# NCP133

# 500 mA, Very Low Dropout Bias Rail CMOS Voltage Regulator

The NCP133 is a 500 mA VLDO equipped with NMOS pass transistor and a separate bias supply voltage ($V_{BIAS}$). The device provides very stable, accurate output voltage with low noise suitable for space constrained, noise sensitive applications. In order to optimize performance for battery operated portable applications, the NCP133 features low $I_Q$ consumption. The XDFN6 1.2 mm x 1.2 mm package is optimized for use in space constrained applications.

### Features

- Input Voltage Range: 0.8 V to 5.5 V
- Bias Voltage Range: 2.4 V to 5.5 V
- Adjustable and Fixed Voltage Versions Available
- Output Voltage Range: 0.8 V to 2.1 V (Fixed) and 0.8 V to 3.6 V (Adjustable)
- ±1.5% Accuracy over Temperature, 0.5% $V_{OUT}$ @ 25°C
- Ultra−Low Dropout: Typ. 140 mV at 500 mA
- Very Low Bias Input Current of Typ. 80 μA
- Very Low Bias Input Current in Disable Mode: Typ. 0.5 μA
- Logic Level Enable Input for ON/OFF Control
- Output Active Discharge Option Available
- Stable with a 2.2 μF Ceramic Capacitor
- Available in XDFN6 − 1.2 mm x 1.2 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

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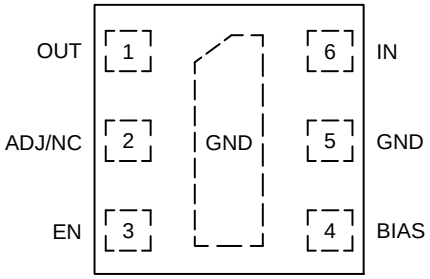
**XDFN6**
**CASE 711AT**

**MARKING DIAGRAM**


XX = Specific Device Code
M = Date Code

**PIN CONNECTIONS**

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**ORDERING INFORMATION**

See detailed ordering and shipping information on page 8 of this data sheet.

