

# NCP706

## 1A, 1% Precision Very Low Dropout Voltage Regulator with Enable

The NCP706 is a Very Low Dropout Regulator which provides up to 1 A of load current and maintains excellent output voltage accuracy of 1% 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 2.1 V and 2.2 V fixed output voltage options. NCP706 is fully protected against overheating and output short circuit.

Very small 8-pin XDFN8 1.6 x 1.2, 04P package makes the device especially suitable for space constrained portable applications such as tablets and smartphones.

### Features

- Operating Input Voltage Range: 2.4 V to 5.5 V
- Fixed Output Voltage Option: 2.1 V, 2.2 V  
Other Output Voltage Options available on request.
- Low Quiescent Current of typ. 200  $\mu$ A
- Very Low Dropout: 300 mV Max. at  $I_{OUT} = 1$  A
- $\pm 1\%$  Accuracy Over Load/Line/Temperature
- High PSRR: 60 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 XDFN8 1.6 x 1.2, 04P 8-pin package
- These are Pb-Free Devices

### Typical Applications

- Tablets, Smartphones,
- Wireless Handsets, Portable Media Players
- Portable Medical Equipment
- Other Battery Powered Applications

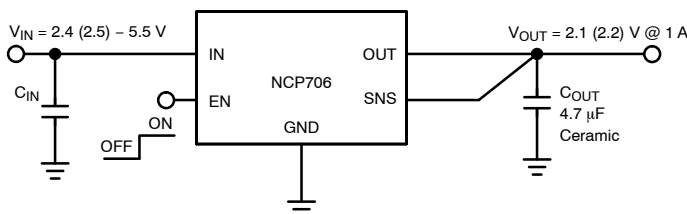


Figure 1. Typical Application Schematic



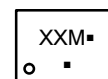
ON Semiconductor®

<http://onsemi.com>

### MARKING DIAGRAM



XDFN8  
CASE 711AS



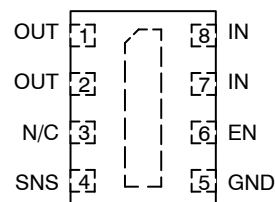
XX = Specific Device Code

M = Date Code

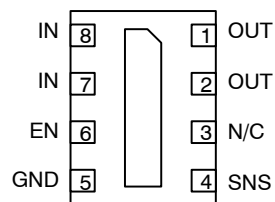
▪ = Pb-Free Package

(\*Note: Microdot may be in either location)

### PIN CONNECTION



(Top View)

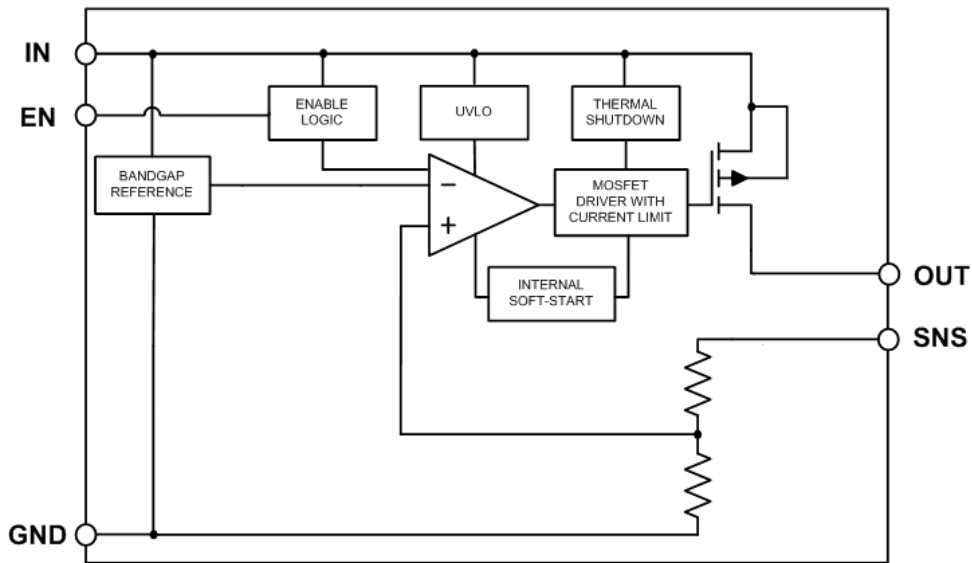


(Bottom View)

### ORDERING INFORMATION

See detailed ordering and shipping information on page 11 of this data sheet.

## NCP706



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

### PIN FUNCTION DESCRIPTION

Pin No. XDFN8	Pin Name	Description
1	OUT	Regulated output voltage. A minimum 4.7 $\mu$ F ceramic capacitor is needed from this pin to ground to assure stability.
2	OUT	
3	N/C	Not connected. This pin can be tied to ground to improve thermal dissipation.
4	SNS	Remote sense connection. This pin should be connected to the output voltage rail.
5	GND	Power supply ground.
6	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.
7	IN	Input pin. A small capacitor is needed from this pin to ground to assure stability.
8	IN	
-	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	$T_{J(MAX)}$	125	°C
Storage Temperature	$T_{STG}$	-55 to 150	°C
ESD Capability, Human Body Model (Note 2)	ESD <sub>HBM</sub>	2000	V
ESD Capability, Machine Model (Note 2)	ESD <sub>MM</sub>	200	V

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.

