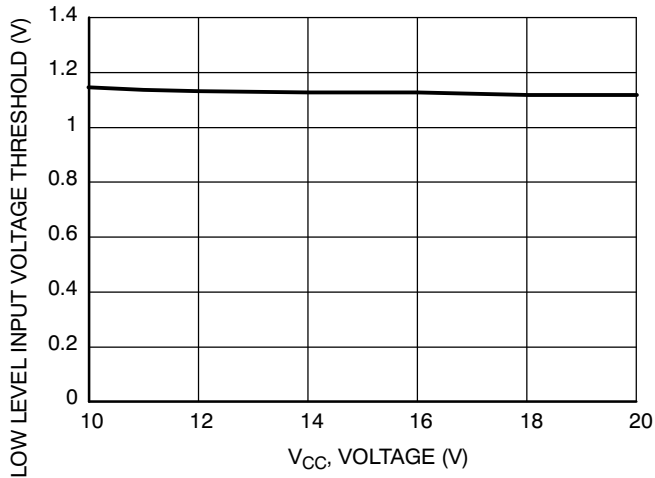


Figure 19. Low Level Input Voltage Threshold vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

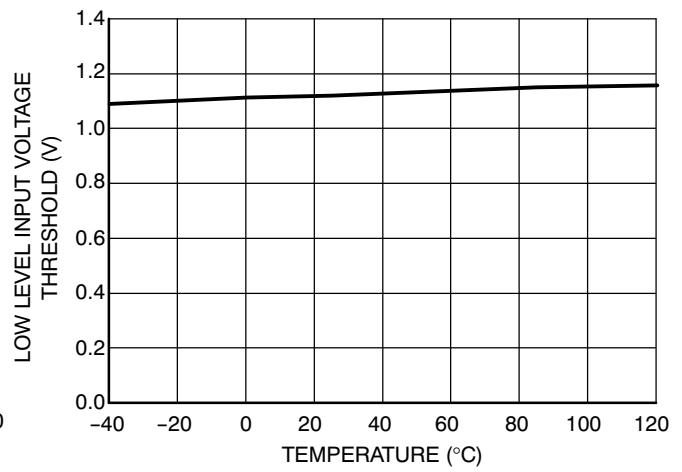


Figure 20. Low Level Input Voltage Threshold vs. Temperature

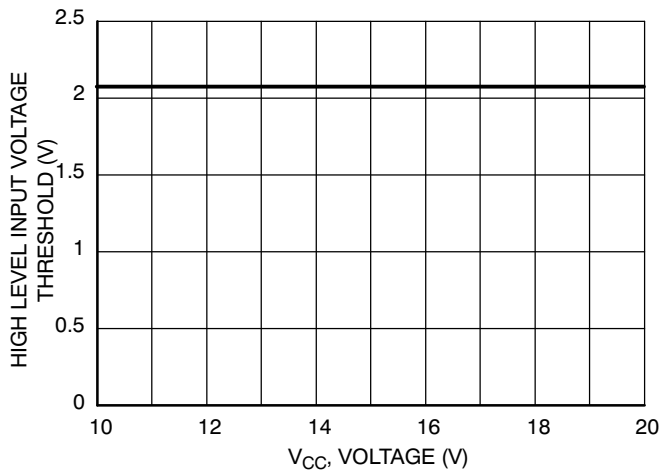


Figure 21. High Level Input Voltage Threshold vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