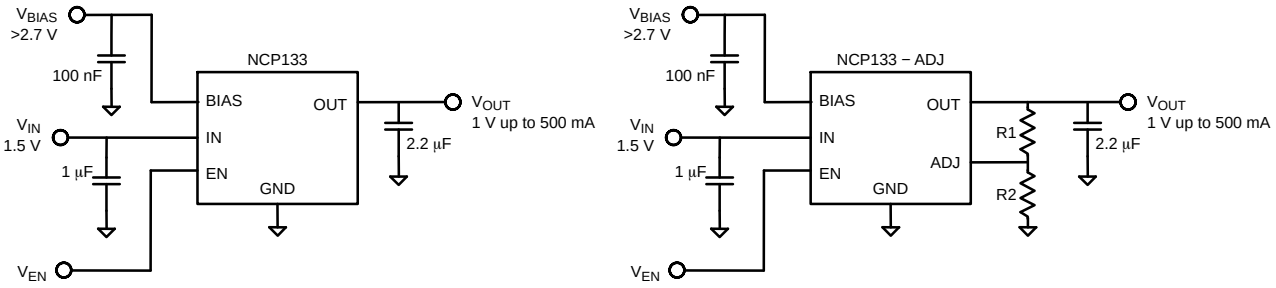
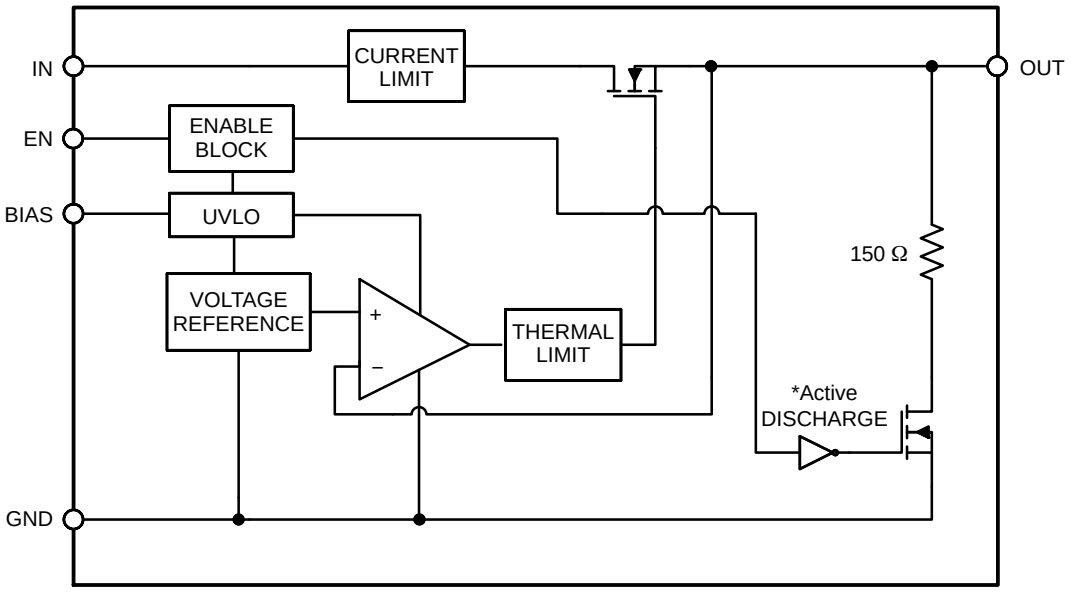
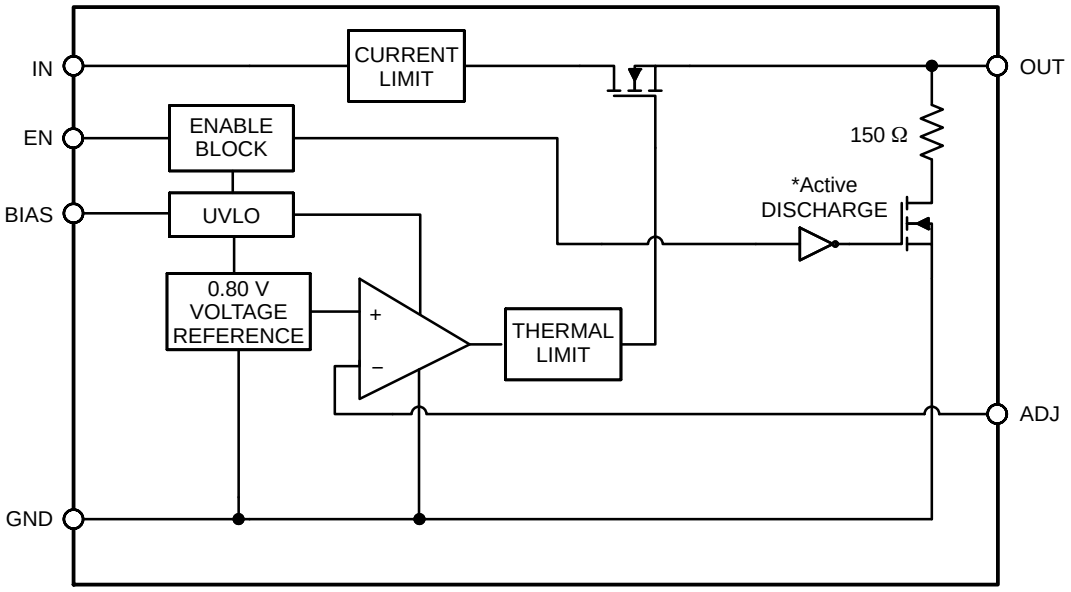



**Figure 1. Typical Application Schematics**




*Active output discharge function is present only in NCP133AMXyyyTCG devices.
yyy denotes the particular output voltage option.

**Figure 2. Simplified Schematic Block Diagram − Fixed Version**




*Active output discharge function is present only in NCP133AMXADJTCG devices.

**Figure 3. Simplified Schematic Block Diagram − Adjustable Version**

## PIN FUNCTION DESCRIPTION

| Pin No. XDFN6 | Pin Name | Description |
|---|---|---|
| 1 | OUT | Regulated Output Voltage pin |
| 2 (Fixed) | N/C | Not internally connected (Note 1) |
| 2 (Adj) | ADJ | Adjustable Regulator Feedback Input. Connect to output voltage resistor divider central node. |
| 3 | EN | Enable pin. Driving this pin high enables the regulator. Driving this pin low puts the regulator into shutdown mode. |
| 4 | BIAS | Bias voltage supply for internal control circuits. This pin is monitored by internal Under-Voltage Lockout Circuit. |
| 5 | GND | Ground |
| 6 | IN | Input Voltage Supply pin |
| Pad | | Should be soldered to the ground plane for increased thermal performance. |

1. True no connect. Printed circuit board traces are allowable

## ABSOLUTE MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Input Voltage (Note 2) | $V_{IN}$ | −0.3 to 6 | V |
| Output Voltage | $V_{OUT}$ | −0.3 to ($V_{IN}$+0.3) ≤ 6 | V |
| Chip Enable, Bias and Adj Input | $V_{EN}$, $V_{BIAS}$, $V_{ADJ}$ | −0.3 to 6 | V |
| Output Short Circuit Duration | $t_{SC}$ | unlimited | s |
| Maximum Junction Temperature | $T_J$ | 150 | °C |
| Storage Temperature | $T_{STG}$ | −55 to 150 | °C |
| ESD Capability, Human Body Model (Note 3) | $ESD_{HBM}$ | 2000 | V |
| ESD Capability, Machine Model (Note 3) | $ESD_{MM}$ | 200 | 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.

2. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
3. This device series incorporates ESD protection (except OUT pin) 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

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Thermal Characteristics, XDFN6 1.2 mm x 1.2 mm Thermal Resistance, Junction−to−Air | $R_{\theta JA}$ | 170 | °C/W |

**ELECTRICAL CHARACTERISTICS** $-40°C \le T_J \le 85°C$; $V_{BIAS}$ = 2.7 V or ($V_{OUT}$ + 1.6 V), whichever is greater, $V_{IN} = V_{OUT(NOM)}$ + 0.3 V, $I_{OUT}$ = 1 mA, $V_{EN}$ = 1 V, unless otherwise noted. $C_{IN}$ = 1 μF, $C_{OUT}$ = 2.2 μF. Typical values are at $T_J$ = +25°C. Min/Max values are for $-40°C \le T_J \le 85°C$ unless otherwise noted. (Note 5)

| Parameter | Test Conditions | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Operating Input Voltage Range | | $V_{IN}$ | $V_{OUT}$ + $V_{DO}$ | | 5.5 | V |
| Operating Bias Voltage Range | | $V_{BIAS}$ | ($V_{OUT}$ + 1.40) ≥ 2.4 | | 5.5 | V |
| Undervoltage Lock−out | $V_{BIAS}$ Rising<br>Hysteresis | UVLO | | 1.6<br>0.2 | | V |
| Reference Voltage (Adj devices only) | $T_J$ = +25°C | $V_{REF}$ | | 0.800 | | V |
| Output Voltage Accuracy | (Note 4) | $V_{OUT}$ | | ±0.5 | | % |
| Output Voltage Accuracy (Note 4) | $-40°C \le T_J \le 85°C$, $V_{OUT(NOM)}$ + 0.3 V ≤ $V_{IN}$ ≤ $V_{OUT(NOM)}$ + 1.0 V, 2.7 V or ($V_{OUT(NOM)}$ + 1.6 V), whichever is greater < $V_{BIAS}$ < 5.5 V, 1 mA < $I_{OUT}$ < 500 mA | $V_{OUT}$ | −1.5 | | +1.5 | % |
| $V_{IN}$ Line Regulation | $V_{OUT(NOM)}$ + 0.3 V ≤ $V_{IN}$ ≤ 5.0 V | $Line_{Reg}$ | | 0.01 | | %/V |
| $V_{BIAS}$ Line Regulation | 2.7 V or ($V_{OUT(NOM)}$ + 1.6 V), whichever is greater < $V_{BIAS}$ < 5.5 V | $Line_{Reg}$ | | 0.01 | | %/V |
| Load Regulation | $I_{OUT}$ = 1 mA to 500 mA | $Load_{Reg}$ | | 1.5 | | mV |
| $V_{IN}$ Dropout Voltage | $I_{OUT}$ = 150 mA (Note 6) | $V_{DO}$ | | 37 | 75 | mV |
| | $I_{OUT}$ = 500 mA (Note 6) | $V_{DO}$ | | 140 | 250 | |
| $V_{BIAS}$ Dropout Voltage | $I_{OUT}$ = 500 mA, $V_{IN} = V_{BIAS}$ (Notes 6, 7) | $V_{DO}$ | | 1.1 | 1.5 | V |
| Output Current Limit | $V_{OUT}$ = 90% $V_{OUT(NOM)}$ | $I_{CL}$ | 550 | 800 | 1000 | mA |
| ADJ Pin Operating Current (ADJ devices only) | | $I_{ADJ}$ | | 0.1 | 0.5 | μA |
| Bias Pin Operating Current | $V_{BIAS}$ = 2.7 V | $I_{BIAS}$ | | 80 | 110 | μA |
| Bias Pin Disable Current | $V_{EN}$ ≤ 0.4 V | $I_{BIAS(DIS)}$ | | 0.5 | 1 | μA |
| Vinput Pin Disable Current | $V_{EN}$ ≤ 0.4 V | $I_{VIN(DIS)}$ | | 0.5 | 1 | μA |
| EN Pin Threshold Voltage | EN Input Voltage “H” | $V_{EN(H)}$ | 0.9 | | | V |
| | EN Input Voltage “L” | $V_{EN(L)}$ | | | 0.4 | |
| EN Pull Down Current | $V_{EN}$ = 5.5 V | $I_{EN}$ | | 0.3 | 1 | μA |
| Turn−On Time | From assertion of $V_{EN}$ to $V_{OUT}$ = 98% $V_{OUT(NOM)}$. $V_{OUT(NOM)}$ = 1.0 V | $t_{ON}$ | | 150 | | μs |
| Power Supply Rejection Ratio | $V_{IN}$ to $V_{OUT}$, f = 1 kHz, $I_{OUT}$ = 150 mA, $V_{IN} \ge V_{OUT}$ +0.5 V | PSRR($V_{IN}$) | | 70 | | dB |
| | $V_{BIAS}$ to $V_{OUT}$, f = 1 kHz, $I_{OUT}$ = 150 mA, $V_{IN} \ge V_{OUT}$ +0.5 V | PSRR($V_{BIAS}$) | | 80 | | dB |
| Output Noise Voltage (Fixed Volt.) | $V_{IN} = V_{OUT}$ +0.5 V, $V_{OUT(NOM)}$ = 1 V, f = 10 Hz to 100 kHz | $V_N$ | | 40 | | $\mu V_{RMS}$ |
| Output Noise Voltage (Adj devices) | $V_{IN} = V_{OUT}$ +0.5 V, f = 10 Hz to 100 kHz | $V_N$ | | 50 x $V_{OUT}$ | | $\mu V_{RMS}$ |
| Thermal Shutdown Threshold | Temperature increasing | | | 160 | | °C |
| | Temperature decreasing | | | 140 | | |
| Output Discharge Pull−Down | $V_{EN}$ ≤ 0.4 V, $V_{OUT}$ = 0.5 V, NCP133A options only | $R_{DISCH}$ | | 150 | | Ω |