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, XDFN8 1.6x1.2, 04P Thermal Resistance, Junction-to-Air	$R_{\theta JA}$	160	°C/W

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## ELECTRICAL CHARACTERISTICS – VOLTAGE VERSION 2.1 V

–40°C ≤ T<sub>J</sub> ≤ 125°C; V<sub>IN</sub> = V<sub>OUT(NOM)</sub> + 0.3 V or 2.4 V, whichever is greater; I<sub>OUT</sub> = 10 mA, C<sub>IN</sub> = C<sub>OUT</sub> = 4.7 μF, V<sub>EN</sub> = 0.9 V, unless otherwise noted. Typical values are at T<sub>J</sub> = +25°C. (Note 3)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage		V <sub>IN</sub>	2.4		5.5	V
Undervoltage lock-out	V <sub>IN</sub> rising	UVLO	1.2	1.6	1.9	V
Output Voltage Accuracy	V <sub>OUT</sub> + 0.3 V ≤ V <sub>IN</sub> ≤ 4.5 V, I <sub>OUT</sub> = 0 – 1 A	V <sub>OUT</sub>	2.079	2.10	2.121	V
Line Regulation	V <sub>OUT</sub> + 0.3 V ≤ V <sub>IN</sub> ≤ 4.5 V, I <sub>OUT</sub> = 10 mA	Reg <sub>LINE</sub>		2		mV
Load Regulation	I <sub>OUT</sub> = 0 mA to 1 A	Reg <sub>LOAD</sub>		2		mV
Load Transient	I <sub>OUT</sub> = 10 mA to 1 A or 10 mA to 1 A in 10 μs, C <sub>OUT</sub> = 10 μF	Tran <sub>LOAD</sub>		±120		mV
Dropout voltage (Note 4)	I <sub>OUT</sub> = 1 A, V <sub>OUT(nom)</sub> = 2.1 V	V <sub>DO</sub>			300	mV
Output Current Limit	V <sub>OUT</sub> = 90% V <sub>OUT(nom)</sub>	I <sub>CL</sub>	1.1			A
Quiescent current	I <sub>OUT</sub> = 0 mA	I <sub>Q</sub>		180	230	μA
Ground current	I <sub>OUT</sub> = 1 A	I <sub>IGND</sub>		200		μA
Shutdown current	V <sub>EN</sub> ≤ 0 V, V <sub>IN</sub> = 2.0 to 5.5 V			0.1	1	μA
Reverse Leakage Current in Shutdown	V <sub>IN</sub> = 5.5 V, V <sub>OUT</sub> = V <sub>OUT(NOM)</sub> , V <sub>EN</sub> < 0.4 V	I <sub>REV</sub>		1.5	5	μA
EN Pin High Threshold	V <sub>EN</sub> Voltage increasing	V <sub>EN_HI</sub>	0.9			V
EN Pin Low Threshold	V <sub>EN</sub> Voltage decreasing	V <sub>EN_LO</sub>			0.4	V
EN Pin Input Current	V <sub>EN</sub> = 5.5 V	I <sub>EN</sub>		100	500	nA
Turn-on Time	C <sub>OUT</sub> = 4.7 μF, from assertion EN pin to 98% V <sub>out(nom)</sub>	t <sub>ON</sub>		200		μs
Power Supply Rejection Ratio	V <sub>IN</sub> = 2.6 V, V <sub>OUT</sub> = 2.1 V I <sub>OUT</sub> = 0.5 A	PSRR	f = 100 Hz f = 1 kHz f = 10 kHz	60 60 40		dB
Output Noise Voltage	V <sub>OUT</sub> = 2.1 V, V <sub>IN</sub> = 2.6 V, I <sub>OUT</sub> = 0.5 A f = 100 Hz to 100 kHz	V <sub>NOISE</sub>		280		μV <sub>rms</sub>
Thermal Shutdown Temperature	Temperature increasing from T <sub>J</sub> = +25°C	T <sub>SD</sub>		160		°C
Thermal Shutdown Hysteresis	Temperature falling from T <sub>SD</sub>	T <sub>SDH</sub>	–	20	–	°C

3. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at

T<sub>J</sub> = T<sub>A</sub> = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.

4. Characterized when V<sub>OUT</sub> falls 100 mV below the regulated voltage at V<sub>IN</sub> = V<sub>OUT(NOM)</sub> + 0.3 V.