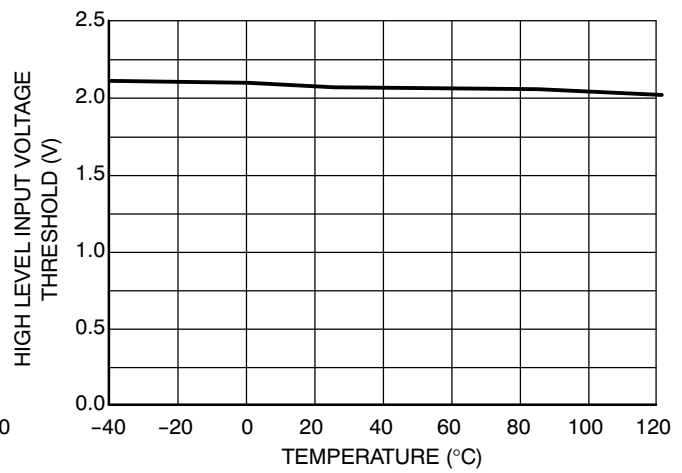


Figure 22. High Level Input Voltage Threshold vs. Temperature

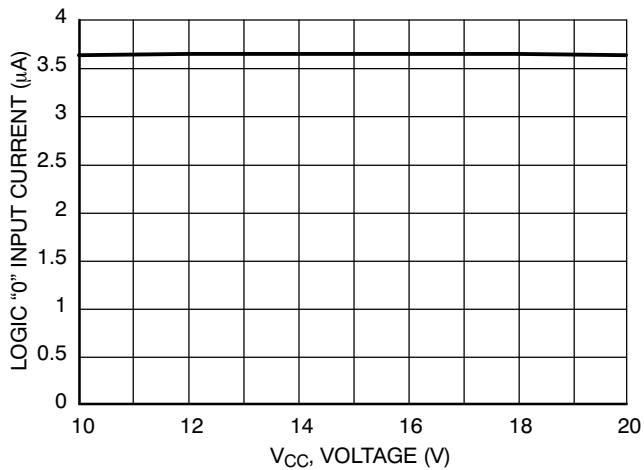


Figure 23. Logic "0" Input Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

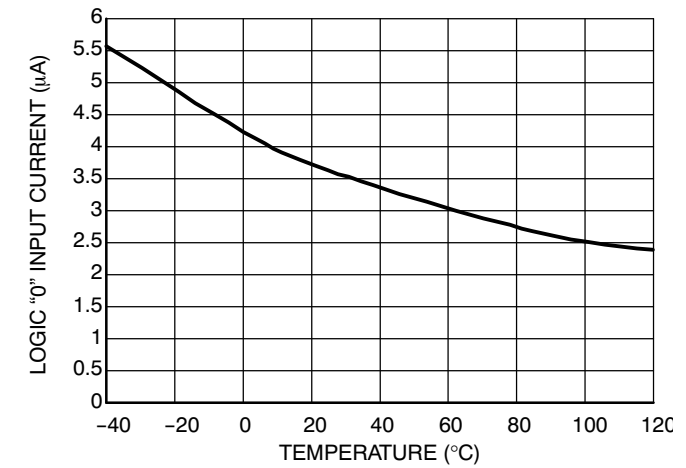


Figure 24. Logic "0" Input Current vs. Temperature



CHARACTERIZATION CURVES

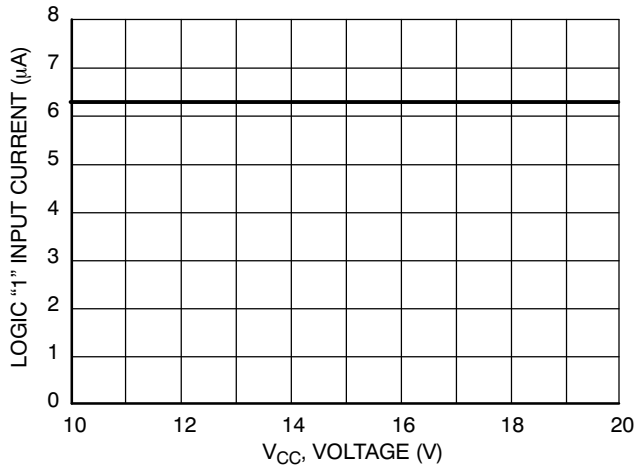


Figure 25. Logic "1" Input Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