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. Adjustable devices tested at 0.8 V; external resistor tolerance is not taken into account.
5. Performance guaranteed over the indicated operating temperature range by design and/or characterization. Production tested at $T_A$ = 25°C. Low duty cycle pulse techniques are used during the testing to maintain the junction temperature as close to ambient as possible.
6. Dropout voltage is characterized when $V_{OUT}$ falls 3% below $V_{OUT(NOM)}$.
7. For output voltages below 0.9 V, $V_{BIAS}$ dropout voltage does not apply due to a minimum Bias operating voltage of 2.4 V.

## TYPICAL CHARACTERISTICS

At $T_J$ = +25°C, $V_{IN}$ = $V_{OUT(TYP)}$ + 0.3 V, $V_{BIAS}$ = 2.7 V, $V_{EN}$ = $V_{BIAS}$, $V_{OUT(NOM)}$ = 1.0 V, $I_{OUT}$ = 500 mA, $C_{IN}$ = 1 μF, $C_{BIAS}$ = 0.1 μF, and $C_{OUT}$ = 2.2 μF (effective capacitance), unless otherwise noted.

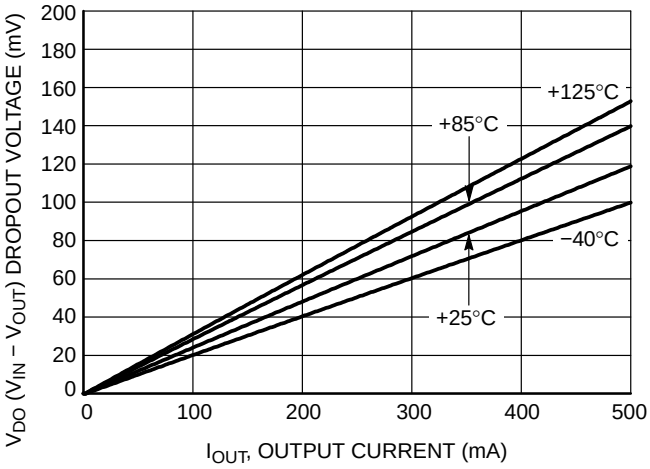



