

# NCP708

## Voltage Regulator - 1% Precision, Very Low Dropout, Enable

### 1 A

The NCP708 is a Very Low Dropout Regulator which provides up to 1 A of load current and maintains excellent output voltage accuracy of 1.5% including line, load and temperature variations. The operating input voltage range from 2.4 V up to 5.5 V makes this device suitable for Li-ion battery powered products as well as post-regulation applications. The product is available in 3.3 V fixed output voltage option. Other voltage options are possible on request. NCP708 is fully protected against overheating and output short circuit.

Small 6-pin UDFN6 3x3 package makes the device especially suitable for space constrained applications.

#### Features

- Operating Input Voltage Range: 2.4 V to 5.5 V
- Fixed Output Voltage Option: 3.3 V  
Other Output Voltage Options Available on Request.
- Low Quiescent Current of Typ. 200  $\mu$ A
- Very Low Dropout: 250 mV Max. at  $I_{OUT} = 1$  A
- $\pm 1.5\%$  Accuracy Over Load/Line/Temperature
- High PSRR: 70 dB at 1 kHz
- Internal Soft-Start to Limit the Inrush Current
- Thermal Shutdown and Current Limit Protections
- Stable with a 4.7  $\mu$ F Ceramic Output Capacitor
- Available in UDFN6 3x3 mm Package
- These are Pb-Free Devices

#### Typical Applications

- Hard-Drives, SSDs
- Servers, Networking Equipment
- Telecom Equipment
- Battery Powered Applications

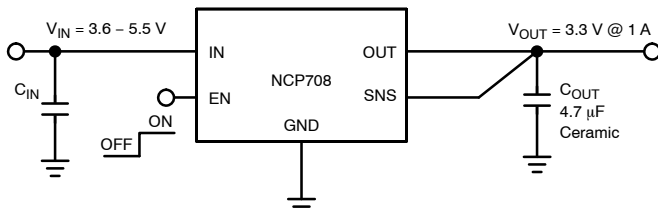


Figure 1. Typical Application Schematic



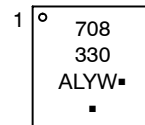
ON Semiconductor®

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UDFN6  
CASE 517DD

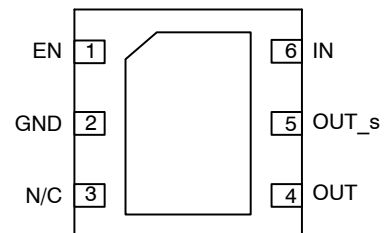
#### MARKING DIAGRAM



- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

#### PIN CONNECTION

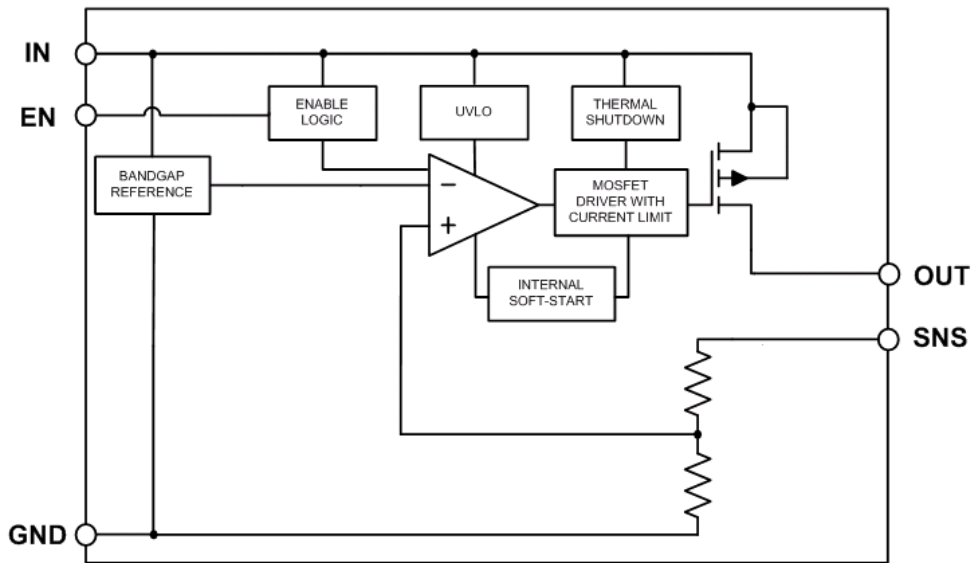


(Top View)

#### ORDERING INFORMATION

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

## NCP708



**Figure 2. Simplified Internal Schematic Block Diagram**

### PIN FUNCTION DESCRIPTION

Pin No.	Pin Name	Description
1	EN	Enable pin. Driving EN over 0.9 V turns on the regulator. Driving EN below 0.4 V puts the regulator into shutdown mode.
2	GND	Power supply ground.
3	N/C	Not connected. This pin can be tied to ground to improve thermal dissipation.
4	OUT	Regulated output voltage. A minimum 4.7 $\mu$ F ceramic capacitor is needed from this pin to ground to assure stability.
5	OUT_S	Output voltage sense connection. This pin should be connected to the output voltage rail.
6	IN	Input pin. A small capacitor is needed from this pin to ground to assure stability.
-	Exposed Pad	This pad enhances thermal performance and is electrically connected to GND. It is recommended that the exposed pad is connected to the ground plane on the board or otherwise left open.

