Nuvoton
Maximum 2A, Ultra Low
Dropout Regulator
NCT3720S/ NCT3720S-L

- *Table of Contents –*

1. GENERAL DESCRIPTION

The NCT3720S/S-L is a high performance positive voltage regulator which designed for use in applications requiring very low input voltage and very low dropout voltage up to 2A(peak) current rating. It operates with a VIN as low as 1.0V and control voltage 3V with output voltage programmable as low as 0.8V. The significant feature includes ultra low dropout, ideal for applications where VOUT is very close to VIN. Additionally, there is an enable pin to further reduce power dissipation while shutdown. The NCT3720S/S-L provides excellent regulation over variations in line, load and temperature, and provides a Power Good indicator to indicate if the voltage level of output voltage reaches 90% of its rating value.

2. FEATURES

- Maximum 2A Ultra Low-Dropout Voltage Regulator
- High Accuracy Output Voltage ±1.5%
- Adjustable Output from 0.8V
- Typically 150mV Dropout at 2A
- Input Voltage as low as 1.0V
- Power Good Indicator
- Thermal and Over Current Protection
- EN internal Pull High (NCT3720S) and Internal Pull Low Available (NCT3720S-L)
- SOP-8 150mil with Exposed Pad Package
- Lead Free (ROHS Compliant) and Halogen Free Package

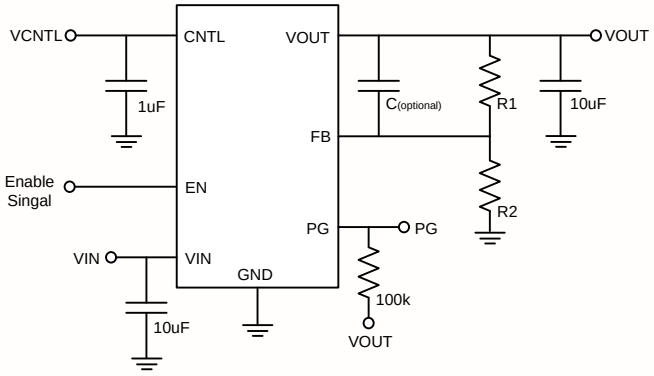
3. APPLICATIONS

- Desktop PCs, Notebooks, and Workstations
- Graphics Card
- Set Top Boxes, Digital TVs and Printers
- Portable instruments
- uP/ASIC/DSP/FPGA Core and I/O Supplies