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## ELECTRICAL CHARACTERISTICS – VOLTAGE VERSION 2.2 V

–40°C ≤ T<sub>J</sub> ≤ 125°C; V<sub>IN</sub> = V<sub>OUT(NOM)</sub> + 0.3 V or 2.5 V, whichever is greater; I<sub>OUT</sub> = 10 mA, C<sub>IN</sub> = C<sub>OUT</sub> = 4.7 μF, V<sub>EN</sub> = 0.9 V, unless otherwise noted. Typical values are at T<sub>J</sub> = +25°C. (Note 5)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage		V <sub>IN</sub>	2.5		5.5	V
Undervoltage lock-out	V <sub>IN</sub> rising	UVLO	1.2	1.6	1.9	V
Output Voltage Accuracy	V <sub>OUT</sub> + 0.3 V ≤ V <sub>IN</sub> ≤ 4.5 V, I <sub>OUT</sub> = 0 – 1 A	V <sub>OUT</sub>	2.178	2.2	2.222	V
Line Regulation	V <sub>OUT</sub> + 0.3 V ≤ V <sub>IN</sub> ≤ 4.5 V, I <sub>OUT</sub> = 10 mA	Reg <sub>LINE</sub>		2		mV
Load Regulation	I <sub>OUT</sub> = 0 mA to 1 A	Reg <sub>LOAD</sub>		2		mV
Load Transient	I <sub>OUT</sub> = 10 mA to 1 A or 10 mA to 1 A in 10 μs, C <sub>OUT</sub> = 10 μF	Tran <sub>LOAD</sub>		±120		mV
Dropout voltage (Note 6)	I <sub>OUT</sub> = 1 A, V <sub>OUT(nom)</sub> = 2.2 V	V <sub>DO</sub>			300	mV
Output Current Limit	V <sub>OUT</sub> = 90% V <sub>OUT(nom)</sub>	I <sub>CL</sub>	1.1			A
Quiescent current	I <sub>OUT</sub> = 0 mA	I <sub>Q</sub>		180	230	μA
Ground current	I <sub>OUT</sub> = 1 A	I <sub>IGND</sub>		200		μA
Shutdown current	V <sub>EN</sub> ≤ 0 V, V <sub>IN</sub> = 2.0 to 5.5 V			0.1	1	μA
EN Pin High Threshold EN Pin Low Threshold	V <sub>EN</sub> Voltage increasing V <sub>EN</sub> Voltage decreasing	V <sub>EN_HI</sub> V <sub>EN_LO</sub>	0.9		0.4	V
EN Pin Input Current	V <sub>EN</sub> = 5.5 V	I <sub>EN</sub>		100	500	nA
Turn-on Time	C <sub>OUT</sub> = 4.7 μF, from assertion EN pin to 98% V <sub>out(nom)</sub>	t <sub>ON</sub>		200		μs
Power Supply Rejection Ratio	V <sub>IN</sub> = 3.2 V, V <sub>OUT</sub> = 2.2 V I <sub>OUT</sub> = 0.5 A	PSRR		55 70 60		dB
Output Noise Voltage	V <sub>OUT</sub> = 2.2 V, V <sub>IN</sub> = 2.7 V, I <sub>OUT</sub> = 0.5 A f = 100 Hz to 100 kHz	V <sub>NOISE</sub>		300		μV <sub>rms</sub>
Thermal Shutdown Temperature	Temperature increasing from T <sub>J</sub> = +25°C	T <sub>SD</sub>		160		°C
Thermal Shutdown Hysteresis	Temperature falling from T <sub>SD</sub>	T <sub>SDH</sub>	–	20	–	°C

5. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at T<sub>J</sub> = T<sub>A</sub> = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
6. Characterized when V<sub>OUT</sub> falls 100 mV below the regulated voltage at V<sub>IN</sub> = V<sub>OUT(NOM)</sub> + 0.3 V.