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## ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage (Note 1)	$V_{IN}$	-0.3 V to 6 V	V
Output Voltage	$V_{OUT}$	-0.3 V to $V_{IN} + 0.3$ V	V
Enable Input	$V_{EN}$	-0.3 V to $V_{IN} + 0.3$ V	V
Output Short Circuit Duration	$t_{SC}$	Indefinite	s
Maximum Junction Temperature	$T_{J(MAX)}$	150	°C
Storage Temperature	$T_{STG}$	-55 to 150	°C
ESD Capability, Human Body Model (Note 2)	$ESD_{HBM}$	2000	V
ESD Capability, Machine Model (Note 2)	$ESD_{MM}$	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.

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
  - Latch-up Current Maximum Rating tested per JEDEC standard: JESD78

## THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, WDFN6 3 x 3, Thermal Resistance, Junction-to-Air	$R_{\theta JA}$	55	°C/W

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## ELECTRICAL CHARACTERISTICS – VOLTAGE VERSION 3.3 V

$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ;  $V_{IN} = V_{OUT(NOM)} + 0.3\text{ V}$  or  $2.4\text{ V}$ , whichever is greater;  $I_{OUT} = 10\text{ mA}$ ,  $C_{IN} = C_{OUT} = 4.7\text{ }\mu\text{F}$ ,  $V_{EN} = 0.9\text{ V}$ , unless otherwise noted. Typical values are at  $T_J = +25^{\circ}\text{C}$ . (Note 3)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage		$V_{IN}$	2.4		5.5	V
Undervoltage lock-out	$V_{IN}$ rising	UVLO	1.2	1.6	1.9	V
Output Voltage Accuracy	$V_{OUT} + 0.3\text{ V} \leq V_{IN} \leq 5.25\text{ V}$ , $I_{OUT} = 0 - 1\text{ A}$	$V_{OUT}$	3.25	3.3	3.35	V
Line Regulation	$V_{OUT} + 0.3\text{ V} \leq V_{IN} \leq 5.25\text{ V}$ , $I_{OUT} = 10\text{ mA}$	Reg <sub>LINE</sub>		2		mV
Load Regulation	$I_{OUT} = 0\text{ mA}$ to $1\text{ A}$	Reg <sub>LOAD</sub>		2		mV
Load Transient	Any 200 mA load step from $I_{OUT} = 10\text{ mA}$ to $1\text{ A}$ or $10\text{ mA}$ to $1\text{ A}$ in $10\text{ }\mu\text{s}$ , $C_{OUT} = 10\text{ }\mu\text{F}$	Tran <sub>LOAD</sub>		$\pm 60$		mV
Dropout voltage (Note 4)	$I_{OUT} = 1\text{ A}$ , $V_{OUT(nom)} = 3.3\text{ V}$	$V_{DO}$		220	330	mV
Output Current Limit	$V_{OUT} = 90\% V_{OUT(nom)}$	$I_{CL}$	1.1			A
Quiescent current	$I_{OUT} = 0\text{ mA}$	$I_Q$		180	230	$\mu\text{A}$
Ground current	$I_{OUT} = 1\text{ A}$	$I_{GND}$		200		$\mu\text{A}$
Shutdown current	$V_{EN} \leq 0\text{ V}$ , $V_{IN} = 2.0$ to $5.5\text{ V}$			0.1	1	$\mu\text{A}$
Reverse Leakage Current in Shutdown	$V_{IN} = 5.5\text{ V}$ , $V_{OUT} = V_{OUT(NOM)}$ , $V_{EN} < 0.4\text{ V}$	$I_{REV}$		1.5	5	$\mu\text{A}$
EN Pin High Threshold	$V_{EN}$ Voltage increasing	$V_{EN\_HI}$	0.9			V
EN Pin Low Threshold	$V_{EN}$ Voltage decreasing	$V_{EN\_LO}$			0.4	V
EN Pin Input Current	$V_{EN} = 5.5\text{ V}$	$I_{EN}$		100	500	nA
Turn-on Time	$C_{OUT} = 4.7\text{ }\mu\text{F}$ , from assertion EN pin to 98% $V_{out(nom)}$	$t_{ON}$		200		$\mu\text{s}$
Power Supply Rejection Ratio	$V_{IN} = 3.8\text{ V}$ , $V_{OUT} = 3.3\text{ V}$ , $I_{OUT} = 0.1\text{ A}$	$f = 1\text{ kHz}$ PSRR		70		dB
Output Noise Voltage	$V_{OUT} = 3.3\text{ V}$ , $V_{IN} = 3.6\text{ V}$ , $I_{OUT} = 0.1\text{ A}$ $f = 200\text{ Hz}$ to $100\text{ kHz}$	$V_{NOISE}$		100		$\mu\text{V}_{rms}$
Thermal Shutdown Temperature	Temperature increasing from $T_J = +25^{\circ}\text{C}$	$T_{SD}$		160		$^{\circ}\text{C}$
Thermal Shutdown Hysteresis	Temperature falling from $T_{SD}$	$T_{SDH}$	-	20	-	$^{\circ}\text{C}$