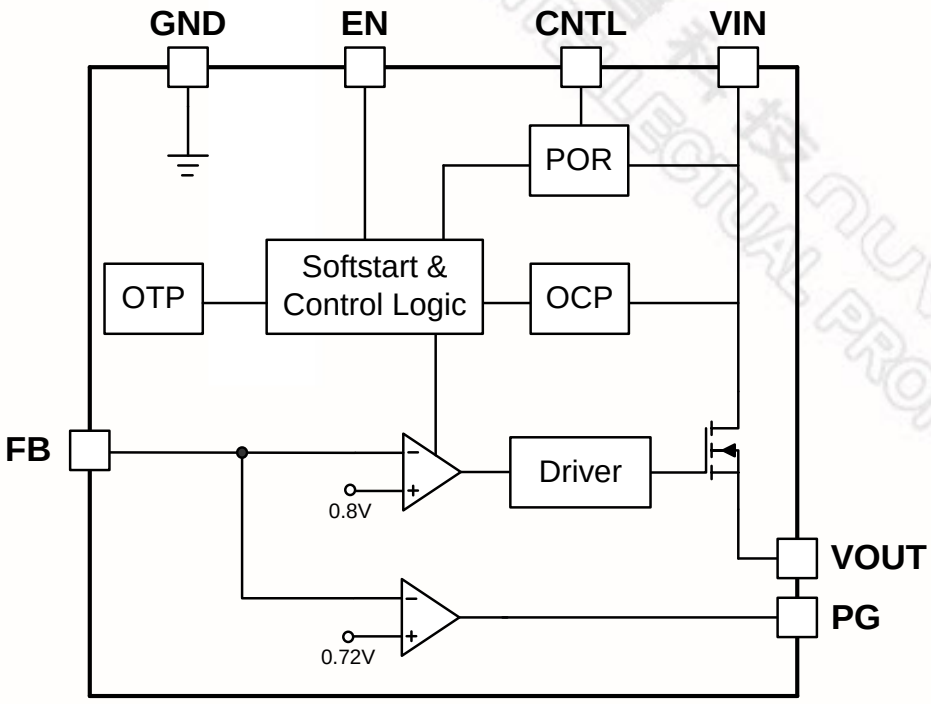
4. PIN CONFIGURATION AND DESCRIPTION

PIN NO.	PIN NAME	I/O	FUNCTION
1	**PG**	O	Power Good indicator. This is an open drain output. Connect it with a resistor to power source.
2	**EN**	I	Chip Enable Input. It is high active.
3	**VIN**	P	Supply Input Voltage.
4	**VCNTL**	P	Supply Input Voltage for Control Circuit.
5	**NC**	N/A	No Internal Connection.
6	**VOUT**	P	Output Voltage. Vout = 0.8*(1+R1/R2)
7	**FB**	I	Feedback Input.
8	**GND**	P	Ground.
9(Exposed pad)	**--**	--	The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

5. TYPICAL APPLICATION CIRCUIT



6. BLOCK DIAGRAM



7. FUNCTIONAL DESCRIPTION

The NCT3720S/S-L is intended for applications where high current capability and very low dropout voltage are required. It provides a very simple, low cost solution that uses very little pcb real estate. Additional features include an enable pin to allow for a very low power consumption at disable, and a fully adjustable output.

Output Voltage Selection

The output voltage of NCT3720S/S-L is adjustable from 0.8V to (VIN-VDROP) by external voltage divider resisters as shown in Typical Application Circuit. The value of resisters R1 and R2 should be more than 10kΩ to reduce the power loss. The VCNTL must be greater than (VOUT + 1.5V).

Input capacitor

A minimum of 10uF ceramic capacitor is recommended to be placed directly next to the VIN pin. This allows for the device being some distance from any bulk capacitance on the rail. Additionally, bulk capacitance of about ≧10uF may be added closely to the input supply pin of the NCT3720S/S-L to ensure that VIN does not sag, improving load transient response.

Output capacitor

A minmum bulk capacitance of ≧ 10uF, along with a 0.1uF ceramic decoupling capacitor is recommended. Increaseing the bulk capacitance will improve the overall transient response. The use of multiple lower value ceramic capacitors in parallel to achieve the desired bulk capacitance will not cause stability issues. Although designed for use with ceramic output capacitors, the NCT3720S/S-L is extremely tolerant of output capacitor ESR values and thus will also work comfortably with tantalum output capacitors.

Noise immunity

In very electrically noisy environments, it is recommended that 0.1uF ceramic capacitors be placed from VIN to GND and VOUT to GND as close to device pins as possible.

Power Good

The power good function is an open-drain output. Connects 100kΩ pull up resistor to VOUT to obtain an output voltage. The PG pin will output high immediately after the output voltage arrives 90% of normal output voltage. The PG pin will output high with typical 4ms delay time.

Enable

The NCT3720S/S-L goes into shutdown mode when the EN pin is in the logic low condition. During this condition, the pass transistor, error amplifier, and band gap are turned off, reducing the supply current to 10uA typical. If the EN pin is floating, NCT3720S and NCT3720S-L operating behaviors are different. For NCT3720S, the EN pin function pulls high level internally. So the regulator will be turn on when EN pin is floating. As for NCT3720S-L, the EN pin function pulls low level internally. So the regulator will be turn off when EN pin is floating.

Current Limit

The NCT3720S/S-L contains an independent current limit and the short circuit current protection to prevent unexpected applications. The current limit monitors and controls the pass transistor's gate voltage, limiting the output current while higher than 3A typical. When the output voltage is less than 0.25V, the short circuit current protection starts the current fold back function and

maintains the loading current 1.5A. The output can be shorted to ground indefinitely without damaging the part.

Thermal Consideration

The NCT3720S/S-L has a thermal shutdown circuitry to limit the junction temperature. When the junction temperature exceeds 150°C, the thermal shutdown circuit disables the output, allowing the device to cool down. The output circuitry is enabled again after the junction temperature cools down by 30°C, resulting in a pulsed output during continuous thermal overload conditions. The thermal protection is designed to protect the IC in the event of over temperature conditions. For reliabile operation, the junction temperature cannot exceed 125°C.