**Figure 4. $V_{IN}$ Dropout Voltage vs. $I_{OUT}$ and Temperature $T_J$**

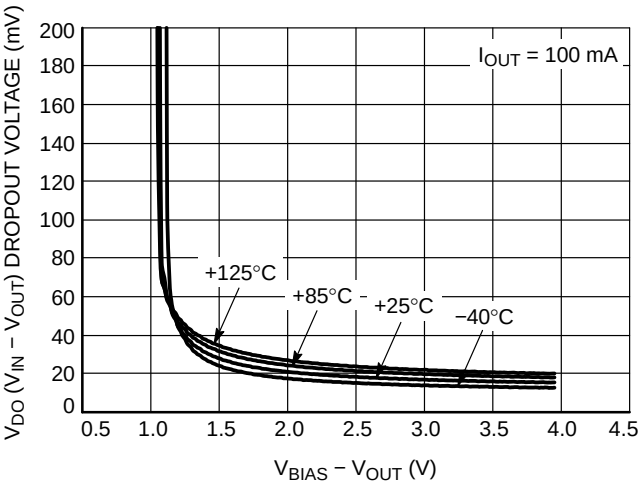



**Figure 5. $V_{IN}$ Dropout Voltage vs. ($V_{BIAS}$ − $V_{OUT}$) and Temperature $T_J$**

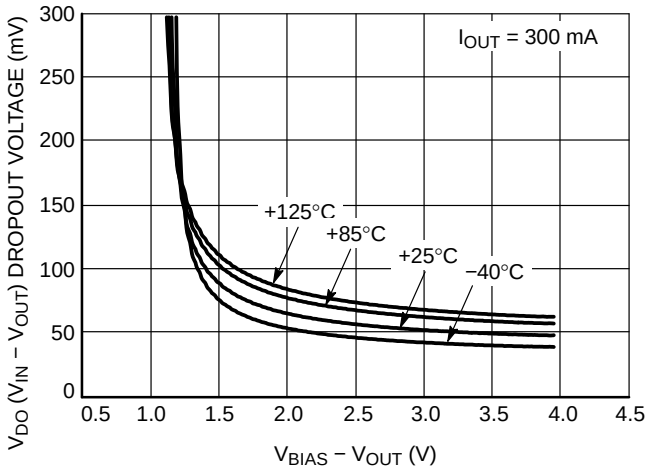



**Figure 6. $V_{IN}$ Dropout Voltage vs. ($V_{BIAS}$ − $V_{OUT}$) and Temperature $T_J$**

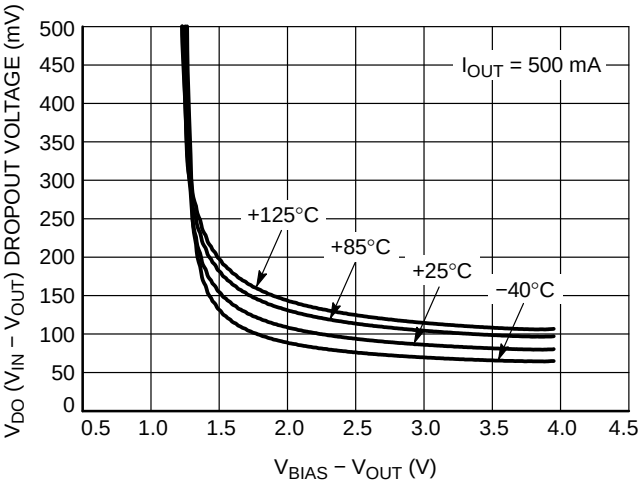



**Figure 7. $V_{IN}$ Dropout Voltage vs. ($V_{BIAS}$ − $V_{OUT}$) and Temperature $T_J$**

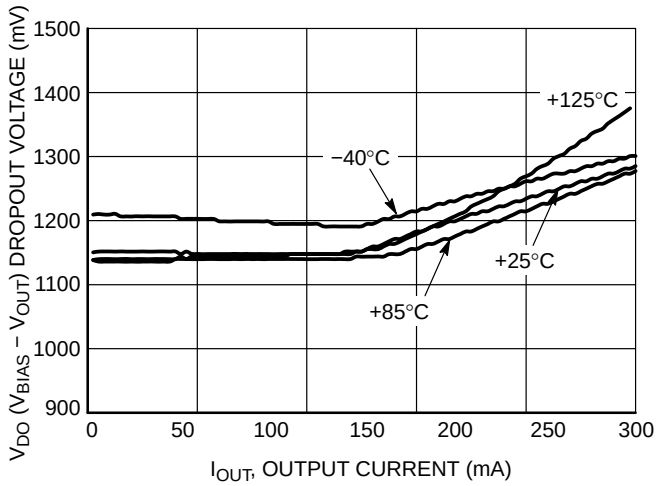



**Figure 8. $V_{BIAS}$ Dropout Voltage vs. $I_{OUT}$ and Temperature $T_J$**

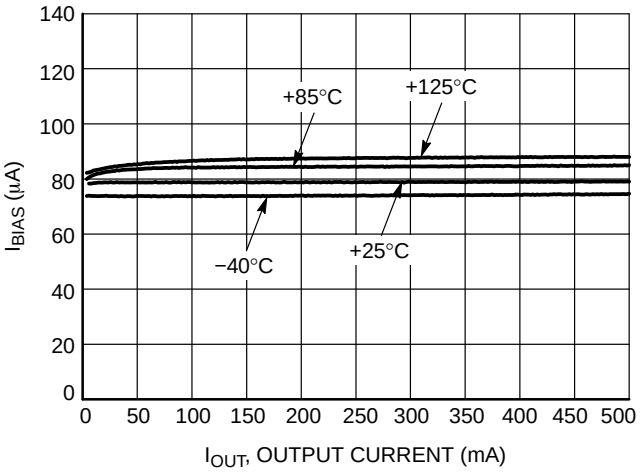



**Figure 9. BIAS Pin Current vs. $I_{OUT}$ and Temperature $T_J$**

## TYPICAL CHARACTERISTICS

At $T_J$ = +25°C, $V_{IN}$ = $V_{OUT(TYP)}$ + 0.3 V, $V_{BIAS}$ = 2.7 V, $V_{EN}$ = $V_{BIAS}$, $V_{OUT(NOM)}$ = 1.0 V, $I_{OUT}$ = 500 mA, $C_{IN}$ = 1 μF, $C_{BIAS}$ = 0.1 μF, and $C_{OUT}$ = 2.2 μF (effective capacitance), unless otherwise noted.