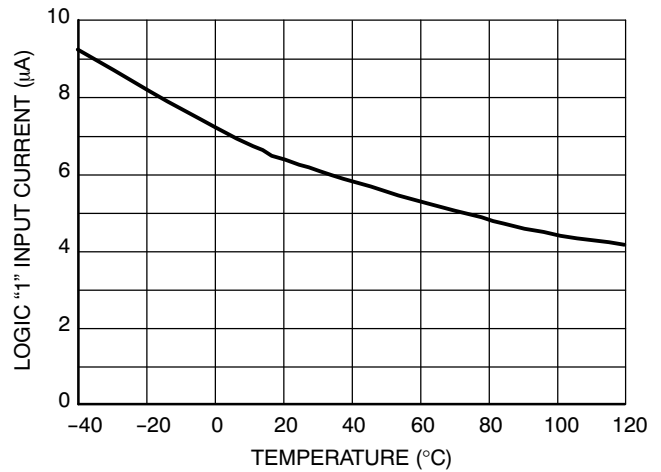


Figure 26. Logic "1" Input Current vs. Temperature

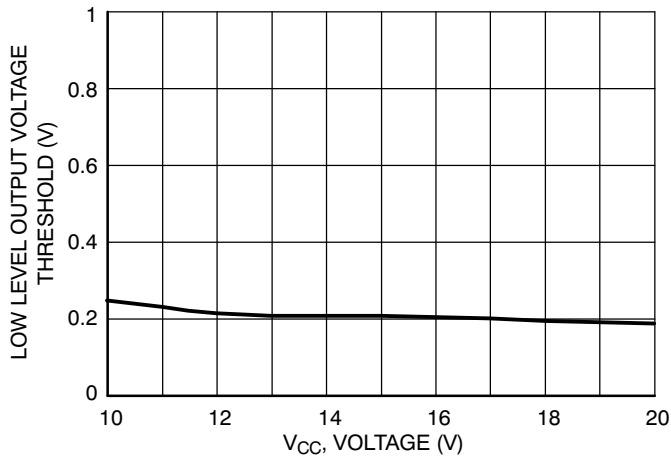


Figure 27. Low Level Output Voltage vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

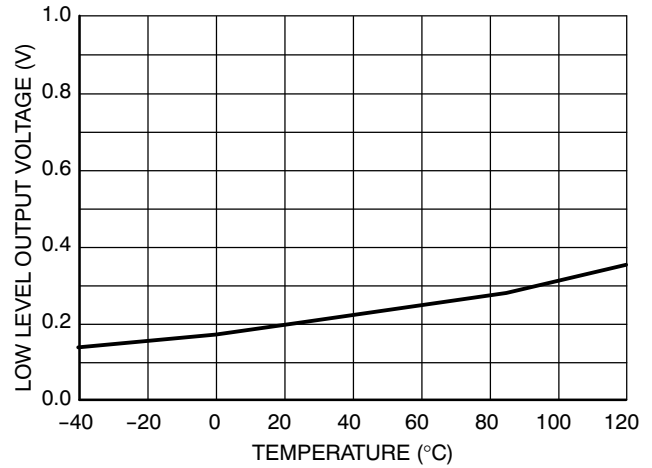


Figure 28. Low Level Output Voltage vs. Temperature

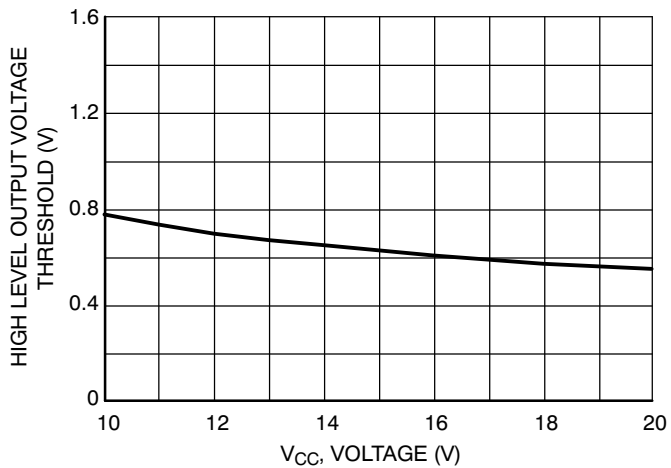


Figure 29. High Level Output Voltage vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