The definition of power dissipation in chip is as following equation:

$P_D = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_Q$

P_D represents the power dissipation.

The power dissipation depends on the thermal resistance of chip package, PCB layout, the airflow and temperature difference between junction and ambient. Refers to JEDEC51-1, The power dissipation can be calculated by following equation:

$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$

Where $T_{J(MAX)}$ is the maximum operation junction temperature 125℃, TA is the ambient temperature and the θ_{JA} is the junction to ambient thermal resistance. θ_{JA} for ESOP-8 package is 75℃/W on JEDEC51-7 (4 layers, 2S2P) thermal test board with minimum copper area. The maximum power dissipation at T_A = 25℃ can be calculated as:

$P_{D(MAX)}$ = (125℃ - 25℃) / 75℃/W = 1.33W

θ_{JA} highly depends on IC package, PCB layout, the aireflow. Thermal resistance θ_{JA} can be improved by adding copper under the exposed pad of ESOP-8 while the IC package is fixed. The copper under the exposed pad of ESOP-8 is an effective heatsink and is useful for improving thermal conductivity. Figure show the relationship between thermal resistance θ_{JA} vs. copper area on a standard JEDEC 51-7 (4 layers, 2S2P) thermal test board at TA = 25℃, PCB copper thickness = 2oz. The 70mm^2 copper plane reduce θ_{JA} from 75℃/W to 45℃/W and increases maximum power disspation from 1.33W to 2.22W.

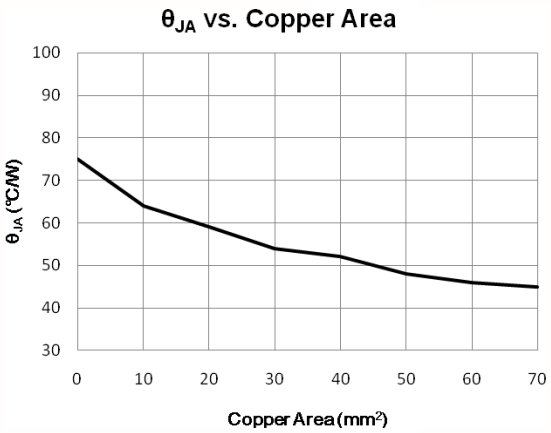


Figure01. Thermal Resistance θ_{JA} vs. Copper Area of ESOP Packages

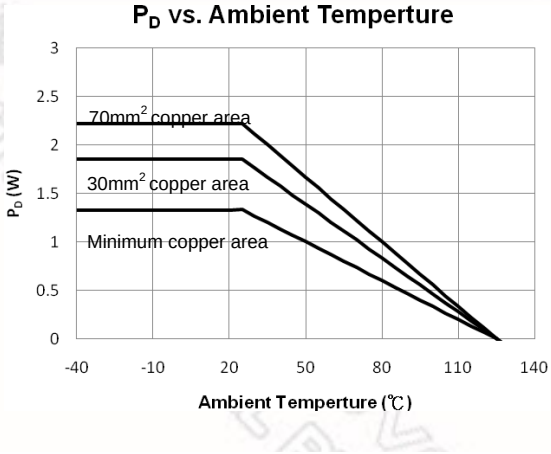


Figure02. Power dissipation vs. ambient temperature

8. ELECTRICAL CHARACTERISTIC

8.1 Absolute Maximum Ratings

PARAMETER		RATING	UNIT
Input Supply Voltage, VCNTL and VIN		-0.3 to 6V	V
Other Pins		-0.3 to 6V	V
Power Dissipation, PD @ TA=25℃		Internal Limited	W
Package Thermal Resistance, SOP8-EP, θ_{JA}		75	℃/W
Storage Temperature		-50 to 150	℃
Junction Temperature		150	℃
ESD Protection	Human Body Mode	2	kV
	Machine Mode	200	V
	Latch-up	100	mA

Note: Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and reliability of the device.