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.

- Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at  $T_J = T_A = 25^{\circ}\text{C}$ . Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
- Characterized when  $V_{OUT}$  falls 100 mV below the regulated voltage at  $V_{IN} = V_{OUT(NOM)} + 0.3\text{ V}$ .

## TYPICAL CHARACTERISTICS

$V_{IN} = V_{OUT-NOM} + 0.3\text{ V}$  or  $V_{IN} = 2.4\text{ V}$  whatever is greater,  $V_{EN} = 0.9\text{ V}$ ,  $I_{OUT} = 10\text{ mA}$ ,  $C_{IN} = C_{OUT} = 4.7\text{ }\mu\text{F}$ ,  $T_J = 25^{\circ}\text{C}$ .

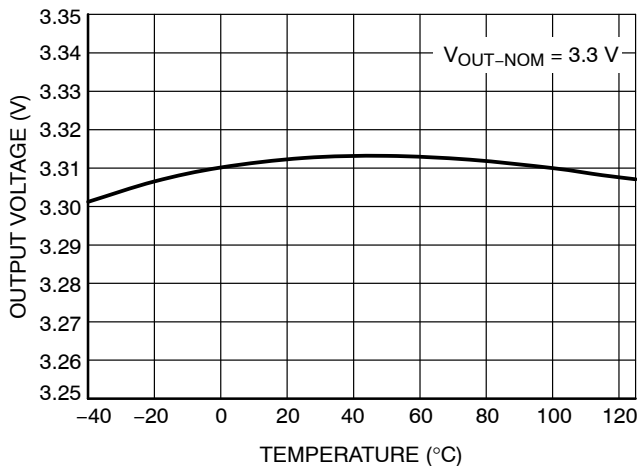


Figure 3. Output Voltage vs. Temperature

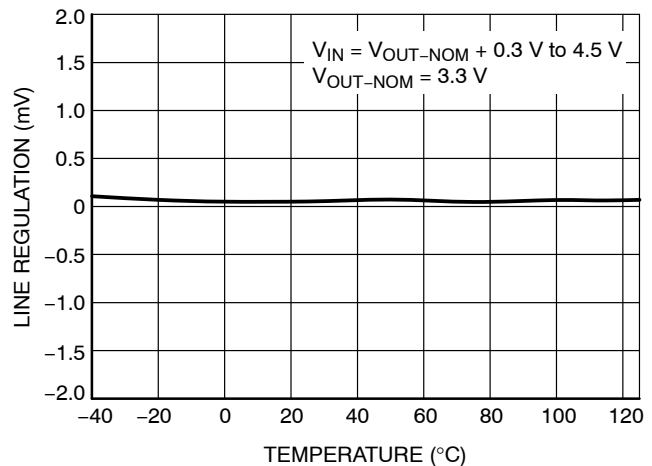


Figure 4. Line Regulation vs. Temperature

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## TYPICAL CHARACTERISTICS

$V_{IN} = V_{OUT-NOM} + 0.3\text{ V}$  or  $V_{IN} = 2.4\text{ V}$  whatever is greater,  $V_{EN} = 0.9\text{ V}$ ,  $I_{OUT} = 10\text{ mA}$ ,  $C_{IN} = C_{OUT} = 4.7\text{ }\mu\text{F}$ ,  $T_J = 25^\circ\text{C}$ .

