NCP140

LDO Voltage Regulator, 150 mA, Capacitor Free, Low Noise

The NCP140 is a 150 mA very low dropout regulator which offers excellent voltage accuracy and clean output voltage for power sensitive application. The NCP140 is very suitable for battery powered application due to very low quiescent current and virtually zero current at disable mode. This device is stable with or without output capacitors and allows minimize footprint and BOM. The XDFN4 package is optimized for use in space constrained applications.

Features

• Stable Operation with or without Capacitors
• Operating Input Voltage Range: 1.6 V to 5.5 V
• Available in Fixed Voltage Options: 1.5 V to 5 V
• Contact Factory for Other Voltage Options
• ±1% Typical Accuracy @ 25°C
• Very Low Quiescent Current of Typ. 45 µA
• Standby Current: 0.1 µA
• Very Low Dropout: 125 mV for 3.3 V @ 150 mA
• High PSRR: 55 dB @ 1 kHz
• Available in – XDFN4 – 0.8 mm x 0.8 mm x 0.4 mm Package
  – XDFN4 – 1.0 mm x 1.0 mm x 0.4 mm Package
• These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

Typical Applications

• Battery–powered Equipment
• Smartphones, Tablets
• Cameras, DVRs, STB and Camcorders

Figure 1. Typical Application Schematic
*Active output discharge is available only for NCP140Axxx options.

![Simplified Schematic Block Diagram](image)

**PIN FUNCTION DESCRIPTION**

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>OUT</td>
<td>Regulated output voltage pin. A small ceramic capacitor can be connected to improve fast load transient.</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground pin</td>
</tr>
<tr>
<td>3</td>
<td>EN</td>
<td>Driving EN over 0.9 V turns on the regulator. Driving EN below 0.4 V puts the regulator into shutdown mode.</td>
</tr>
<tr>
<td>4</td>
<td>IN</td>
<td>Input pin</td>
</tr>
<tr>
<td>−</td>
<td>EPAD</td>
<td>Expose pad must be connect to GND pin as short as possible. Soldered to a large ground copper plane allows for effective heat removal.</td>
</tr>
</tbody>
</table>

**ABSOLUTE MAXIMUM RATINGS**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage (Note 1)</td>
<td>$V_{IN}$</td>
<td>−0.3 V to 6</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>$V_{OUT}$</td>
<td>−0.3 V to $V_{IN} + 0.3$ V or 6 V</td>
<td>V</td>
</tr>
<tr>
<td>Chip Enable Input</td>
<td>$V_{CE}$</td>
<td>−0.3 V to 6 V</td>
<td>V</td>
</tr>
<tr>
<td>Output Short Circuit Duration</td>
<td>$I_{SC}$</td>
<td>unlimited</td>
<td>s</td>
</tr>
<tr>
<td>Maximum Junction Temperature</td>
<td>$T_{J}$</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>$T_{STG}$</td>
<td>−55 to 150</td>
<td>°C</td>
</tr>
<tr>
<td>ESD Capability, Human Body Model (Note 2)</td>
<td>$ESD_{HBM}$</td>
<td>2000</td>
<td>V</td>
</tr>
<tr>
<td>ESD Capability, Machine Model (Note 2)</td>
<td>$ESD_{MM}$</td>
<td>200</td>
<td>V</td>
</tr>
</tbody>
</table>

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 and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection and is tested by the following methods:
   - ESD Human Body Model tested per EIA/JESD22−A114
   - ESD Machine Model tested per EIA/JESD22−A115
   - Latchup Current Maximum Rating tested per JEDEC standard: JESD78.