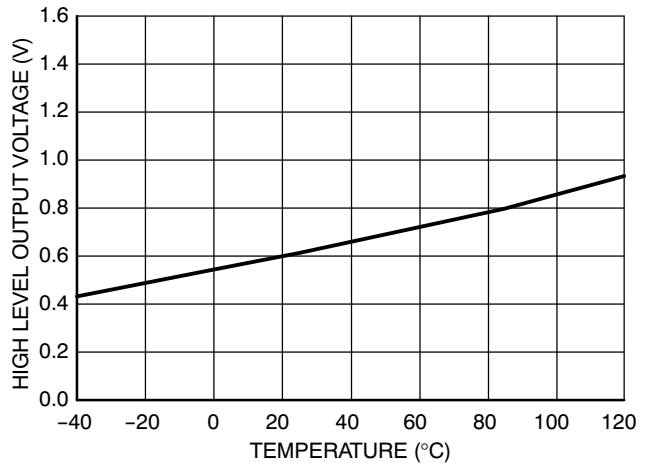


Figure 30. High Level Output Voltage vs. Temperature

CHARACTERIZATION CURVES

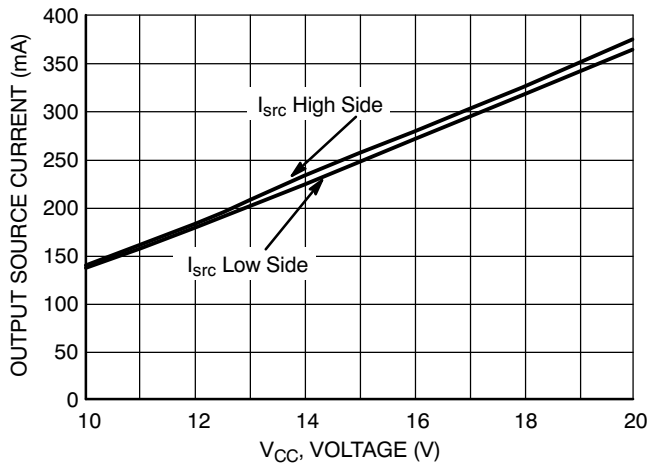


Figure 31. Output Source Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

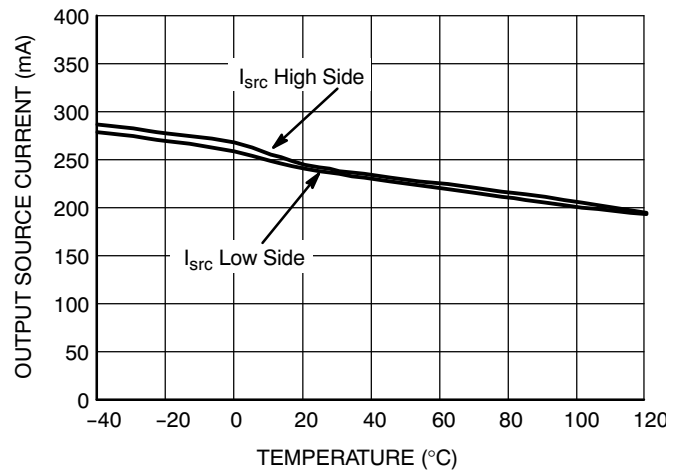


Figure 32. Output Source Current vs. Temperature

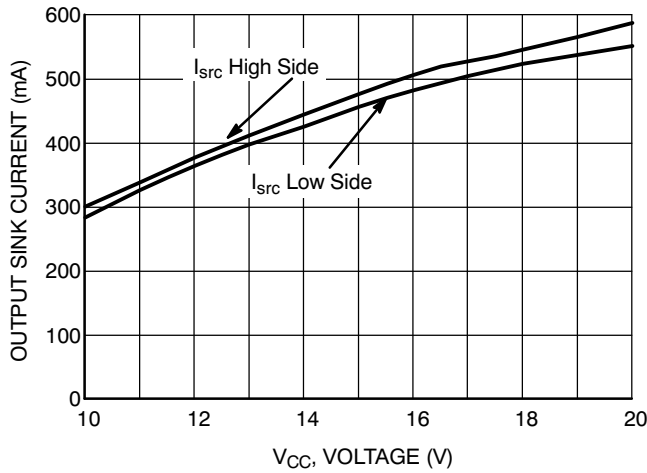


Figure 33. Output Sink Current vs. Supply Voltage ( $V_{CC} = V_{BOOT}$ )