8.2 Recommended Operating Conditions

PARAMETER	RATING	UNIT
CNTL Voltage, VCNTL	3.0 to 5.5	V
Supply Voltage, VIN	1.0 to VCNTL	V
Output Current, IOUT	0 to 2	A
Operating Temperature	-40 to 85	℃
Junction Temperature	-40 to 125	℃

8.3 DC Electrical Characteristics

(VIN = VOUT + 500mV, VEN = VIN = 5V, CIN = COUT = 10uF, T_A = TJ = 25° C, unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Supply voltage						
Control Input Voltage	V_{CNTL}	VOUT = VREF	3.0		5.5	V
POR Threshold		VCNTL Rising		2.7		V
POR Hysteresis				0.2		
Power Input Voltage	V_{IN}	VOUT = VREF	1.0		5.5	V
Control Input Current in shutdown	I_{CNTL_SD}	VCNTL = VIN = 5.0V, IOUT = 0A, VOUT = VREF		20	30	uA
Control Input Current	I_{CNTL}	VCNTL = VIN = VEN = 5.0V, IOUT = 0A, VOUT = VREF		0.4	0.6	mA
Quiescent Current	I_Q	VCNTL = VIN = VEN = 5.0V, IOUT = 0A, VOUT = VREF		0.6	1	mA
Feedback Voltage						
Reference Voltage	V_{FB}	VCNTL = VIN = VEN = 5.0V, IOUT = 0A, VOUT = VREF	0.788	0.8	0.812	V
Feedback Input Current	I_{FB}			20		nA
VIN Line Regulation		1.2V < VIN < 5.0V, VCNTL = VEN = 5.0V, IOUT = 0A, VOUT = VREF		0.01	0.1	%/V
VCNTL Line Regulation		3.0V < VCNTL < 5.0V, VIN = 1.2V, IOUT = 0A, VOUT = VREF		0.2	0.6	%/V
Load Regulation		0A < I_{LOAD} < 2A, VCNTL = VIN = VEN = 5.0V, VOUT = VREF		0.8	1.5	%/A
Load Regulation over Temperature		0mA < ILOAD < 2A, VCNTL = VIN = VEN = 5.0V, VOUT = VREF, -40 < TJ < 125, by design		1.4	3	%
Dropout Voltage	V_{DROP}	IOUT = 2.0A, VCNTL = VEN = 5.0V, VOUT = VREF		150	250	mV
VOUT Pull Low Resistance		VCNTL = VIN = 5.0V, VEN = 0V		90		Ω
Enable						

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Enable High Level	V_{EN}		1.4			V
Enable Low Level	V_{SD}				0.4	V
Enable Current	I_{EN}	VEN = 0V, VCNTL = 5.0V		12	20	uA
Softstart Time			1.5	3.0	4.5	ms
PG						
FB Power OK Threshold	V_{POKTH}	IOUT = 0A, VCNTL = VIN = VEN = 5.0V, VOUT = VREF		92		%
Power OK Hysteresis	V_{POKHYS}	IOUT = 0A, VCNTL = VIN = VEN = 5.0V, VOUT = VREF		8		%
PG sink Capability		IPG = 10mA		0.2	0.4	V
POK Delay Time		From VOUT >92% VNOM to POK rising		3		ms
Overcurrent Protection						
OCP Threshold Level	I_{OCP}	VCNTL = VIN = VEN = 5.0V, VOUT = VREF		4		A
Averaged Output Short Circuit Current		VCNTL = VIN = VEN = 5.0V, VOUT = 0V		1.5		A
Thermal Protection						
Themal Shutdown Temperature	T_{SD}	IOUT = 0A, VCNTL = VIN = VEN = 5.0V, VOUT = VREF		150		℃
Thermal Shutdown Hysteresis	T_{SDHYS}	IOUT = 0A, VCNTL = VIN = VEN = 5.0V, VOUT = VREF		50		℃

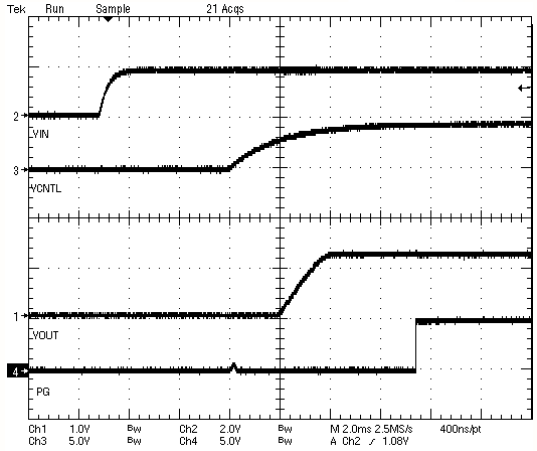
Note1. The dropout voltage is defined as VIN – VOUT, which is measured when VOUT is VOUT(normal) – 100mV.