**THERMAL CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Characteristics, XDFN4 0.8 mm x 0.8 mm Thermal Resistance, Junction−to−Air (Note 3)</td>
<td>$R_{JA}$</td>
<td>252</td>
<td>°C/W</td>
</tr>
<tr>
<td>Thermal Characteristics, XDFN4 1.0 mm x 1.0 mm Thermal Resistance, Junction−to−Air (Note 3)</td>
<td>$R_{JA}$</td>
<td>265</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

3. Measured according to JEDEC board specification. Detailed description of the board can be found in JESD51–7
ELECTRICAL CHARACTERISTICS  

−40°C ≤ TJ ≤ 85°C; VIN = VOUT(NOM) + 0.5 V; IOUT = 1 mA, CIN = COUT = none, unless otherwise noted. VEN = 0.9 V. Typical values are at TJ = +25°C. Min/Max values are for −40°C ≤ TJ ≤ 85°C (Note 3).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ.</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Input Voltage</td>
<td></td>
<td>VIN</td>
<td>1.6</td>
<td></td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>Output Voltage Accuracy</td>
<td>VOUT ≥ 1.8 V, TJ = 25°C</td>
<td>VOUT</td>
<td>±1</td>
<td>%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VOUT &lt; 1.8 V, TJ = 25°C</td>
<td></td>
<td>±20</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VOUT ≥ 1.8 V, −40°C ≤ TJ ≤ 85°C</td>
<td></td>
<td>−2</td>
<td>+2</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VOUT &lt; 1.8 V, −40°C ≤ TJ ≤ 85°C</td>
<td></td>
<td>−50</td>
<td>+50</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Line Regulation</td>
<td>VOUT(NOM) + 0.5 V ≤ VIN ≤ 5.5 V</td>
<td>LineReg</td>
<td>1.0</td>
<td>5.0</td>
<td>0.0</td>
<td>mV</td>
</tr>
<tr>
<td>Load Regulation</td>
<td>IOUT = 0 mA to 150 mA</td>
<td>LoadReg</td>
<td>10</td>
<td>30</td>
<td>0.0</td>
<td>mV</td>
</tr>
<tr>
<td>Dropout Voltage (Note 5)</td>
<td>IOUT = 150 mA</td>
<td></td>
<td>VOUT(NOM) = 1.8 V</td>
<td>VDO</td>
<td>255</td>
<td>420</td>
</tr>
<tr>
<td></td>
<td>VOUT(NOM) = 3.3 V</td>
<td></td>
<td>125</td>
<td>220</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Current Limit</td>
<td>VOUT = 90% VOUT(NOM)</td>
<td>ICL</td>
<td>230</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Circuit Current</td>
<td>VOUT = 0 V</td>
<td>ISC</td>
<td>250</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiescent Current</td>
<td>IOUT = 0 mA</td>
<td>IQ</td>
<td>45</td>
<td>75</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Shutdown Current</td>
<td>VEN = 0.4 V, VIN = 5.5 V</td>
<td>IDIS</td>
<td>0.1</td>
<td>1.0</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>EN Pin Threshold Voltage</td>
<td>EN Input Voltage “H”</td>
<td>VENH</td>
<td>0.9</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EN Input Voltage “L”</td>
<td>VENL</td>
<td>0.4</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>EN Pin Current</td>
<td>VEN = 5.5 V</td>
<td>IEN</td>
<td>0.01</td>
<td>1.0</td>
<td>µA</td>
<td></td>
</tr>
<tr>
<td>Turn–On Time</td>
<td>COUT = 1 µF, IOUT=150 mA, From assertion of VEN to VOUT = 98%VOUT(NOM)</td>
<td>TON</td>
<td>100</td>
<td>µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>VOUT(NOM) = 2.5 V, f = 100 Hz</td>
<td>PSRR</td>
<td>62</td>
<td></td>
<td>dB</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VOUT(NOM) = 2.5 V, f = 1 kHz</td>
<td></td>
<td>55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Noise Voltage</td>
<td>VIN = 2.3 V, IOUT = 10 mA f = 100 Hz to 1 kHz</td>
<td>VN</td>
<td>17</td>
<td>µVRMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Shutdown Temperature</td>
<td>Temperature increasing from TJ = +25°C</td>
<td>TSD</td>
<td>160</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Shutdown Hysteresis</td>
<td>Temperature falling from TSD</td>
<td>TSDH</td>
<td>20</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Discharge Pull–Down</td>
<td>VEN ≤ 0.4 V, A options only</td>
<td>RDISCH</td>
<td>100</td>
<td></td>
<td>Ω</td>
<td></td>
</tr>
</tbody>
</table>

