

# NCP81151

## MOSFET Driver, VR12.5 Compatible Synchronous Buck

The NCP81151 is a high performance dual MOSFET gate driver optimized to drive the gates of both high-side and low-side power MOSFETs in a synchronous buck converter. It can drive up to 3 nF load with a 25 ns propagation delay and 20 ns transition time.

Adaptive anti-cross-conduction and power saving operation circuit can provide a low switching loss and high efficiency solution for notebook systems.

The UVLO function guarantees the outputs are low when the supply voltage is low.

### Features

- Faster Rise and Fall Times
- Adaptive Anti-Cross-Conduction Circuit
- Zero Cross Detection function
- Output Disable Control Turns Off Both MOSFETs
- Undervoltage Lockout
- Power Saving Operation Under Light Load Conditions
- Direct Interface to NCP6131 and Other Compatible PWM Controllers
- Thermally Enhanced Package
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Typical Applications

- Power Management Solutions for Notebook Systems



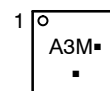
ON Semiconductor®

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DFN8  
CASE 506AA

### MARKING DIAGRAM



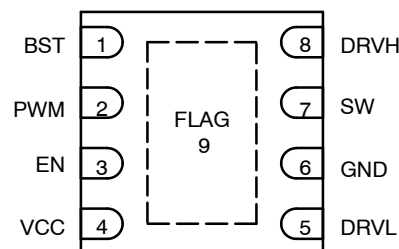
A3 = Specific Device Code

M = Date Code

▪ = Pb-Free Package

(Note: Microdot may be in either location)

### PINOUT DIAGRAM



### ORDERING INFORMATION

| Device        | Package           | Shipping†             |
|---------------|-------------------|-----------------------|
| NCP81151MNTAG | DFN8<br>(Pb-Free) | 3000 / Tape &<br>Reel |
| NCP81151MNTBG | DFN8<br>(Pb-Free) | 3000 / Tape &<br>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.

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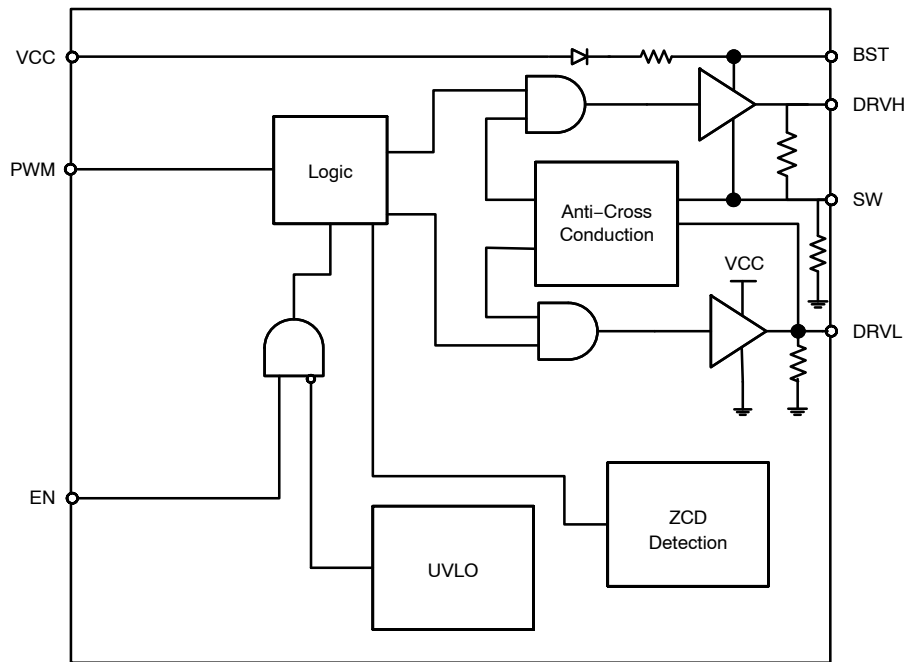