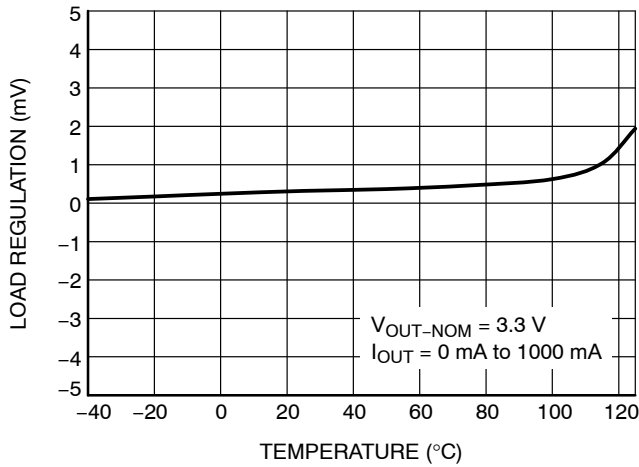


Figure 5. Load Regulation vs. Temperature

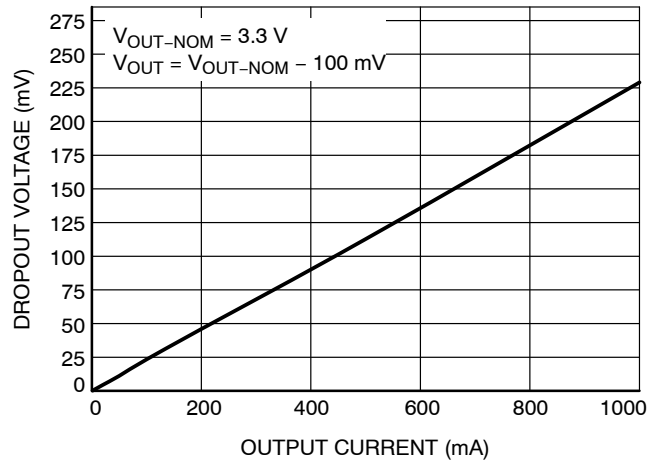


Figure 6. Dropout Voltage vs. Output Current

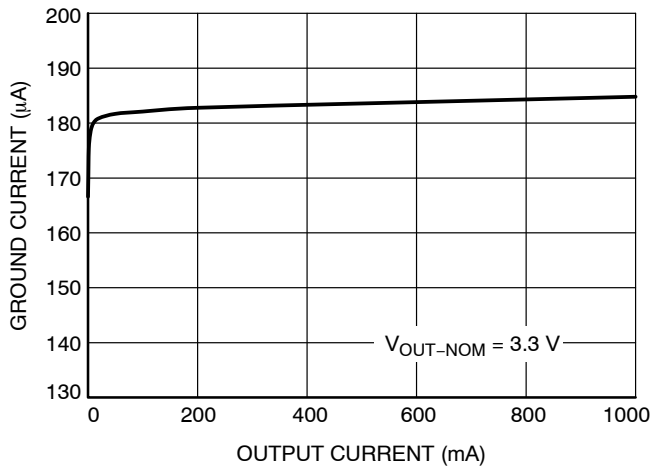


Figure 7. Ground Current vs. Output Current

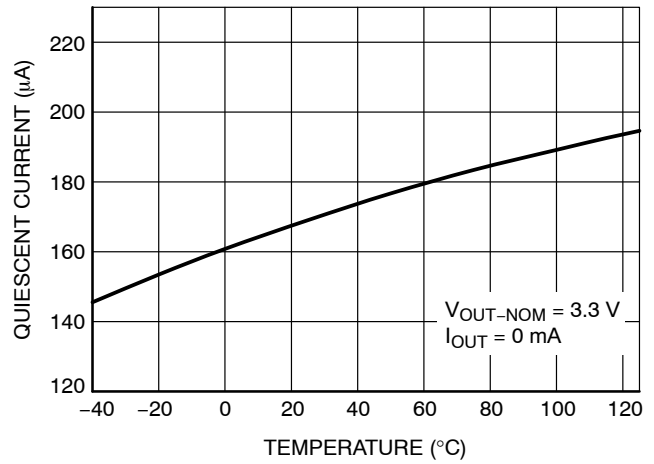


Figure 8. Quiescent Current vs. Temperature

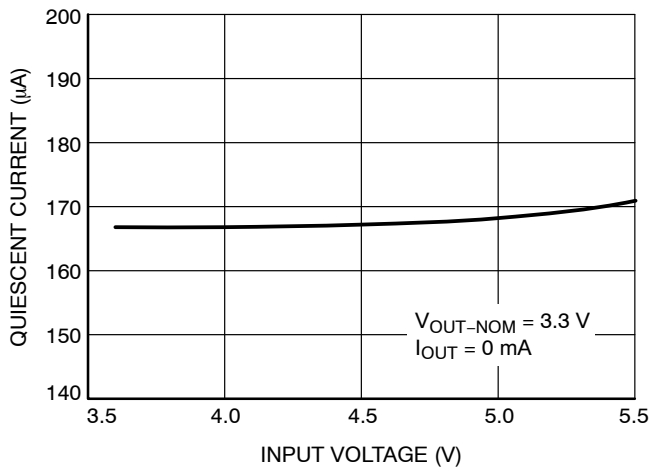


Figure 9. Quiescent Current vs. Input Voltage

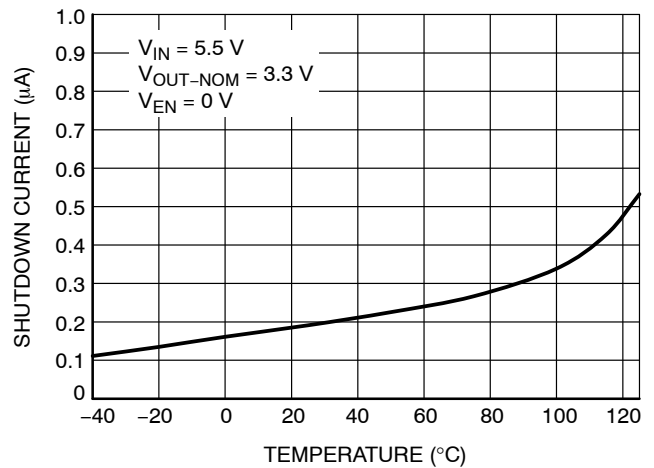


Figure 10. Shutdown Current vs. Temperature

# NCP708

## TYPICAL CHARACTERISTICS

$V_{IN} = V_{OUT-NOM} + 0.3\text{ V}$  or  $V_{IN} = 2.4\text{ V}$  whatever is greater,  $V_{EN} = 0.9\text{ V}$ ,  $I_{OUT} = 10\text{ mA}$ ,  $C_{IN} = C_{OUT} = 4.7\text{ }\mu\text{F}$ ,  $T_J = 25^\circ\text{C}$ .