Note2. The device is not guaranteed to function ouside its operating conditions.

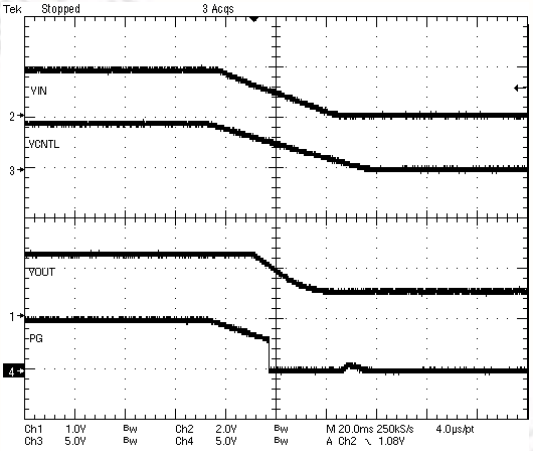
9. TYPICAL OPERATING WAVEFORMS

(VIN = VOUT + 0.5V, VCNTL = VEN = 5V, CIN = COUT=10uF, CVCNTL = 1uF, TA = 25℃)

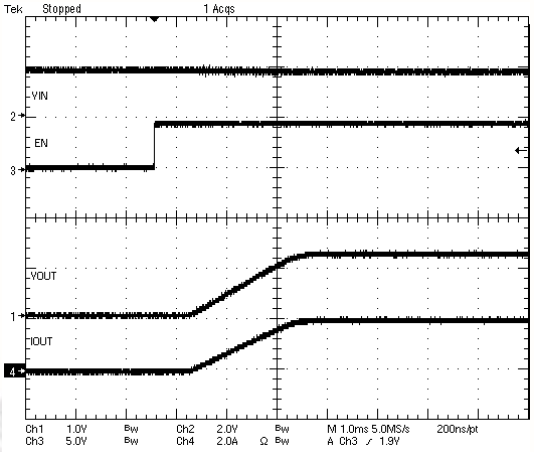
Power On



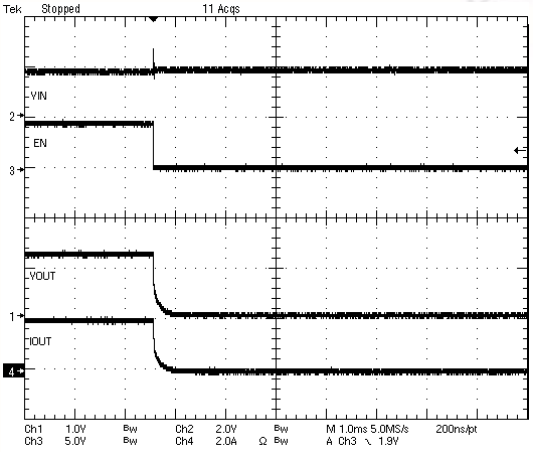
Power Off



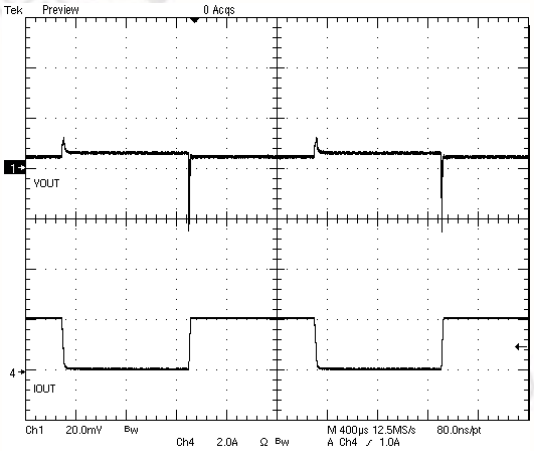
Enable



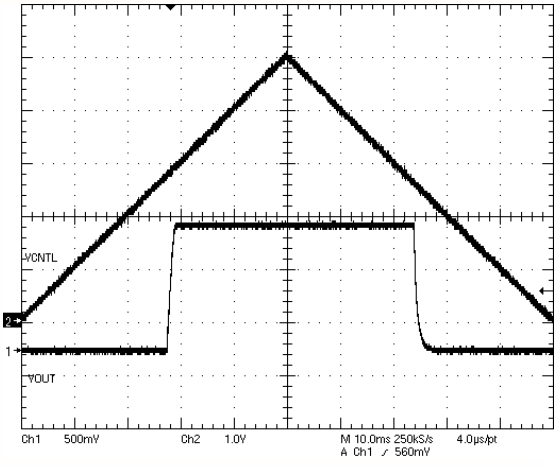