Figure 1. Block Diagram

## PIN DESCRIPTIONS

| Pin No. | Symbol | Description                                                                                                                                                                                                                                                                  |
|---------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | BST    | Floating bootstrap supply pin for high side gate driver. Connect the bootstrap capacitor between this pin and the SW pin.                                                                                                                                                    |
| 2       | PWM    | Control input. The PWM signal has three distinctive states: Low = Low Side FET Enabled, Mid = Diode Emulation Enabled, High = High Side FET Enabled.                                                                                                                         |
| 3       | EN     | Logic input. A logic high to enable the part and a logic low to disable the part. Three states logic input:<br>EN = High to enable the gate driver;<br>EN = Low to disable the driver;<br>EN = Mid to go into diode mode (both high and low side gate drive signals are low) |
| 4       | VCC    | Power supply input. Connect a bypass capacitor (0.1 $\mu$ F) from this pin to ground.                                                                                                                                                                                        |
| 5       | DRVL   | Low side gate drive output. Connect to the gate of low side MOSFET.                                                                                                                                                                                                          |
| 6       | GND    | Bias and reference ground. All signals are referenced to this node.                                                                                                                                                                                                          |
| 7       | SW     | Switch node. Connect this pin to the source of the high side MOSFET and drain of the low side MOSFET.                                                                                                                                                                        |
| 8       | DRVH   | High side gate drive output. Connect to the gate of high side MOSFET.                                                                                                                                                                                                        |
| 9       | FLAG   | Thermal flag. There is no electrical connection to the IC. Connect to ground plane.                                                                                                                                                                                          |