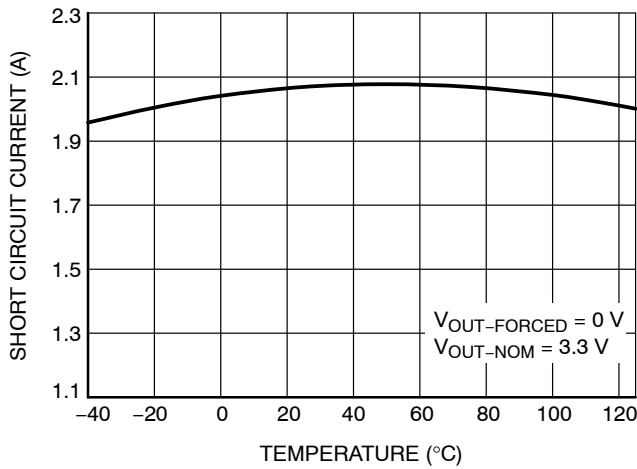


Figure 11. Short Circuit Current vs. Temperature

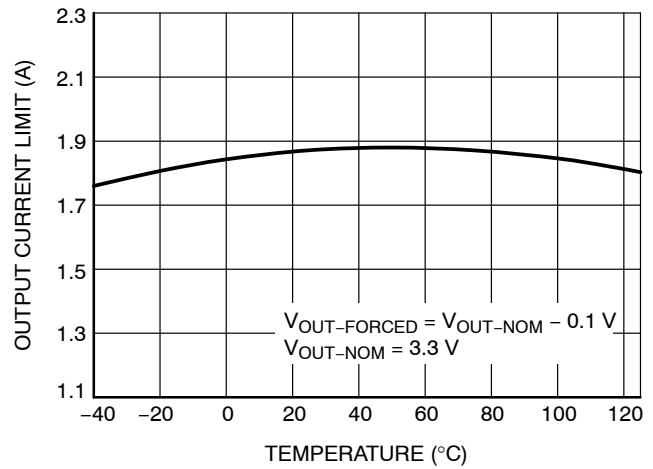


Figure 12. Output Current Limit vs. Temperature

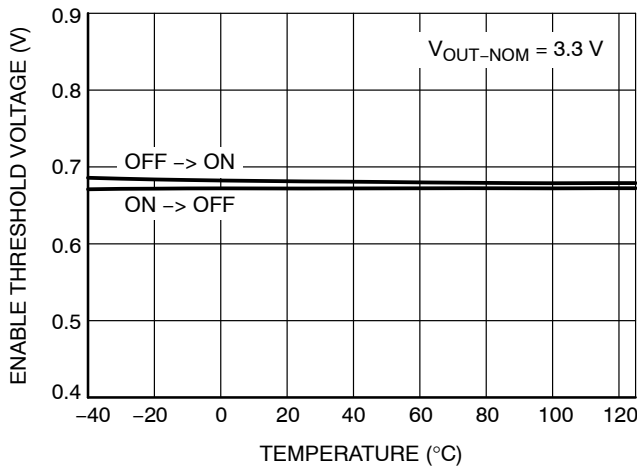


Figure 13. Enable Threshold Voltage vs. Temperature

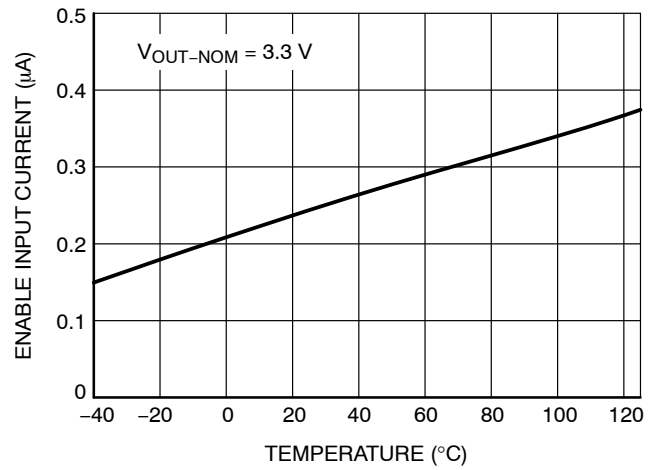


Figure 14. Enable Input Current vs. Temperature

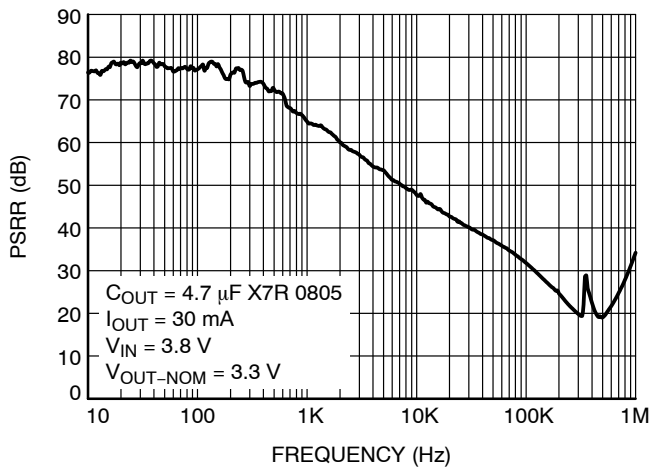


Figure 15. Power Supply Rejection Ratio