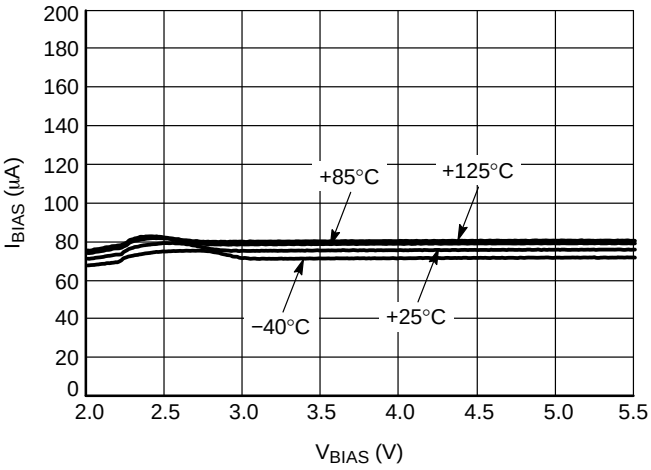



**Figure 10. BIAS Pin Current vs. $V_{BIAS}$ and Temperature $T_J$**

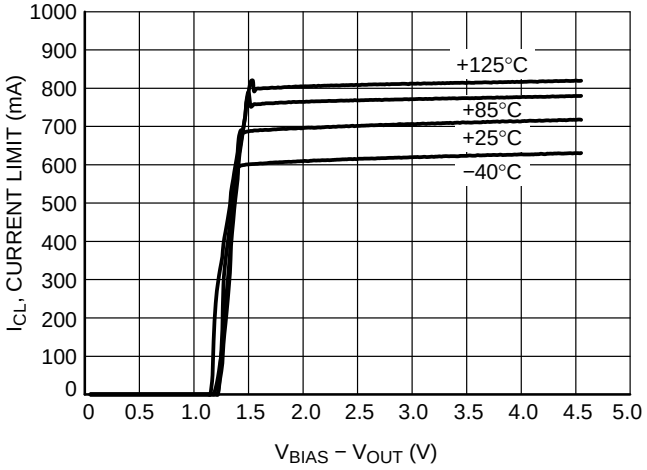



**Figure 11. Current Limit vs. ($V_{BIAS}$ − $V_{OUT}$)**

## APPLICATIONS INFORMATION

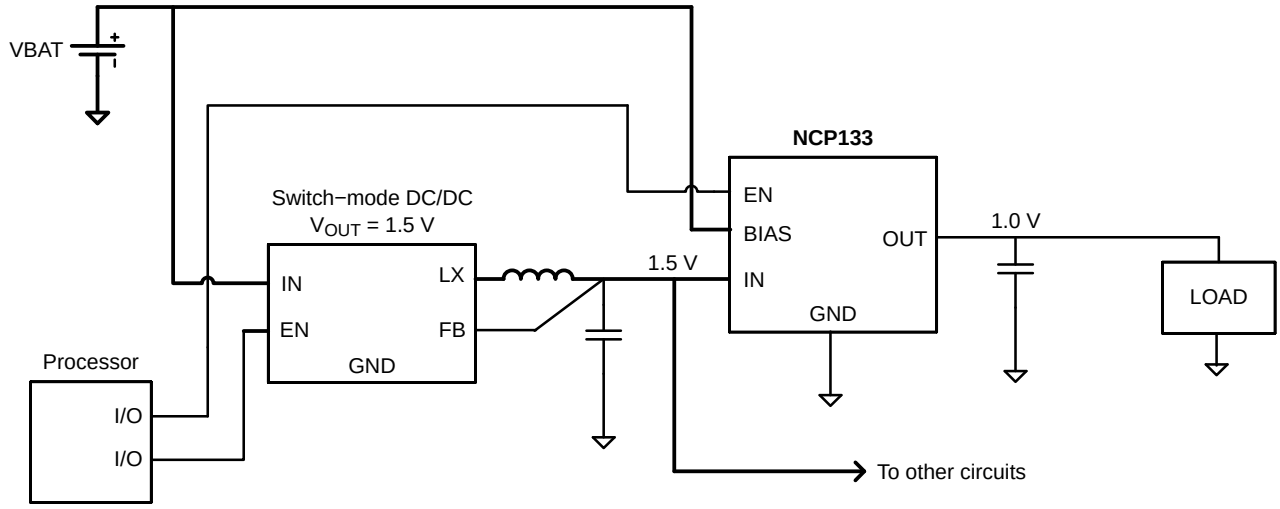



**Figure 12. Typical Application: Low−Voltage DC/DC Post−Regulator with ON/OFF Functionality**

The NCP133 dual−rail very low dropout voltage regulator is using NMOS pass transistor for output voltage regulation from $V_{IN}$ voltage. All the low current internal control circuitry is powered from the $V_{BIAS}$ voltage.