# NCP81151

## APPLICATION CIRCUIT

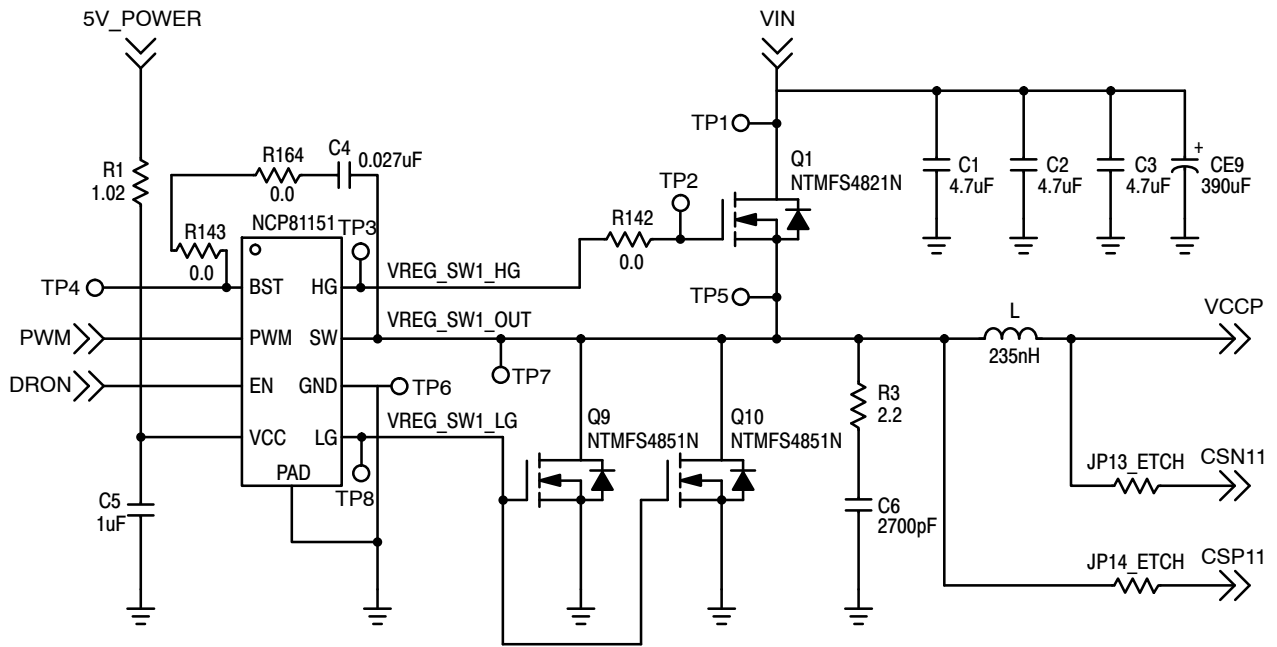


Figure 2. Application Circuit

# NCP81151

## ABSOLUTE MAXIMUM RATINGS

### ELECTRICAL INFORMATION

| Symbol          | Pin Name                                 | V <sub>MAX</sub>                                                                 | V <sub>MIN</sub>                        |
|-----------------|------------------------------------------|----------------------------------------------------------------------------------|-----------------------------------------|
| V <sub>CC</sub> | Main Supply Voltage Input                | 6.5 V                                                                            | -0.3 V                                  |
| BST             | Bootstrap Supply Voltage                 | 35 V wrt/ GND<br>40 V ≤ 50 ns wrt/ GND<br>6.5 V wrt/ SW<br>7.7 V < 50 ns wrt/ SW | -0.3 V wrt/SW                           |
| SW              | Switching Node (Bootstrap Supply Return) | 35 V<br>40 V ≤ 50 ns                                                             | -5 V<br>-10 V (200 ns)                  |
| DRVH            | High Side Driver Output                  | BST + 0.3 V                                                                      | -0.3 V wrt/SW<br>-2 V (< 200 ns) wrt/SW |
| DRVL            | Low Side Driver Output                   | V <sub>CC</sub> + 0.3 V                                                          | -0.3 V DC<br>-5 V (< 200 ns)            |
| PWM             | DRVH and DRVL Control Input              | 6.5 V                                                                            | -0.3 V                                  |
| EN              | Enable Pin                               | 6.5 V                                                                            | -0.3 V                                  |
| GND             | Ground                                   | 0 V                                                                              | 0 V                                     |

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.

\*All signals referenced to AGND unless noted otherwise.

### THERMAL INFORMATION

| Symbol           | Parameter                                     | Value       | Unit |
|------------------|-----------------------------------------------|-------------|------|
| R <sub>θJA</sub> | Thermal Characteristic QFN Package (Note 1)   | 119         | °C/W |
| T <sub>J</sub>   | Operating Junction Temperature Range (Note 2) | -40 to 150  | °C   |
| T <sub>A</sub>   | Operating Ambient Temperature Range           | -40 to +100 | °C   |
| T <sub>STG</sub> | Maximum Storage Temperature Range             | -55 to +150 | °C   |
| MSL              | Moisture Sensitivity Level – QFN Package      | 1           |      |

\*The maximum package power dissipation must be observed.

1. 1 in<sup>2</sup> Cu, 1 oz. thickness.

2. JESD 51-7 (1S2P Direct-Attach Method) with 1 LFM.

# NCP81151

**NCP81151 ELECTRICAL CHARACTERISTICS** ( $-40^{\circ}\text{C} < T_A < +100^{\circ}\text{C}$ ;  $4.5\text{ V} < V_{\text{CC}} < 5.5\text{ V}$ ,  $4.5\text{ V} < \text{BST-SWN} < 5.5\text{ V}$ ,  $4.5\text{ V} < \text{BST} < 30\text{ V}$ ,  $0\text{ V} < \text{SWN} < 21\text{ V}$ , unless otherwise noted)

| Parameter | Test Conditions | Min | Typ | Max | Unit |
|-----------|-----------------|-----|-----|-----|------|
|-----------|-----------------|-----|-----|-----|------|

## SUPPLY VOLTAGE

|                       |  |     |  |     |   |
|-----------------------|--|-----|--|-----|---|
| VCC Operation Voltage |  | 4.5 |  | 5.5 | V |
|-----------------------|--|-----|--|-----|---|

## UNDERVOLTAGE LOCKOUT

|                     |  |     |      |     |    |
|---------------------|--|-----|------|-----|----|
| VCC Start Threshold |  | 3.8 | 4.35 | 4.5 | V  |
| VCC UVLO Hysteresis |  | 150 | 200  | 250 | mV |

## SUPPLY CURRENT

|                 |                                                                                     |  |     |    |               |
|-----------------|-------------------------------------------------------------------------------------|--|-----|----|---------------|
| Shutdown Mode   | $I_{\text{CC}} + I_{\text{BST}}$ , EN = GND                                         |  | 11  | 20 | $\mu\text{A}$ |
| Normal Mode     | $I_{\text{CC}} + I_{\text{BST}}$ , EN = 5 V, PWM = OSC                              |  | 4.7 |    | mA            |
| Standby Current | $I_{\text{CC}} + I_{\text{BST}}$ , EN = HIGH, PWM = LOW, No loading on DRVH & DRVL  |  | 0.9 |    | mA            |
| Standby Current | $I_{\text{CC}} + I_{\text{BST}}$ , EN = HIGH, PWM = HIGH, No loading on DRVH & DRVL |  | 1.1 |    | mA            |