TYPICAL CHARACTERISTICS

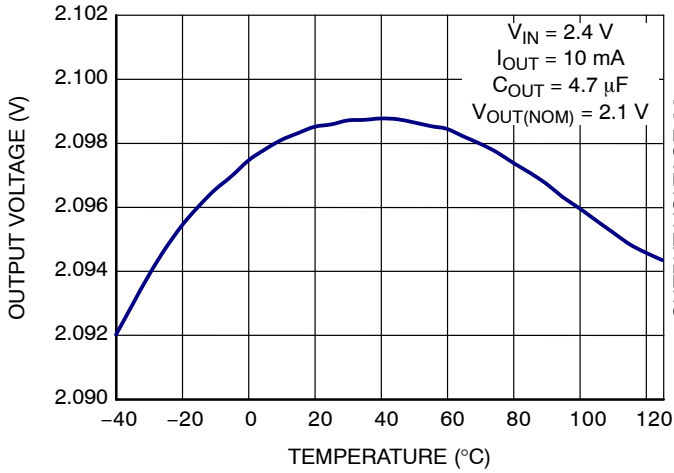


Figure 3. Output Voltage vs. Temperature

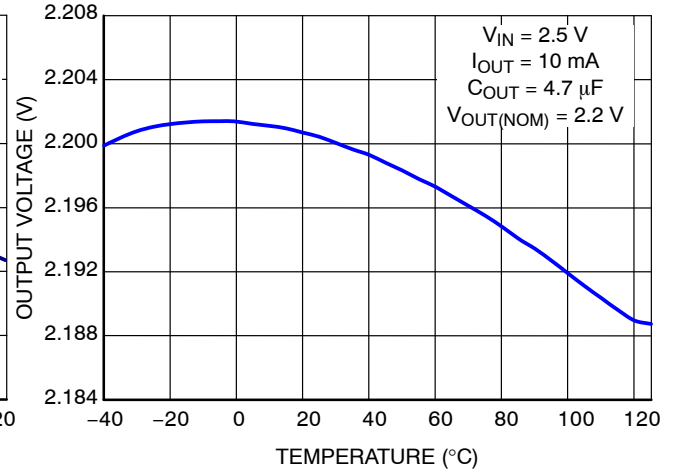


Figure 4. Output Voltage vs. Temperature

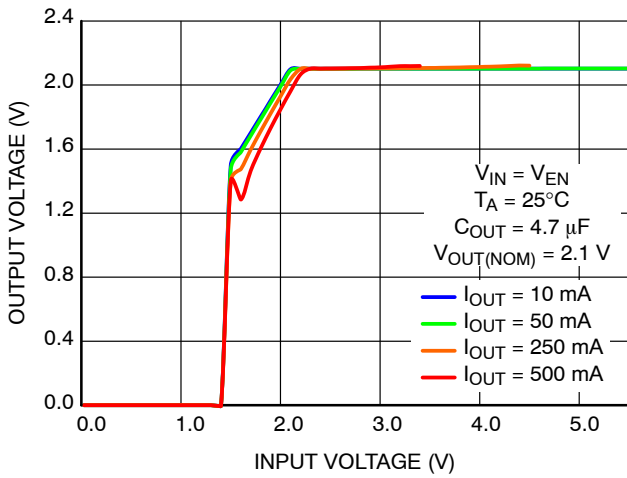


Figure 5. Output Voltage vs. Input Voltage

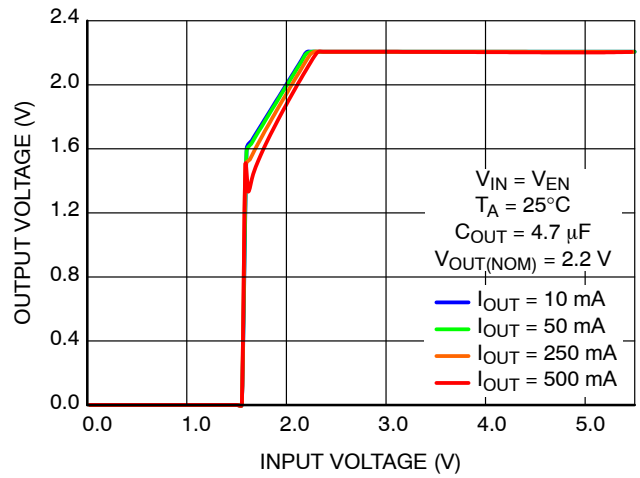


Figure 6. Output Voltage vs. Input Voltage

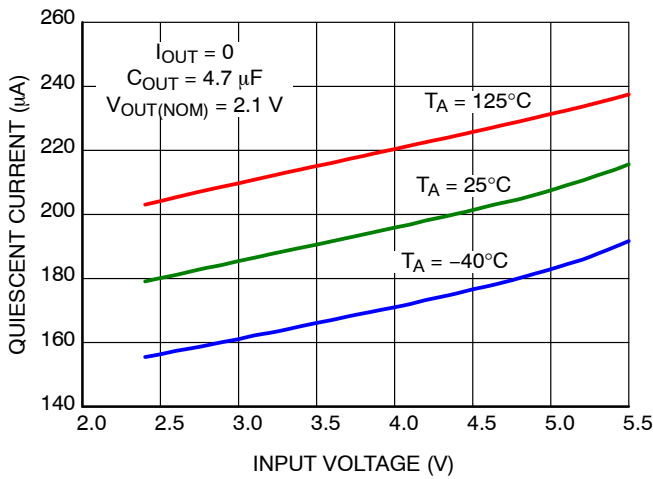


Figure 7. Quiescent Current vs. Input Voltage

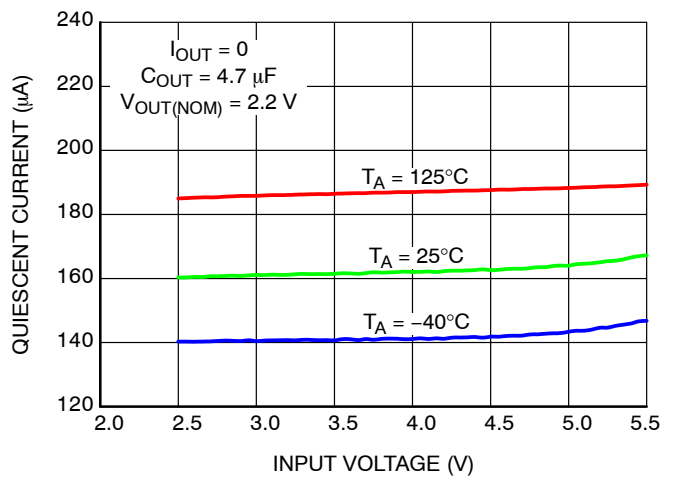


Figure 8. Quiescent Current vs. Input Voltage

TYPICAL CHARACTERISTICS