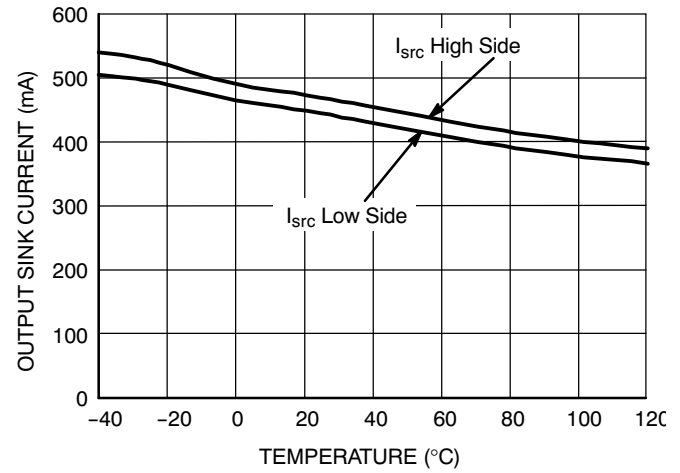


Figure 34. Output Sink Current vs. Temperature

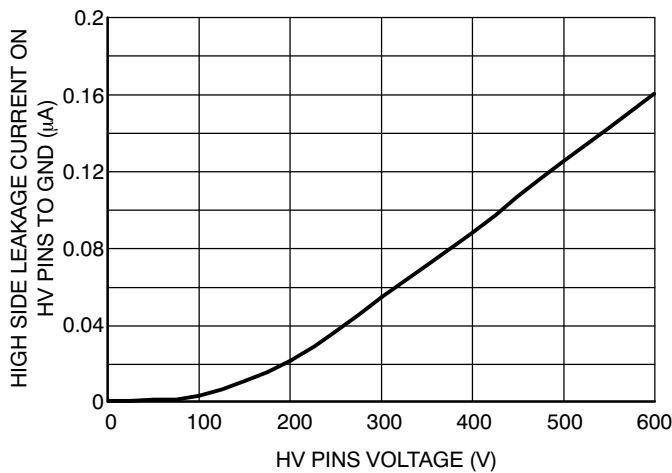


Figure 35. Leakage Current on High Voltage Pins (600 V) to Ground vs.  $V_{BRIDGE}$  Voltage ( $V_{BRIDGE} = V_{BOOT} = V_{DRV\_HI}$ )

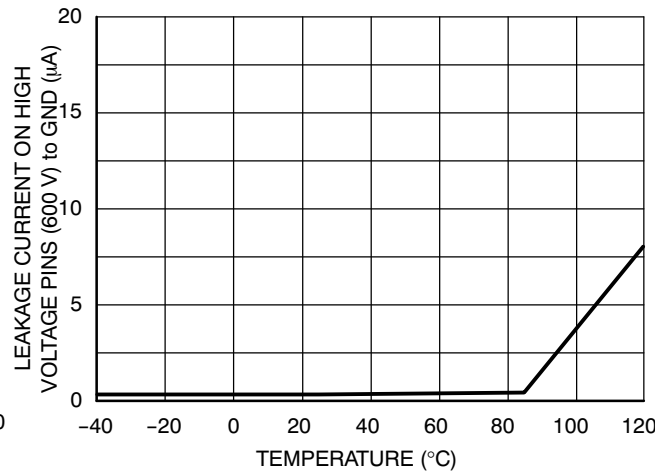


Figure 36. Leakage Current on High Voltage Pins (600 V) to Ground vs. Temperature ( $V_{BRIDGE} = V_{BOOT} = V_{DRV\_HI} = 600$  V)