## BOOTSTRAP DIODE

|                 |                                                            |     |     |     |   |
|-----------------|------------------------------------------------------------|-----|-----|-----|---|
| Forward Voltage | $V_{\text{CC}} = 5\text{ V}$ , forward bias current = 2 mA | 0.1 | 0.4 | 0.6 | V |
|-----------------|------------------------------------------------------------|-----|-----|-----|---|

## PWM INPUT

|                    |  |     |     |     |    |
|--------------------|--|-----|-----|-----|----|
| PWM Input High     |  | 3.4 |     |     | V  |
| PWM Mid-State      |  | 1.3 |     | 2.7 | V  |
| PWM Input Low      |  |     |     | 0.7 | V  |
| ZCD Blanking Timer |  |     | 350 |     | ns |

## HIGH SIDE DRIVER

|                                                             |                                                                                         |    |     |     |            |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------|----|-----|-----|------------|
| Output Impedance, Sourcing Current                          | $V_{\text{BST}} - V_{\text{SW}} = 5\text{ V}$                                           |    | 0.9 | 1.7 | $\Omega$   |
| Output Impedance, Sinking Current                           | $V_{\text{BST}} - V_{\text{SW}} = 5\text{ V}$                                           |    | 0.7 | 1.7 | $\Omega$   |
| DRVH Rise Time $t_{\text{rDRVH}}$                           | $V_{\text{CC}} = 5\text{ V}$ , 3 nF load, $V_{\text{BST}} - V_{\text{SW}} = 5\text{ V}$ |    | 16  | 25  | ns         |
| DRVH Fall Time $t_{\text{fDRVH}}$                           | $V_{\text{CC}} = 5\text{ V}$ , 3 nF load, $V_{\text{BST}} - V_{\text{SW}} = 5\text{ V}$ |    | 11  | 18  | ns         |
| DRVH Turn-Off Propagation Delay $t_{\text{pd}1\text{DRVH}}$ | $C_{\text{LOAD}} = 3\text{ nF}$                                                         | 10 |     | 30  | ns         |
| DRVH Turn-On Propagation Delay $t_{\text{pd}h\text{DRVH}}$  | $C_{\text{LOAD}} = 3\text{ nF}$                                                         | 10 |     | 40  | ns         |
| SW Pulldown Resistance                                      | SW to PGND                                                                              |    | 45  |     | k $\Omega$ |
| DRVH Pulldown Resistance                                    | DRVH to SW, BST-SW = 0 V                                                                |    | 45  |     | k $\Omega$ |

## LOW SIDE DRIVER

|                                                             |                                             |     |     |     |            |
|-------------------------------------------------------------|---------------------------------------------|-----|-----|-----|------------|
| Output Impedance, Sourcing Current                          |                                             |     | 0.9 | 1.7 | $\Omega$   |
| Output Impedance, Sinking Current                           |                                             |     | 0.4 | 0.8 | $\Omega$   |
| DRVL Rise Time $t_{\text{rDRVL}}$                           | $C_{\text{LOAD}} = 3\text{ nF}$             |     | 16  | 25  | ns         |
| DRVL Fall Time $t_{\text{fDRVL}}$                           | $C_{\text{LOAD}} = 3\text{ nF}$             |     | 11  | 15  | ns         |
| DRVL Turn-Off Propagation Delay $t_{\text{pd}1\text{DRVL}}$ | $C_{\text{LOAD}} = 3\text{ nF}$             | 10  |     | 30  | ns         |
| DRVL Turn-On Propagation Delay $t_{\text{pd}h\text{DRVL}}$  | $C_{\text{LOAD}} = 3\text{ nF}$             | 5.0 |     | 25  | ns         |
| DRVL Pulldown Resistance                                    | DRVL to PGND, $V_{\text{CC}} = \text{PGND}$ |     | 45  |     | k $\Omega$ |

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| Parameter              | Test Conditions | Min  | Typ | Max | Unit          |
|------------------------|-----------------|------|-----|-----|---------------|
| <b>EN INPUT</b>        |                 |      |     |     |               |
| Input Voltage High     |                 | 3.3  |     |     | V             |
| Input Voltage Mid      |                 | 1.35 |     | 1.8 | V             |
| Input Voltage Low      |                 |      |     | 0.6 | V             |
| Input bias current     |                 | -1.0 |     | 1.0 | $\mu\text{A}$ |
| Propagation Delay Time |                 |      | 20  | 40  | ns            |

## SW NODE

|                                        |  |  |      |    |               |
|----------------------------------------|--|--|------|----|---------------|
| SW Node Leakage Current                |  |  |      | 20 | $\mu\text{A}$ |
| Zero Cross Detection Threshold Voltage |  |  | -6.0 |    | 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.