The use of an NMOS pass transistor offers several advantages in applications. Unlike PMOS topology devices, the output capacitor has reduced impact on loop stability. Vin to Vout operating voltage difference can be very low compared with standard PMOS regulators in very low Vin applications.

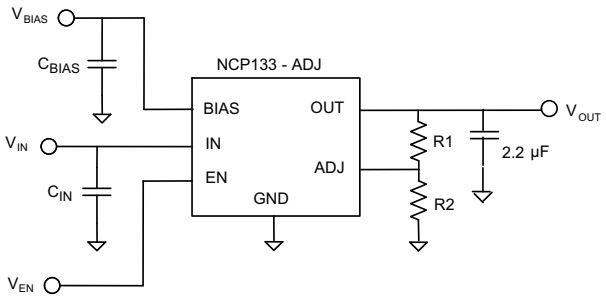
The NCP133 offers smooth monotonic start-up. The controlled voltage rising limits the inrush current.

The Enable (EN) input is equipped with internal hysteresis. NCP133 Voltage linear regulator Fixed and Adjustable version is available.

### Output Voltage Adjust

The required output voltage of Adjustable devices can be adjusted from 0.8 V to 3.6 V using two external resistors.

Typical application schematics is shown in Figure 13.




$$V_{OUT} = 0.8 \times (1 + R1/R2)$$

**Figure 13. Typical Application Schematics**

It is recommended to keep the total serial resistance of resistors (R1 + R2) no greater than 100 kΩ.

Recommended resistor values for programming the frequently used voltages can be found in the Table 1.

### Dropout Voltage

Because of two power supply inputs $V_{IN}$ and $V_{BIAS}$ and one $V_{OUT}$ regulator output, there are two Dropout voltages specified.

The first, the $V_{IN}$ Dropout voltage is the voltage difference ($V_{IN} - V_{OUT}$) when $V_{OUT}$ starts to decrease by percent specified in the Electrical Characteristics table. $V_{BIAS}$ is high enough; specific value is published in the Electrical Characteristics table.

The second, $V_{BIAS}$ dropout voltage is the voltage difference ($V_{BIAS} - V_{OUT}$) when $V_{IN}$ and $V_{BIAS}$ pins are joined together and $V_{OUT}$ starts to decrease.

### Input and Output Capacitors

The device is designed to be stable for ceramic output capacitors with Effective capacitance in the range from 2.2 μF to 10 μF. The device is also stable with multiple capacitors in parallel, having the total effective capacitance in the specified range.

In applications where no low input supplies impedance available (PCB inductance in $V_{IN}$ and/or $V_{BIAS}$ inputs as example), the recommended $C_{IN}$ = 1 μF and $C_{BIAS}$ = 0.1 μF or greater. Ceramic capacitors are recommended**.** For the best performance all the capacitors should be connected to the NCP133 respective pins directly in the device PCB copper layer, not through vias having not negligible impedance.

When using small ceramic capacitor, their capacitance is not constant but varies with applied DC biasing voltage, temperature and tolerance. The effective capacitance can be much lower than their nominal capacitance value, most importantly in negative temperatures and higher LDO output voltages. That is why the recommended Output capacitor capacitance value is specified as Effective value in the specific application conditions.

### Enable Operation

The enable pin will turn the regulator on or off. The threshold limits are covered in the electrical characteristics table in this data sheet. If the enable function is not to be used then the pin should be connected to $V_{IN}$ or $V_{BIAS}$.

### Current Limitation

The internal Current Limitation circuitry allows the device to supply the full nominal current and surges but protects the device against Current Overload or Short.

### Thermal Protection

Internal thermal shutdown (TSD) circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When TSD activated , the regulator output turns off. When cooling down under the low temperature threshold, device output is activated again. This TSD feature is provided to prevent failures from accidental overheating.

Activation of the thermal protection circuit indicates excessive power dissipation or inadequate heatsinking. For reliable operation, junction temperature should be limited to +125°C maximum.