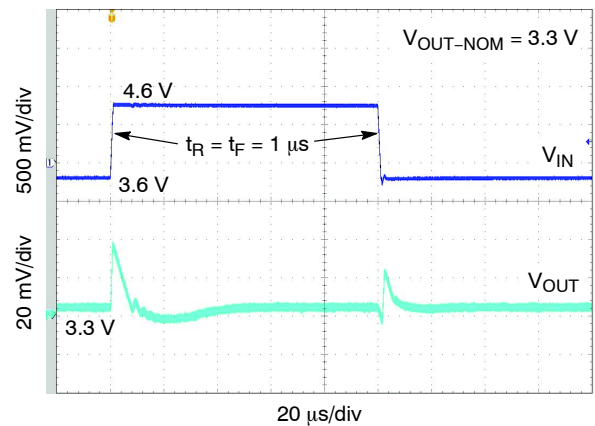


Figure 16. Line Transient Response

# NCP708

## TYPICAL CHARACTERISTICS

$V_{IN} = V_{OUT-NOM} + 0.3 \text{ V}$  or  $V_{IN} = 2.4 \text{ V}$  whatever is greater,  $V_{EN} = 0.9 \text{ V}$ ,  $I_{OUT} = 10 \text{ mA}$ ,  $C_{IN} = C_{OUT} = 4.7 \mu\text{F}$ ,  $T_J = 25^\circ\text{C}$ .

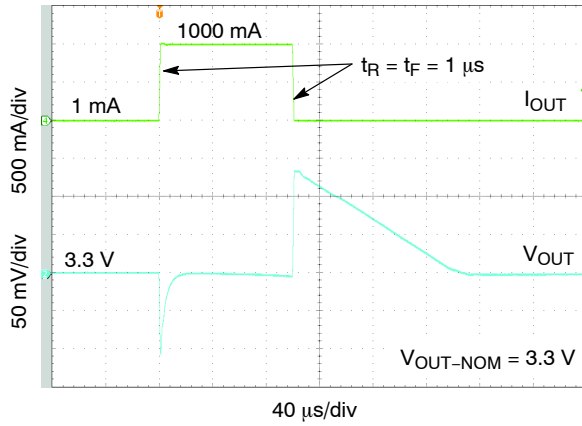


Figure 17. Load Transient Response

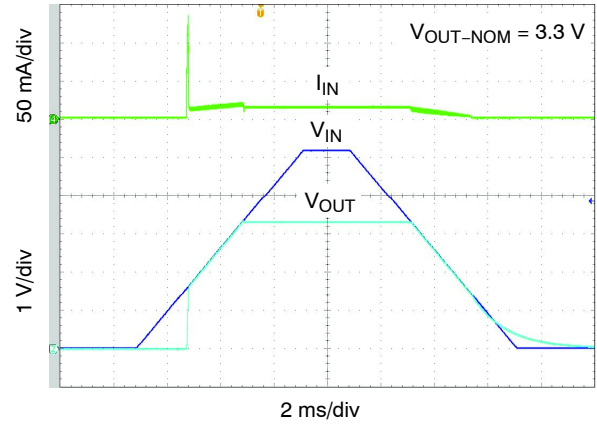


Figure 18. Turn-ON/OFF – VIN Driven (slow)