CHARACTERIZATION CURVES

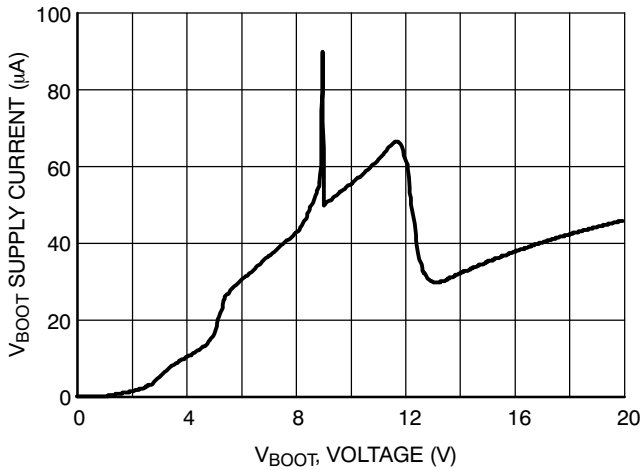


Figure 37.  $V_{BOOT}$  Supply Current vs. Bootstrap Supply Voltage

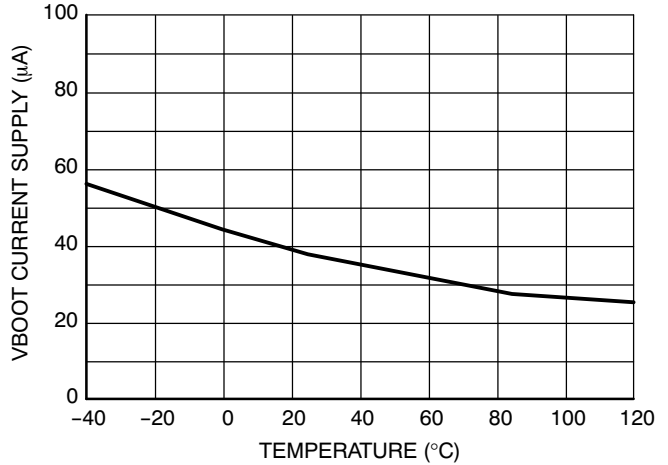


Figure 38.  $V_{BOOT}$  Supply Current vs. Temperature

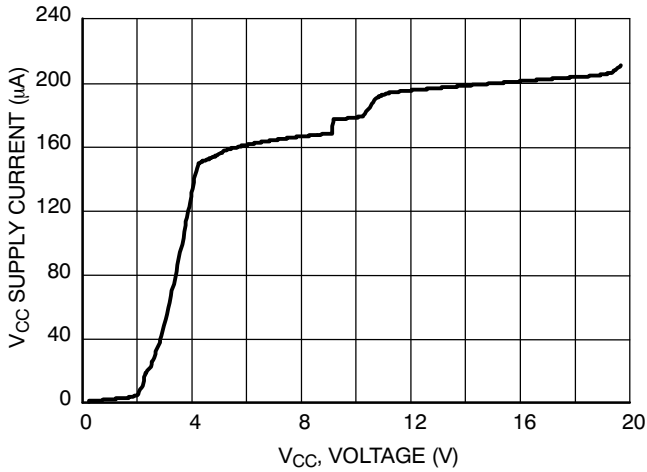


Figure 39.  $V_{CC}$  Supply Current vs.  $V_{CC}$  Supply Voltage

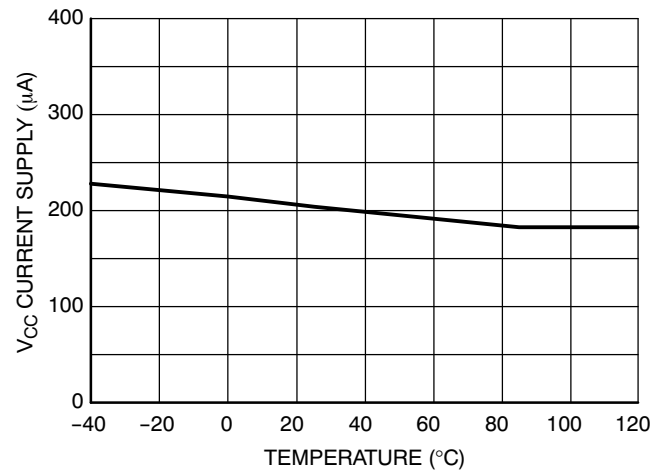


Figure 40.  $V_{CC}$  Supply Current vs. Temperature

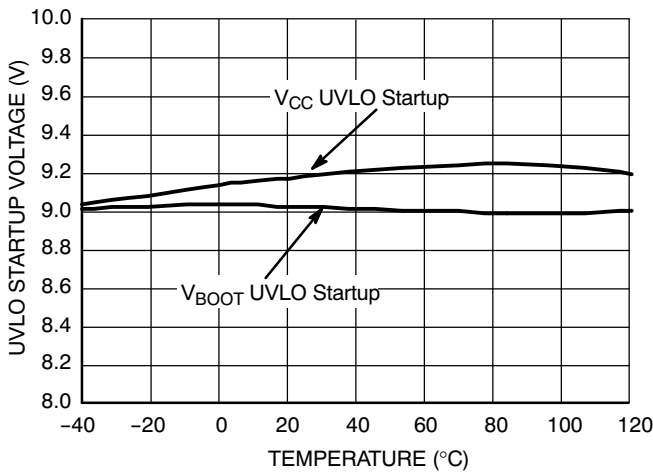