**Table 1. RESISTOR VALUES FOR PROGRAMMING THE OUTPUT VOLTAGE**

| $V_{OUT}$ (V) | $R_1$ (kΩ) | $R_2$ (kΩ) |
|---|---|---|
| 0.8 | Short | Open |
| 0.9 | 10.0 | 80.6 |
| 1.0 | 19.6 | 78.7 |
| 1.05 | 24.3 | 78.7 |
| 1.1 | 24.9 | 66.5 |
| 1.2 | 33.2 | 66.5 |
| 1.5 | 43.2 | 49.9 |
| 1.8 | 41.2 | 33.2 |
| 2.5 | 42.2 | 20.0 |
| 3.3 | 61.9 | 20.0 |

NOTE: $V_{OUT} = 0.8 \times (1 + R_1/R_2)$
Resistors in the table are standard 1% types

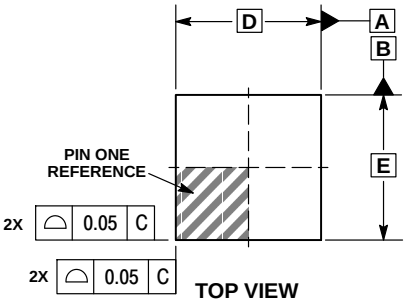
**ORDERING INFORMATION**

| Device | Nominal Output Voltage | Marking | Marking Rotation | Option | Package | Shipping† |
|---|---|---|---|---|---|---|
| NCP133AMX090TCG | 0.90 V | D | 90° | Output Active Discharge | XDFN6 (Pb−Free) | 3000 / Tape & Reel |
| NCP133AMX100TCG | 1.00 V | 3 | 0° | | | |
| NCP133AMX105TCG | 1.05 V | 4 | 0° | | | |
| NCP133AMX110TCG | 1.10 V | 5 | 0° | | | |
| NCP133AMX115TCG | 1.15 V | T | 90° | | | |
| NCP133AMX120TCG | 1.20 V | 6 | 0° | | | |
| NCP133AMX125TCG | 1.25 V | E | 90° | | | |
| NCP133AMX130TCG | 1.30 V | F | 90° | | | |
| NCP133AMX150TCG | 1.50 V | J | 90° | | | |
| NCP133AMX180TCG | 1.80 V | Q | 90° | | | |
| NCP133AMXADJTCG | ADJ | K | 90° | | | |
| NCP133BMXADJTCG | ADJ | P | 90° | Non−Active Discharge | | |

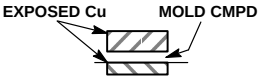
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
To order other package and voltage variants, please contact your ON Semiconductor sales representative

## PACKAGE DIMENSIONS

**XDFN6 1.20x1.20, 0.40P**
CASE 711AT
ISSUE A



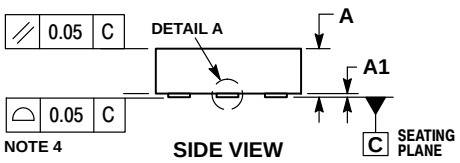

TOP VIEW



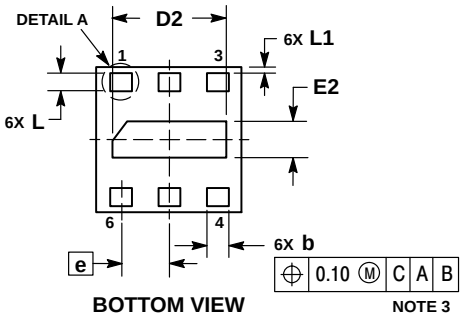

**DETAIL A**
**OPTIONAL CONSTRUCTION**

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 0.25mm FROM TERMINAL TIPS.
4. COPLANARITY APPLIES TO THE PAD AS WELL AS THE TERMINALS.

| | MILLIMETERS | |
|---|---|---|
| DIM | MIN | MAX |
| A | 0.30 | 0.45 |
| A1 | 0.00 | 0.05 |
| b | 0.13 | 0.23 |
| D | 1.20 BSC | |
| D2 | 0.84 | 1.04 |
| E | 1.20 BSC | |
| E2 | 0.20 | 0.40 |
| e | 0.40 BSC | |
| L | 0.15 | 0.25 |
| L1 | 0.05 REF | |

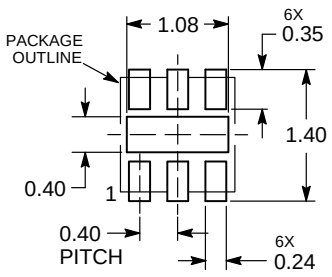



SIDE VIEW




BOTTOM VIEW

### RECOMMENDED MOUNTING FOOTPRINT*




DIMENSIONS: MILLIMETERS

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



**PUBLICATION ORDERING INFORMATION**

**LITERATURE FULFILLMENT**:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
**Phone**: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
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**Email**: orderlit@onsemi.com

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Phone: 421 33 790 2910
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