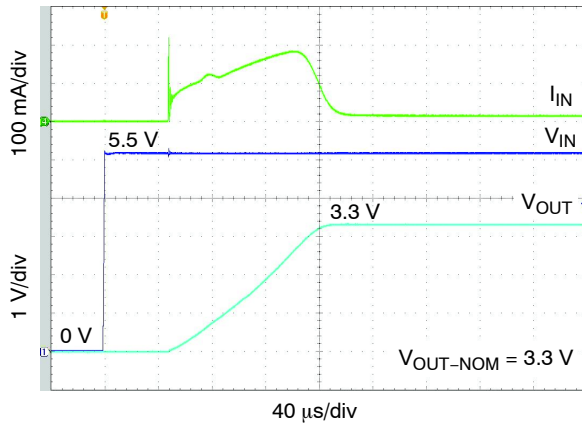


Figure 19. Turn-ON/OFF – VIN Driven (fast)

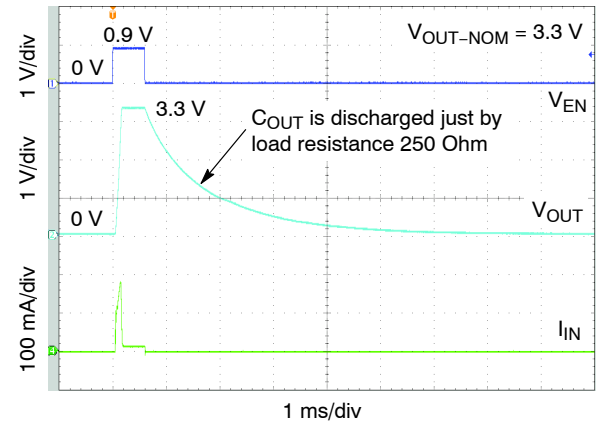


Figure 20. Turn-ON/OFF – EN Driven

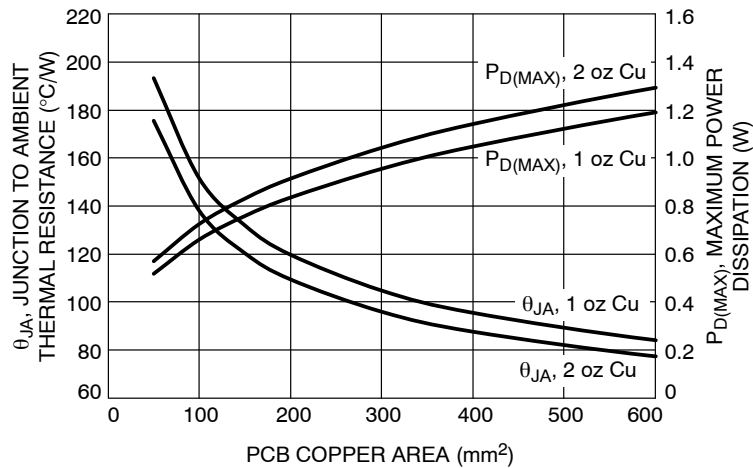


Figure 21.  $\theta_{JA}$  and  $P_{D(MAX)}$  vs. Copper Area

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## APPLICATIONS INFORMATION

### Input Decoupling (C<sub>in</sub>)

A 4.7  $\mu$ F capacitor either ceramic or tantalum is recommended and should be connected as close as possible to the pins of NCP708 device. Higher values and lower ESR will improve the overall line transient response.

### Output Decoupling (C<sub>out</sub>)

The minimum decoupling value is 4.7  $\mu$ F and can be augmented to fulfill stringent load transient requirements. The regulator accepts ceramic chip capacitors MLCC. If a tantalum capacitor is used, and its ESR is large, the loop oscillation may result. Larger values improve noise rejection and PSRR.

### Enable Operation

The enable pin EN will turn on or off the regulator. These limits of threshold are covered in the electrical specification section of this data sheet. If the enable is not used then the pin should be connected to V<sub>IN</sub>.

### Hints

Please be sure the V<sub>in</sub> and GND lines are sufficiently wide. If their impedance is high, noise pickup or unstable operation may result.

Set external components, especially the output capacitor, as close as possible to the circuit.

The sense pin SNS trace is recommended to be kept as far from noisy power traces as possible and as close to load as possible.

### Thermal

As power across the NCP708 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 also the ambient temperature affect the rate of temperature rise for the part. This is stating that when the NCP708 has good thermal conductivity through the PCB, the junction temperature will be relatively low with high power dissipation.