Figure 41. UVLO Startup Voltage vs. Temperature

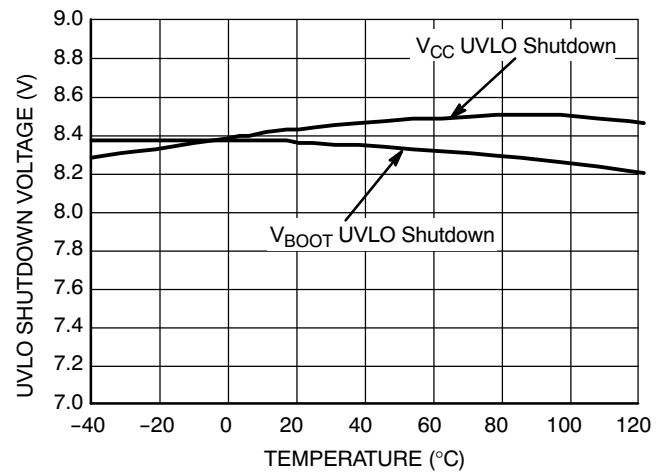
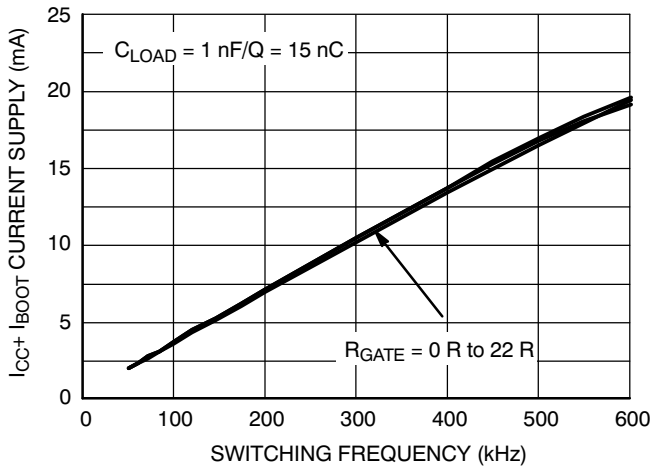
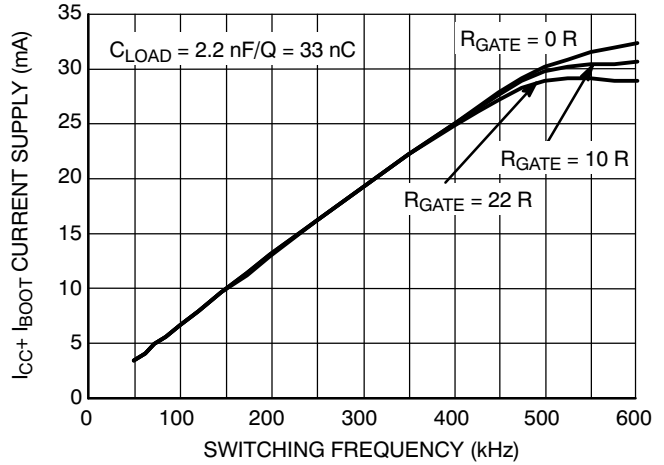


Figure 42. UVLO Shutdown Voltage vs. Temperature

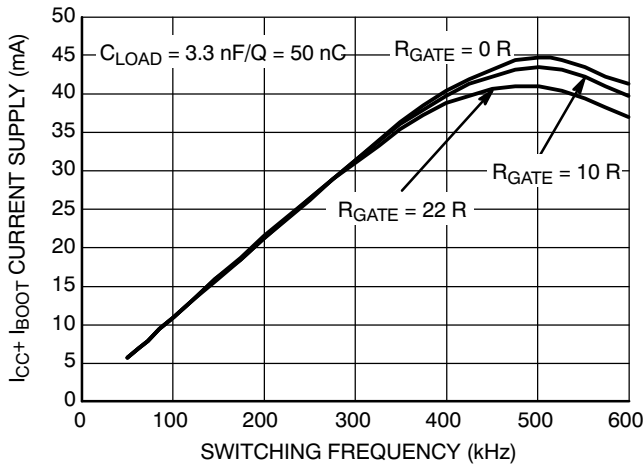
## CHARACTERIZATION CURVES



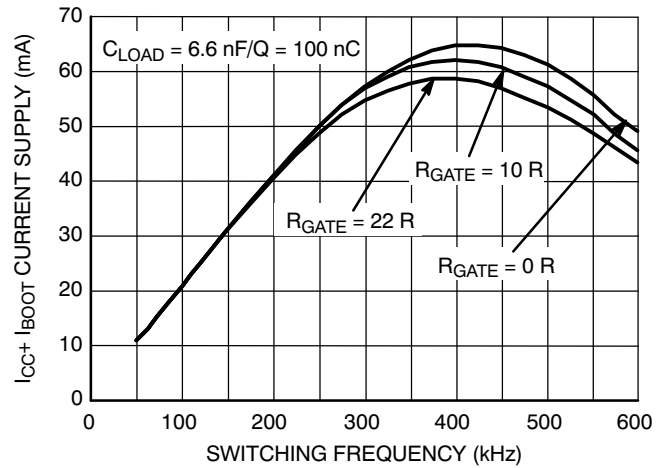
**Figure 43.  $I_{CC1}$  Consumption vs. Switching Frequency with 15 nC Load on Each Driver @  $V_{CC} = 15\text{ V}$**