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.  
4. Performance guaranteed over the indicated operating temperature range by design and/or characterization. Production tested at TA = 25°C.  
Low duty cycle pulse techniques are used during the testing to maintain the junction temperature as close to ambient as possible.  
5. Dropout voltage is characterized when VOUT falls 100 mV below VOUT(NOM).
TYPICAL CHARACTERISTICS

Figure 3. Output Voltage vs. Temperature – \( V_{OUT} = 1.8 \) V

Figure 4. Output Voltage vs. Temperature – \( V_{OUT} = 3.3 \) V

Figure 5. Line Regulation vs. Temperature – \( V_{OUT} = 1.8 \) V

Figure 6. Line Regulation vs. Temperature – \( V_{OUT} = 3.3 \) V

Figure 7. Load Regulation vs. Temperature – \( V_{OUT} = 1.8 \) V

Figure 8. Load Regulation vs. Temperature – \( V_{OUT} = 3.3 \) V

\( V_{IN} = 2.3 \) V
\( V_{OUT} = 1.8 \) V
\( I_{OUT} = 1 \) mA
\( I_{OUT} = 150 \) mA

\( V_{IN} = 3.8 \) V
\( V_{OUT} = 3.3 \) V
\( I_{OUT} = 1 \) mA

\( V_{IN} = 4.3 \) to 5.5 V
\( V_{OUT} = 3.3 \) V
\( I_{OUT} = 0 \) to 150 mA

\( V_{IN} = 2.3 \) V
\( V_{OUT} = 1.8 \) V
\( I_{OUT} = 150 \) mA

\( C_{IN} = 1 \) μF
\( C_{OUT} = 1 \) μF
TYPICAL CHARACTERISTICS

**Figure 9. Ground Current vs. Load Current – V\text{OUT} = 1.8 V**

**Figure 10. Ground Current vs. Load Current – V\text{OUT} = 3.3 V**

**Figure 11. Quiescent Current vs. Input Voltage – V\text{OUT} = 1.8 V**

**Figure 12. Quiescent Current vs. Input Voltage – V\text{OUT} = 3.3 V**

**Figure 13. Dropout Voltage vs. Load Current – V\text{OUT} = 1.8 V**

**Figure 14. Dropout Voltage vs. Load Current – V\text{OUT} = 3.3 V**
TYPICAL CHARACTERISTICS

Figure 15. Dropout Voltage vs. Temperature – $V_{OUT} = 1.8\ V$

Figure 16. Dropout Voltage vs. Temperature – $V_{OUT} = 3.3\ V$

Figure 17. Current Limit vs. Temperature

Figure 18. Short Circuit Current vs. Temperature

Figure 19. Enable Threshold Voltage vs. Temperature

Figure 20. Enable Current vs. Temperature
NCP140

TYPICAL CHARACTERISTICS

Figure 21. Disable Current vs. Temperature

Figure 22. Discharge Resistivity vs. Temperature

Figure 23. Output Voltage Noise Spectral Density – VOUT = 1.8 V

Figure 24. PSRR for Various Output Currents, VOUT = 1.8 V

Figure 25. PSRR for Various Output Currents, VOUT = 3.3 V

<table>
<thead>
<tr>
<th>IOUT</th>
<th>RMS Output Noise (µV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mA</td>
<td>26.21 17.94</td>
</tr>
<tr>
<td>150 mA</td>
<td>27.51 19.11</td>
</tr>
</tbody>
</table>

VIN = 4.3 V
VOUT = 3.3 V
CIN = 1 µF
COUT = 1 µF

VIN = 2.8 V
VOUT = 1.8 V
CIN = 1 µF
COUT = 1 µF

VIN = 3.8 V
VOUT = 100mVpp
CIN = none
COUT = 1 µF MLCC 1206
TYPICAL CHARACTERISTICS

Figure 26. PSRR for Different Output Capacitor, $V_{OUT} = 3.3$ V

Figure 27. PSRR for Different Output $V_{IN}$, $V_{OUT} = 3.3$ V

Figure 28. Enable Turn−on Response − $C_{OUT} = $ None, $I_{OUT} = 10$ mA

Figure 29. Enable Turn−on Response − $C_{OUT} = $ None, $I_{OUT} = 150$ mA

Figure 30. Enable Turn−on Response − $C_{OUT} = 470$ nF, $I_{OUT} = 10$ mA

Figure 31. Enable Turn−on Response − $C_{OUT} = 470$ nF, $I_{OUT} = 150$ mA
TYPICAL CHARACTERISTICS