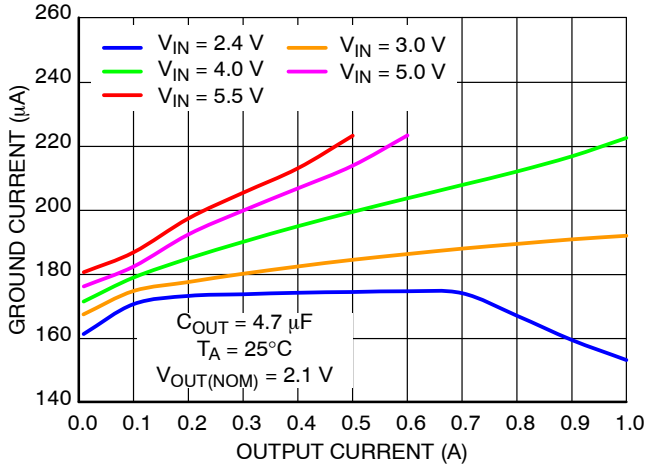


Figure 9. Ground Current vs. Output Current

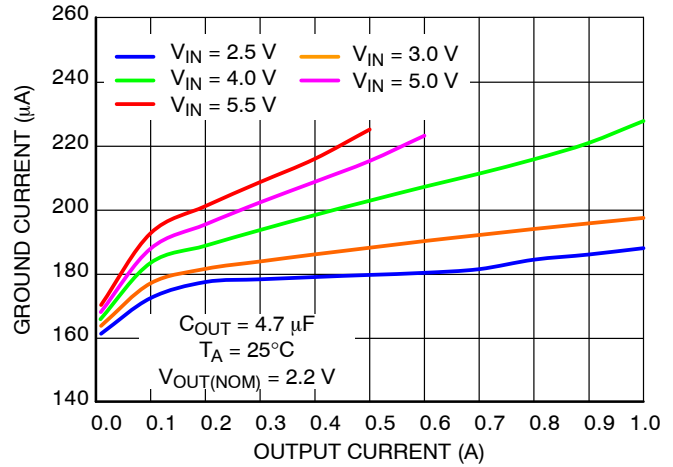


Figure 10. Ground Current vs. Output Current

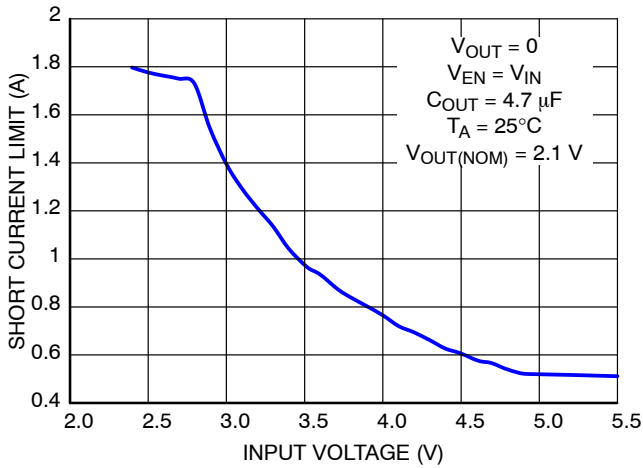


Figure 11. Short Current Limitation vs. Input Voltage

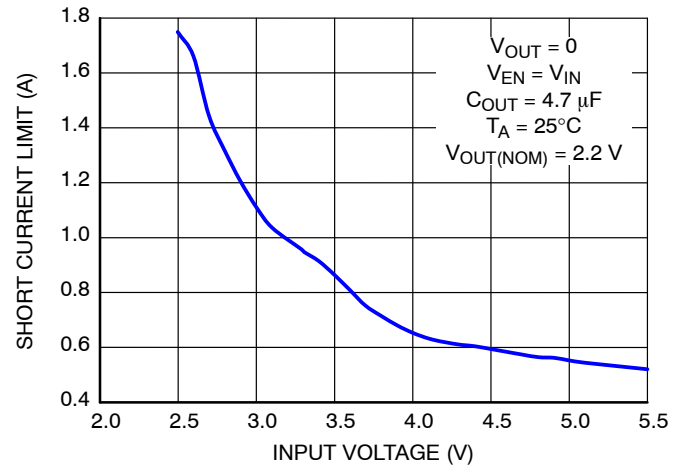


Figure 12. Short Current Limitation vs. Input Voltage

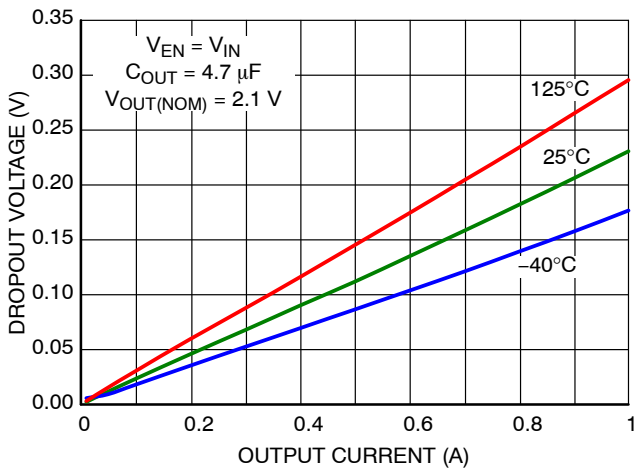


Figure 13. Dropout Voltage vs. Output Current

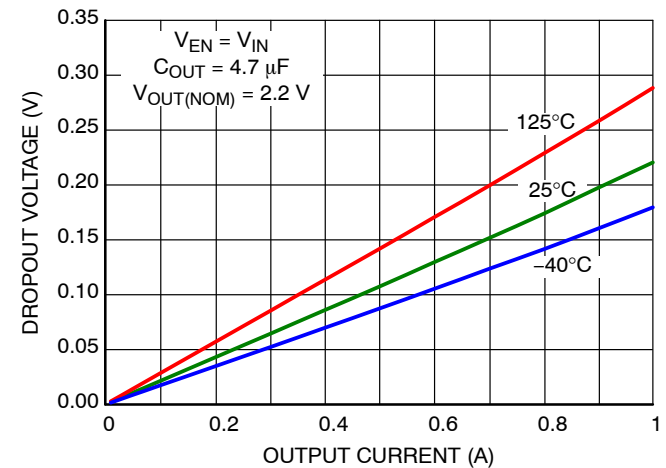
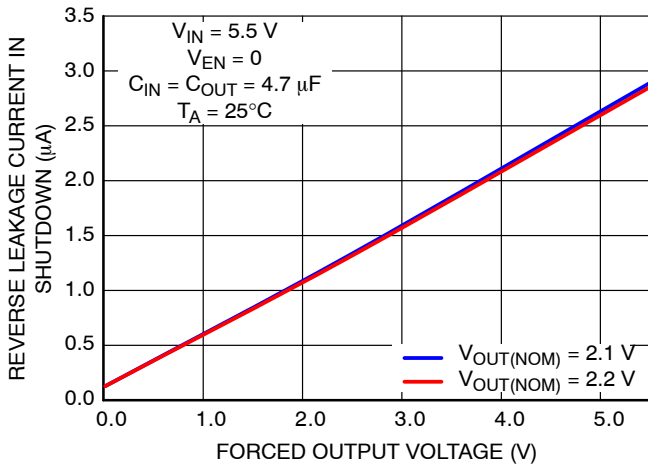
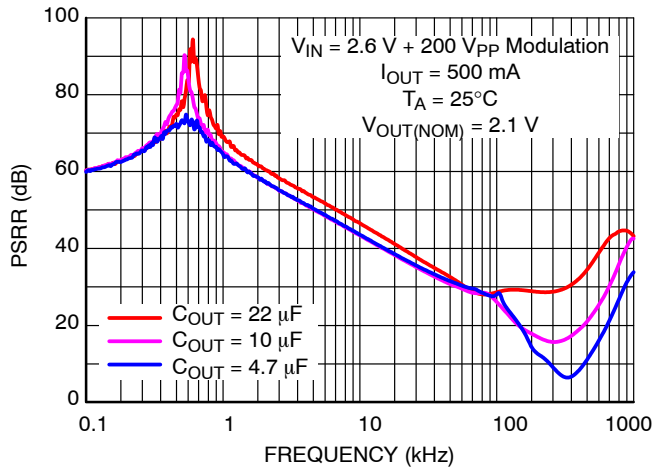