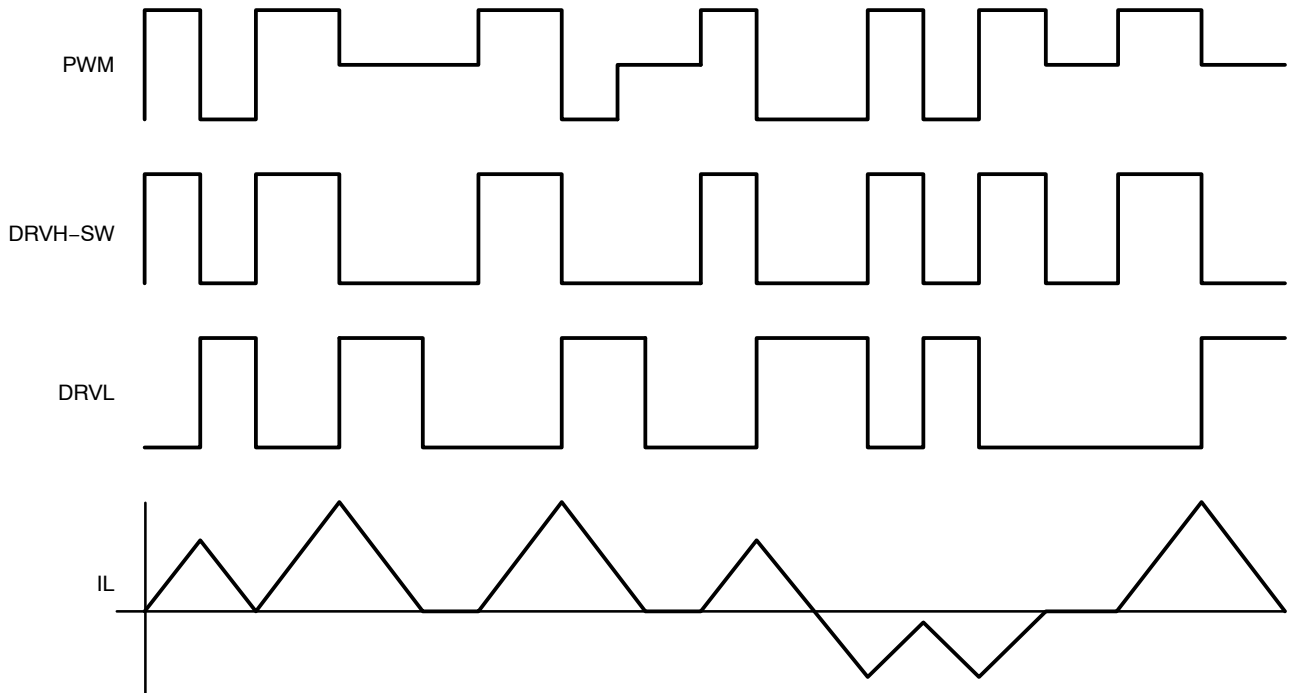
# NCP81151

**Table 1. DECODER TRUTH TABLE**

| Input                  | ZCD                                   | DRVL | DRVH |
|------------------------|---------------------------------------|------|------|
| PWM High (Enable High) | ZCD Reset                             | Low  | High |
| PWM Mid (Enable High)  | Positive Current Through the Inductor | High | Low  |
| PWM Mid (Enable High)  | Zero Current Through the Inductor     | Low  | Low  |
| PWM Low (Enable High)  | ZCD Reset                             | High | Low  |
| Enable at Mid          | X                                     | Low  | Low  |



**Figure 3.**



**Figure 4. Timing Diagram**

APPLICATION INFORMATION

The NCP81151 gate driver is a single phase MOSFET driver designed for driving N-channel MOSFETs in a synchronous buck converter topology. The NCP81151 is designed to work with ON Semiconductor’s NCP6131 multi-phase controller. This gate driver is optimized for notebook applications.