Disable

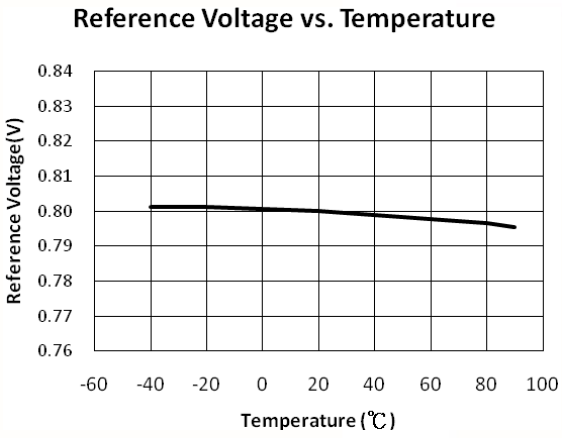


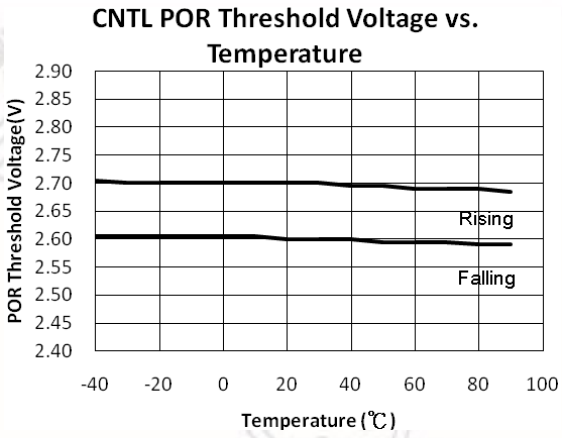
Transient Response

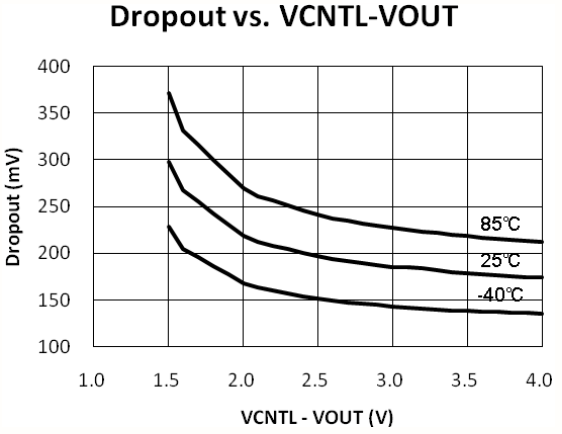


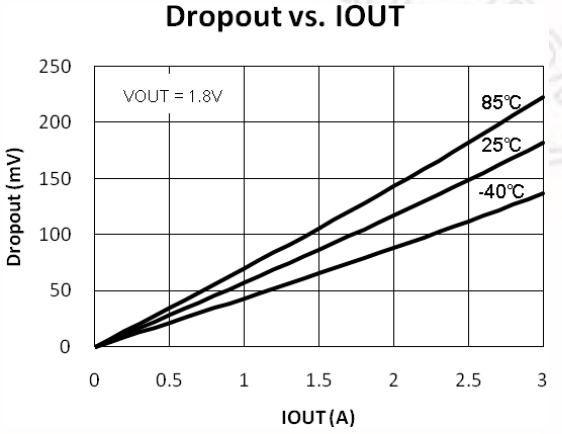
UVLO

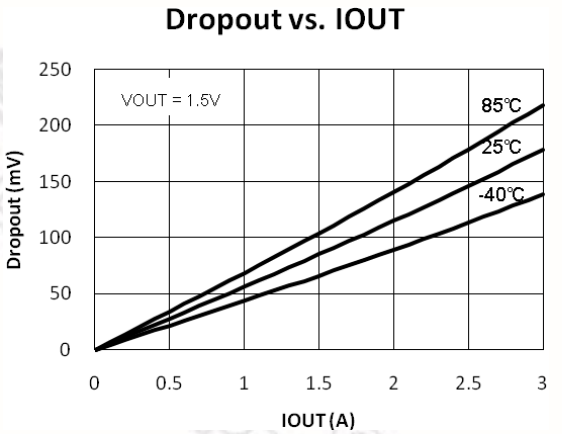



Reference Voltage vs. Temperature
Reference Voltage(V)
0.84
0.83
0.82
0.81
0.80
0.79
0.78
0.77
0.76
-60 -40 -20 0 20 40 60 80 100
Temperature (℃)


CNTL POR Threshold Voltage vs. Temperature