Figure 14. Dropout Voltage vs. Output Current

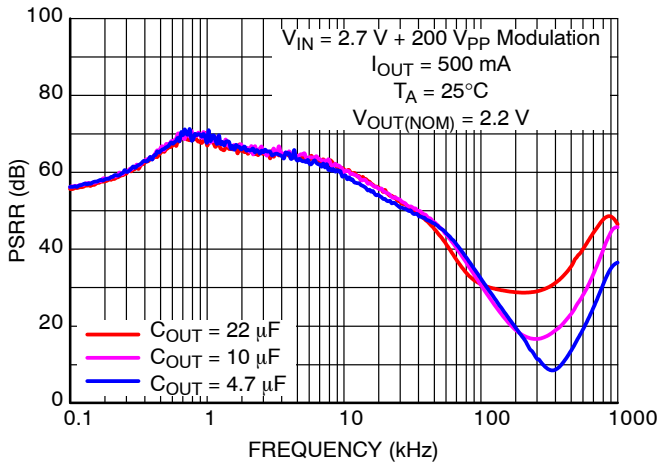
# NCP706



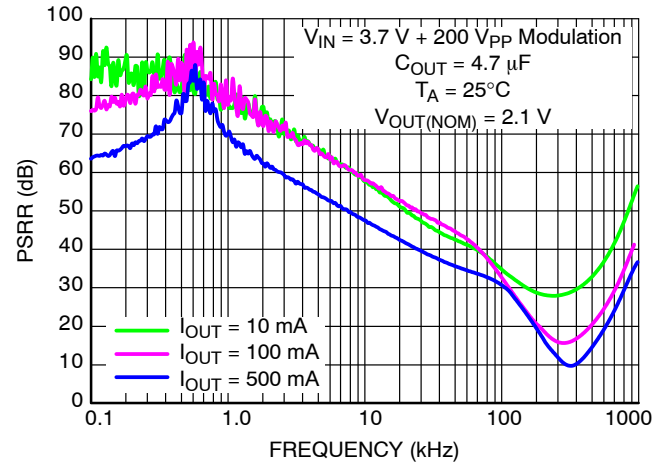
**Figure 15. Reverse Leakage Current in Shutdown**



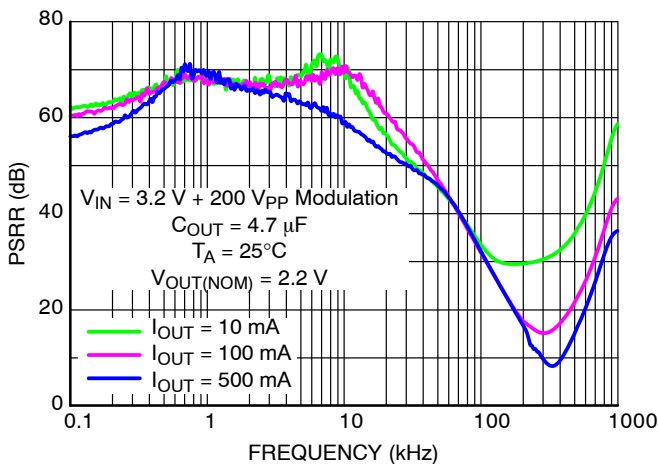
**Figure 16. PSRR vs. Frequency & Output Capacitor**



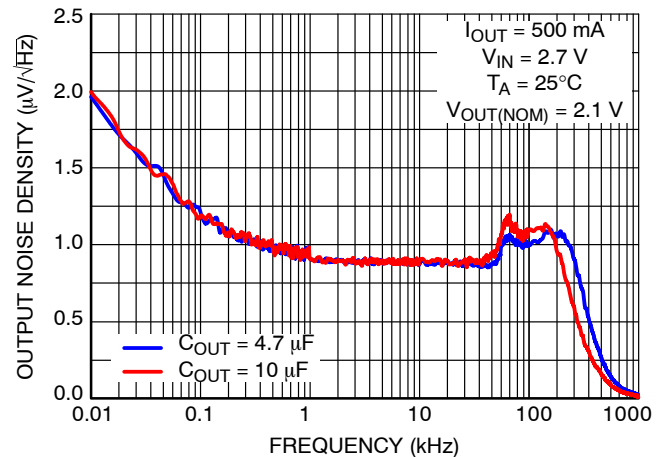
**Figure 17. PSRR vs. Frequency & Output Capacitor**