Figure 32. Line Transient Response – COUT = None

Figure 33. Line Transient Response – COUT = 470 nF

Figure 34. Load Transient Response – 1 mA to 150 mA – COUT = None

Figure 35. Load Transient Response – 150 mA to 1 mA – COUT = None

Figure 36. Load Transient Response – 1 mA to 150 mA – COUT = 1 μF

Figure 37. Load Transient Response – 150 mA to 1 mA – COUT = 1 μF

VOUT = 1.8 V, IOUT = 10 mA
CIN = none, COUT = none
VOUT = 1.8 V, IOUT = 10 mA
CIN = none, COUT = 470 nF (MLCC)

VIN = 3.3 V
VOUT = 2.3 V

VIN = 3.8 V
VOUT = 3.3 V
CIN = none
COUT = none

IOUT

50 mV/div

200 mV/div

5 μs/div

VOUT

VOUT = 1.8 V, IOUT = 10 mA
CIN = none, COUT = 1 μF (MLCC)

VIN = 3.8 V, VOUT = 3.3 V
CIN = 1 μF (MLCC)
COUT = 1 μF (MLCC)

IOUT

200 mV/div

5 μs/div

200 mV/div

50 mV/div

200 mV/div

50 mV/div

20 μs/div

20 μs/div

VOUT = 1.8 V, IOUT = 10 mA
CIN = none, COUT = none

VIN = 3.8 V, VOUT = 3.3 V
CIN = 1 μF (MLCC)
COUT = 1 μF (MLCC)

VOUT = 1.8 V, IOUT = 10 mA
CIN = none, COUT = none

VIN = 3.8 V, VOUT = 3.3 V
CIN = 1 μF (MLCC)
COUT = 1 μF (MLCC)

IOUT

50 mV/div

50 mV/div

200 mV/div

50 mV/div

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TYPICAL CHARACTERISTICS

Figure 38. Load Transient Response – 1 mA to 150 mA – \( t_{\text{RISE}} = 2 \mu s \)

Figure 39. Load Transient Response – 150 mA to 1 mA – \( t_{\text{FALL}} = 2 \mu s \)

Figure 40. Over Temperature Protection – TSD

Figure 41. Enable Turn–Off

Figure 42. Slow \( V_{\text{IN}} \) Ramp
APPLICATIONS INFORMATION

General
The NCP140 is high performance low dropout regulator capable of supplying 150 mA and providing very stable output voltage with or without capacitors. The device is designed to remain stable with any type of capacitor or even without input and output capacitor. The NCP140 also offers low quiescent current and very small packages suitable for space constrains application. In connection with no capacitor requirements the regulator is very useful in wearable application, smartphones and everywhere where is high power density required.

Input and Output Capacitor Selection
In spite of the NCP140 is designed as capless device capacitors can be added to improve dynamic behavior such as fast load transient or PSRR. Recommendation for selection input and output capacitor is very similar as for high performance LDO. Low ESR ceramic capacitor is the most beneficial for improvement load transient and PSRR but suitable is almost any type of capacitor. The NCP140 remains stable with electrolytic and tantalum capacitor too.

Enable Operation
The NCP140 uses the EN pin to enable/disable its device and to deactivate/activate the active discharge function.

If the EN pin voltage is <0.4 V the device is guaranteed to be disabled. The pass transistor is turned−off so that there is virtually no current flow between the IN and OUT. The active discharge transistor is active (only A option) so that the output voltage \( V_{OUT} \) is pulled to GND through a 100 Ω resistor. In the disable state the device consumes as low as typ. 10 nA from the VIN.

If the EN pin voltage >0.9 V the device is guaranteed to be enabled. The NCP140 regulates the output voltage and the active discharge transistor is turned−off.

The EN pin has internal pull−down current source with typ. value of 100 nA which assures that the device is turned−off when the EN pin is not connected. In the case where the EN function isn’t required the EN should be tied directly to IN.