**Undervoltage Lockout**

DRVH and DRVL are held low until VCC reaches 4.5 V during startup. The PWM signal will control the gate status when VCC threshold is exceeded.

**Three-State EN Signal**

When EN is set to the mid state, both DRVH and DRVL are set low, to force diode mode operation.

**PWM Input and Zero Cross Detect (ZCD)**

The PWM input, along with EN and ZCD, control the state of DRVH and DRVL.

When PWM is set high, DRVH will be set high after the adaptive non-overlap delay. When PWM is set low, DRVL will be set high after the adaptive non-overlap delay.

When PWM is set to the mid state, DRVH will be set low, and after the adaptive non-overlap delay, DRVL will be set high. DRVL remains high during the ZCD blanking time. When the timer has expired, the SW pin will be monitored for zero cross detection. After the detection, DRVL will be set low.

**Adaptive Non-overlap**

Adaptive dead time control is used to avoid shoot-through damage of the power MOSFETs. When the PWM signal pulls high, DRVL will be set low and the driver will monitor the gate voltage of the low side MOSFET. When the DRVL voltage falls below the gate threshold, DRVH will be set to

high after the tpdhDRVH delay. When PWM is set low, the driver will monitor the gate voltage of the high side MOSFET. When the DRVH-SWN voltage falls below the top gate drive threshold, DRVL will be set to high after the tpdhDRVL delay.

**Layout Guidelines**

The layout for a DC-DC converter is very important. The bootstrap and VCC bypass capacitors should be placed close to the driver IC.

Connect the GND pin to a local ground plane. The ground plane can provide a good return path for gate drives and reduce the ground noise. The thermal slug should be tied to the ground plane for good heat dissipation. To minimize the ground loop for the low side MOSFET, the driver GND pin should be close to the low-side MOSFET source pin. The gate drive trace should be routed to minimize its length. The minimum width is 20 mils.

**Gate Driver Power Loss Calculation**

The gate driver power loss consists of the gate drive loss and quiescent power loss.

The equation below can be used to calculate the power dissipation of the gate driver. QGMF is the total gate charge for each main MOSFET and QGSF is the total gate charge for each synchronous MOSFET.

$$P_{DRV} = \left[ \frac{f_{SW}}{2 \times n} \times (n_{MF} \times Q_{GMF} + n_{SF} \times Q_{GSF}) + I_{CC} \right] \times V_{CC} \quad (\text{eq. 1})$$

Also shown is the standby dissipation factor (ICC x VCC) of the driver.



# MECHANICAL CASE OUTLINE PACKAGE DIMENSIONS



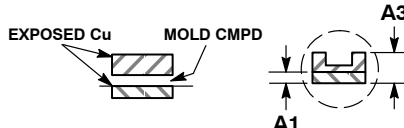
SCALE 4:1

DFN8 2x2, 0.5P  
CASE 506AA  
ISSUE F

DATE 04 MAY 2016



DETAIL A  
OPTIONAL  
CONSTRUCTIONS



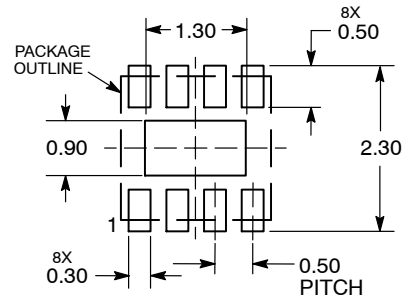
DETAIL B  
ALTERNATE  
CONSTRUCTIONS

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994 .
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.20 MM FROM TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

| DIM | MILLIMETERS |      |
|-----|-------------|------|
|     | MIN         | MAX  |
| A   | 0.80        | 1.00 |
| A1  | 0.00        | 0.05 |
| A3  | 0.20 REF    |      |
| b   | 0.20        | 0.30 |
| D   | 2.00 BSC    |      |
| D2  | 1.10        | 1.30 |
| E   | 2.00 BSC    |      |
| E2  | 0.70        | 0.90 |
| e   | 0.50 BSC    |      |
| K   | 0.30 REF    |      |
| L   | 0.25        | 0.35 |
| L1  | ---         | 0.10 |

### RECOMMENDED SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

### GENERIC MARKING DIAGRAM\*



- XX = Specific Device Code
- M = Date Code
- = Pb-Free Device

\*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.

|                  |                            |                                                                                                                                                                                  |
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