The power dissipation across the device can be roughly represented by the equation:

$$P_D = (V_{IN} - V_{OUT}) * I_{OUT} \text{ [W]} \quad (\text{eq. 1})$$

The maximum power dissipation depends on the thermal resistance of the case and circuit board, the temperature differential between the junction and ambient, PCB orientation and the rate of air flow.

The maximum allowable power dissipation can be calculated using the following equation:

$$P_{MAX} = (T_J - T_A) / \theta_{JA} \text{ [W]} \quad (\text{eq. 2})$$

Where (T<sub>J</sub> - T<sub>A</sub>) is the temperature differential between the junction and the surrounding environment and  $\theta_{JA}$  is the thermal resistance from the junction to the ambient.

Connecting the exposed pad and non connected pin 3 to a large ground pad or plane helps to conduct away heat and improves thermal relief.

## ORDERING INFORMATION

Device	Nominal Output Voltage	Package	Shipping <sup>†</sup>
NCP708MU330TAG	3.3 V	UDFN6 3 x 3 (Pb-Free)	3000 / Tape & Reel

<sup>†</sup>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.



# MECHANICAL CASE OUTLINE

## PACKAGE DIMENSIONS

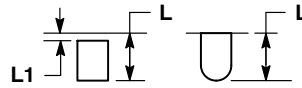
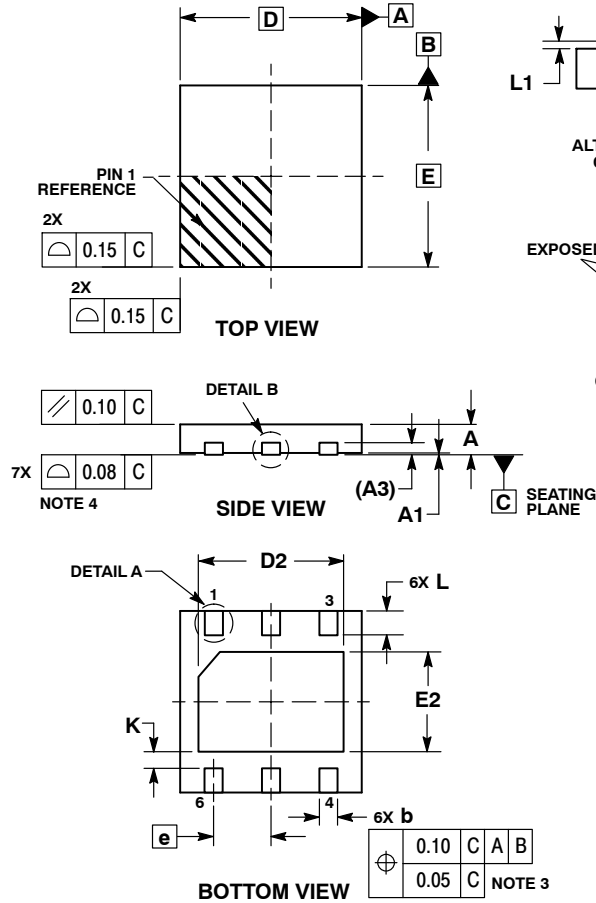
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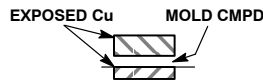
SCALE 2:1

UDFN6 3x3, 0.95P  
CASE 517DD  
ISSUE O

DATE 28 OCT 2014



**DETAIL A**  
ALTERNATE TERMINAL  
CONSTRUCTIONS



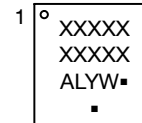
**DETAIL B**  
ALTERNATE  
CONSTRUCTIONS

**NOTES:**

1. DIMENSIONS 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 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS		
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.20	REF
b	0.25	0.35
D	3.00	BSC
D2	2.30	2.50
E	3.00	BSC
E2	1.55	1.75
e	0.95	BSC
K	0.28	REF
L	0.30	0.50
L1	---	0.15

**GENERIC MARKING DIAGRAM\***

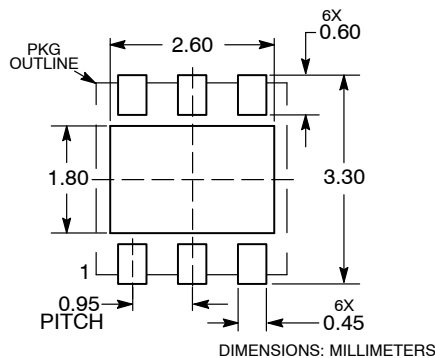


- XXXXX = Specific Device Code
- A = Assembly Location
- L = Wafer Lot
- Y = Year
- W = Work Week
- = Pb-Free Package

(Note: Microdot may be in either location)

\*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.

**RECOMMENDED 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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<b>DESCRIPTION:</b>	<b>UDFN6 3X3, 0.95P</b>	<b>PAGE 1 OF 1</b>

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