Output Current Limit
Output Current is internally limited within the IC to a typical 230 mA. The NCP140 will source this amount of current measured with a voltage drops on the 90% of the nominal \( V_{OUT} \). If the Output Voltage is directly shorted to ground (\( V_{OUT} = 0 \) V), the short circuit protection will limit the output current to approximately 250 mA. The current limit and short circuit protection will work properly over whole temperature range and also input voltage range. There is no limitation for the short circuit duration.

Thermal Shutdown
When the die temperature exceeds the Thermal Shutdown threshold (\( T_{SD} \leq 160^\circ C \) typical), Thermal Shutdown event is detected and the device is disabled. The IC will remain in this state until the die temperature decreases below the Thermal Shutdown Reset threshold (\( T_{SDU} \leq 140^\circ C \) typical). Once the IC temperature falls below the 140°C the LDO is enabled again. The thermal shutdown feature provides the protection from a catastrophic device failure due to accidental overheating. This protection is not intended to be used as a substitute for proper heat sinking.

Power Dissipation
As power dissipated in the NCP140 increases, it might become necessary to provide some thermal relief. The maximum power dissipation supported by the device is dependent upon board design and layout. Mounting pad configuration on the PCB, the board material, and the ambient temperature affect the rate of junction temperature rise for the part.

The maximum power dissipation the NCP140 can handle is given by:

\[
P_{D(MAX)} = \frac{\left[ 85^\circ C - T_A \right]}{\theta_{JA}}
\]

(eq. 1)

The power dissipated by the NCP140 for given application conditions can be calculated from the following equation:

\[
P_D = V_{IN}(I_{GND}@I_{OUT}) + I_{OUT}(V_{IN} - V_{OUT})
\]

(eq. 2)
Reverse Current
The PMOS pass transistor has an inherent body diode which will be forward biased in the case that \( V_{OUT} > V_{IN} \). Due to this fact in cases, where the extended reverse current condition can be anticipated the device may require additional external protection.

Turn–On Time
The turn–on time is defined as the time period from EN assertion to the point in which \( V_{OUT} \) will reach 98% of its nominal value. This time is dependent on various application conditions such as \( V_{OUT\text{NOM}} \), \( C_{OUT} \), \( T_A \).

PCB Layout Recommendations
Larger copper area connected to the pins will improve the device thermal resistance and improve maximum power dissipation. The actual power dissipation can be calculated from the equation above (Equation 2). Expose pad should be tied the shortest path to the GND pin.
### ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Device</th>
<th>Nominal Output Voltage</th>
<th>Description</th>
<th>Marking</th>
<th>Package</th>
<th>Shipping†</th>
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<tr>
<td>NCP140AMXC180TCG</td>
<td>1.8 V</td>
<td>Active Output Discharge</td>
<td>GA</td>
<td>XDFN4 (Pb−Free) CASE 711BF</td>
<td>3000 / Tape &amp; Reel</td>
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<td>GC</td>
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<td>NCP140AMXC330TCG</td>
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<tr>
<td>NCP140BMXC330TCG</td>
<td>3.3 V</td>
<td>Without Active Output Discharge</td>
<td>G2</td>
<td></td>
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<td>Active Output Discharge</td>
<td>GA</td>
<td>XDFN4 (Pb−Free) CASE 711AJ</td>
<td>3000 / Tape &amp; Reel</td>
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<td>NCP140BMXD330TCG</td>
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<td>Without Active Output Discharge</td>
<td>G2</td>
<td></td>
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</tr>
</tbody>
</table>

†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.
PACKAGE DIMENSIONS

XDFN4 0.8x0.8, 0.48P
CASE 711BF
ISSUE O

NOTES:
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINALS.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

<table>
<thead>
<tr>
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<tr>
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<tr>
<td>D</td>
</tr>
<tr>
<td>E2</td>
</tr>
<tr>
<td>e</td>
</tr>
<tr>
<td>L</td>
</tr>
<tr>
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</tr>
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</table>

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.
NCP140

PACKAGE DIMENSIONS

XDFN4 1.0x1.0, 0.65P
CASE 711AJ
ISSUE A

NOTES:
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.20 mm FROM THE TERMINAL TIPS.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

NOTE 3

<table>
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<tr>
<th>DIM</th>
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</table>

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