**Figure 18. PSRR vs. Frequency & Output Current**



**Figure 19. PSRR vs. Frequency & Output Current**



**Figure 20. Output Noise Density vs. Frequency**



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## TYPICAL CHARACTERISTICS

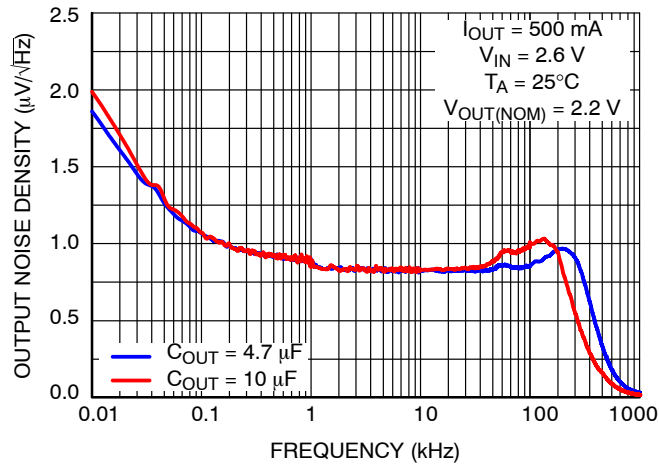


Figure 21. Output Noise Density vs. Frequency

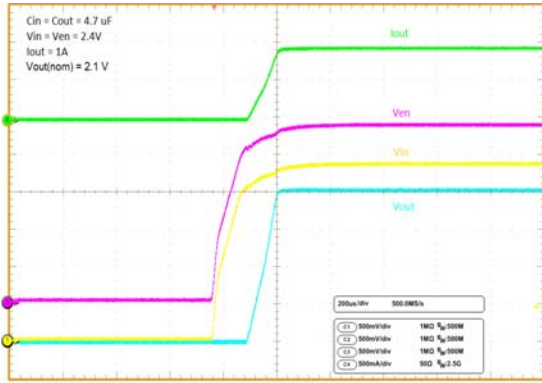


Figure 22. Turn-on by Coupled Input and Enable Pins

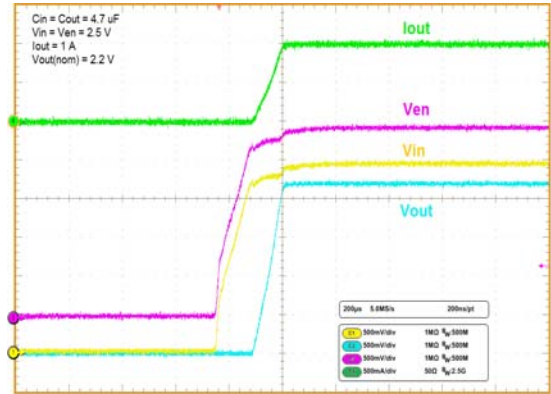


Figure 23. Turn-on by Coupled Input and Enable Pins

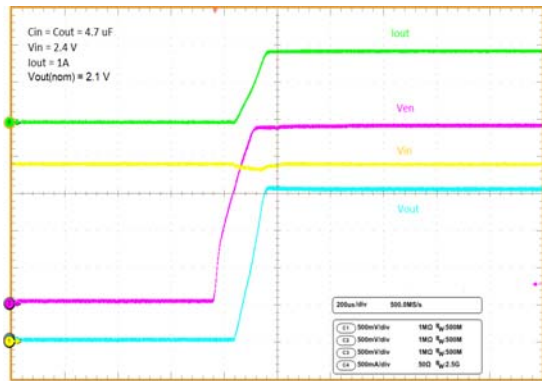


Figure 24. Turn-on by Enable Signal

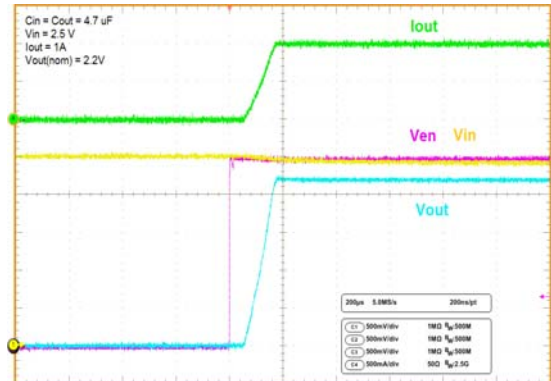


Figure 25. Turn-on by Enable Signal

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## TYPICAL CHARACTERISTICS

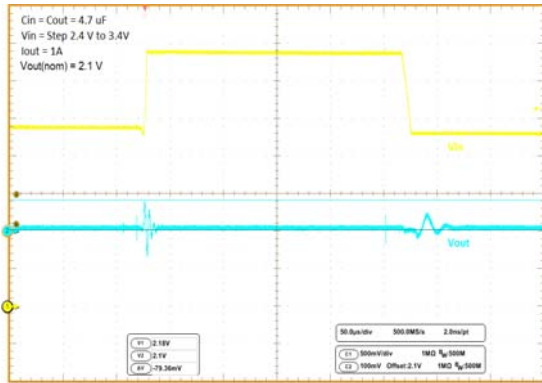


Figure 26. Line Transient Response

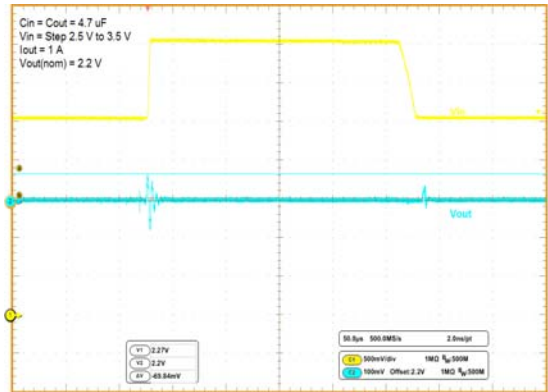


Figure 27. Line Transient Response

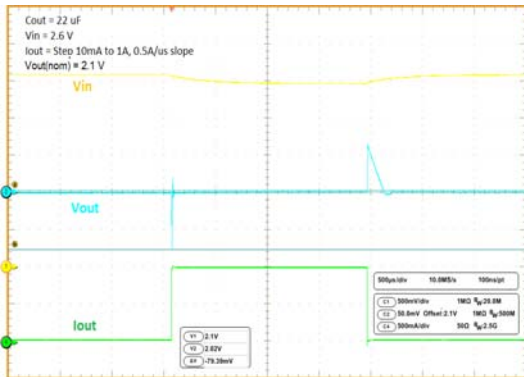


Figure 28. Load Transient Response

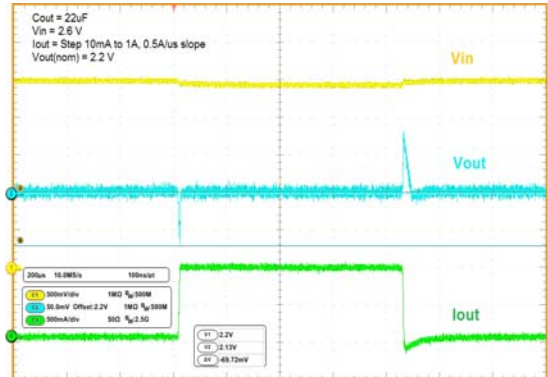


Figure 29. Load Transient Response

# NCP706

## APPLICATIONS INFORMATION

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