**Figure 44.  $I_{CC1}$  Consumption vs. Switching Frequency with 33 nC Load on Each Driver @  $V_{CC} = 15\text{ V}$**



**Figure 45.  $I_{CC1}$  Consumption vs. Switching Frequency with 50 nC Load on Each Driver @  $V_{CC} = 15\text{ V}$**

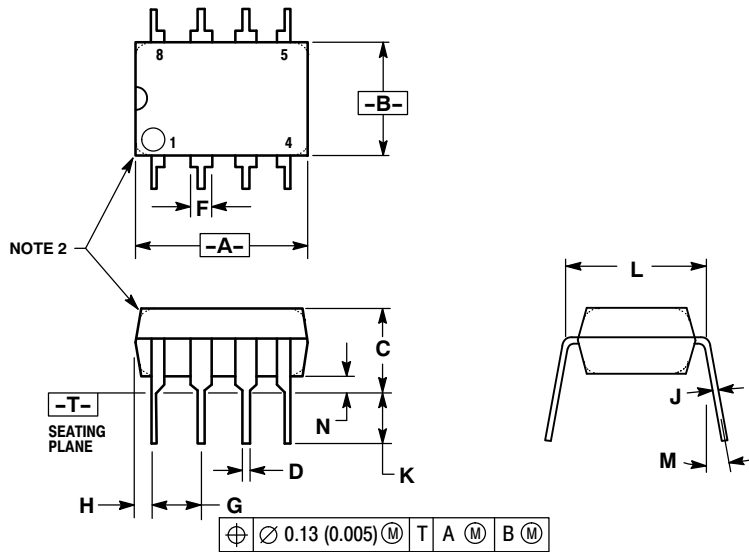


**Figure 46.  $I_{CC1}$  Consumption vs. Switching Frequency with 100 nC Load on Each Driver @  $V_{CC} = 15\text{ V}$**

# NCP5111

## PACKAGE DIMENSIONS

8 LEAD PDIP  
CASE 626-05  
ISSUE L



### NOTES:

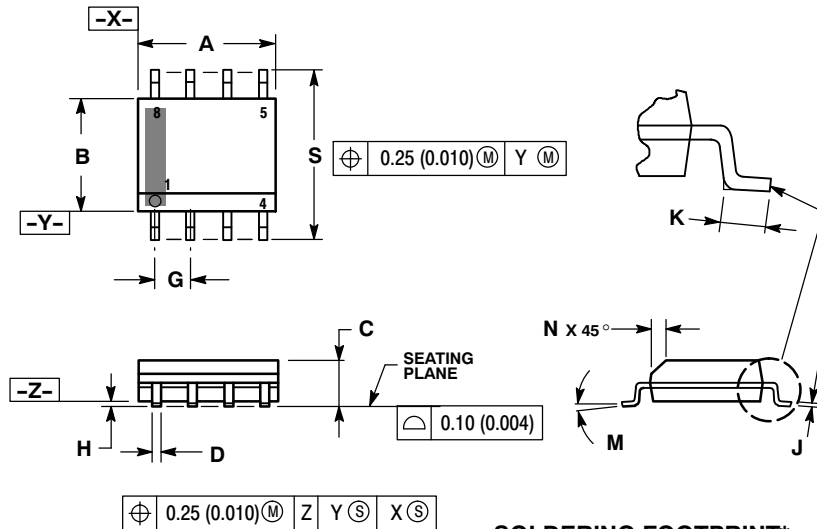
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

| 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 |

# NCP5111

## PACKAGE DIMENSIONS

### SOIC-8 NB CASE 751-07 ISSUE AJ

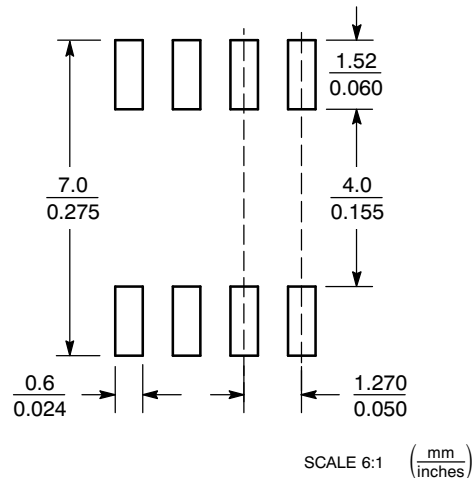


#### NOTES:

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\*



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

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