A 4.7  $\mu\text{F}$  capacitor either ceramic or tantalum is recommended and should be connected as close as possible to the pins of NCP706 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  $\mu\text{F}$  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 NCP706 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 NCP706 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

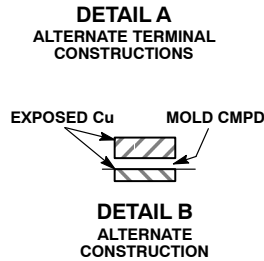
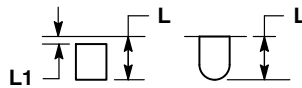
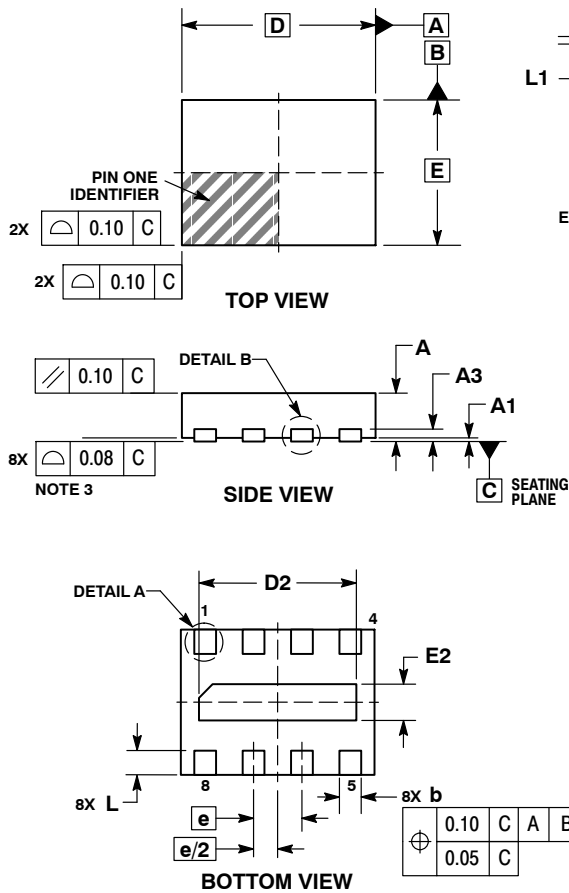
Device	Nominal Output Voltage	Marking	Package	Shipping†
NCP706MX21TAG	2.1 V	QM	XDFN8 (Pb-Free)	3000 / Tape & Reel
NCP706MX22TAG	2.2 V	QR	XDFN8 (Pb-Free)	3000 / Tape & Reel

†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.

# NCP706

## PACKAGE DIMENSIONS

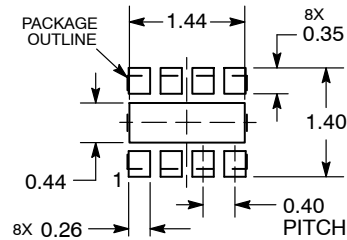
### XDFN8 1.6x1.2, 0.4P CASE 711AS ISSUE O



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

DIM	MILLIMETERS	
	MIN	MAX
A	0.35	0.45
A1	0.00	0.05
A3	0.125 REF	
b	0.13	0.23
D	1.60 BSC	
D2	1.20	1.40
E	1.20 BSC	
E2	0.20	0.40
e	0.40 BSC	
L	0.15	0.25
L1	0.05 REF	

### 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.

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