POR Threshold Voltage(V)
2.90
2.85
2.80
2.75
2.70
2.65
2.60
2.55
2.50
2.45
2.40
Rising
Falling
-40 -20 0 20 40 60 80 100
Temperature (℃)

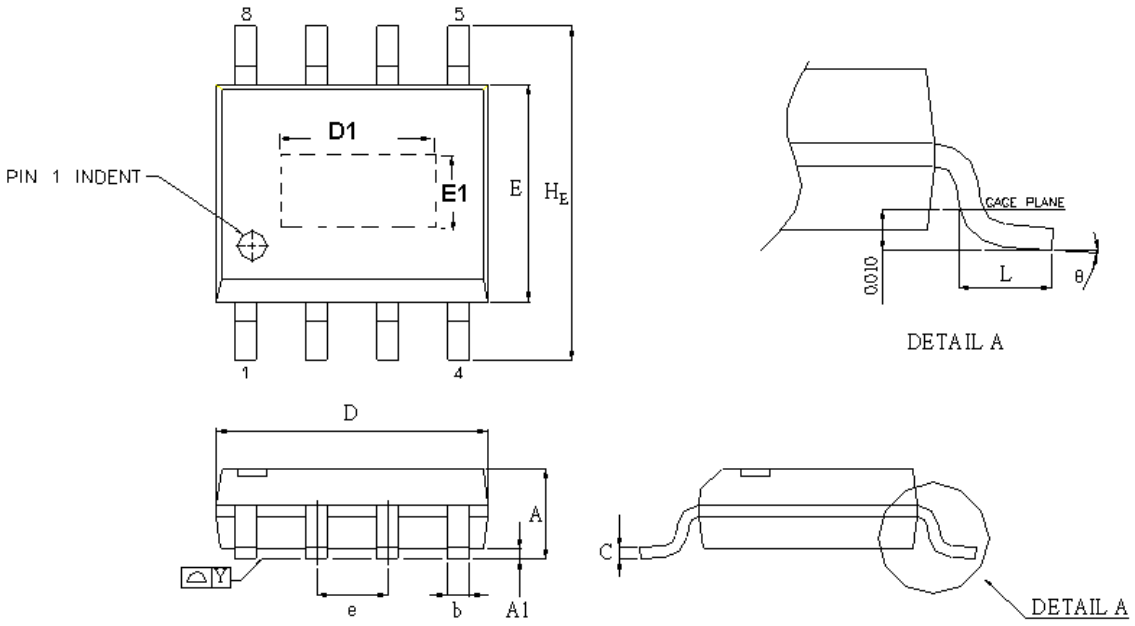

Dropout vs. VCNTL-VOUT
Dropout (mV)
400
350
300
250
200
150
100
85℃
25℃
-40℃
1.0 1.5 2.0 2.5 3.0 3.5 4.0
VCNTL - VOUT (V)


Dropout vs. IOUT
VOUT = 1.8V
Dropout (mV)
250
200
150
100
50
0
85℃
25℃
-40℃
0 0.5 1 1.5 2 2.5 3
IOUT (A)


Dropout vs. IOUT
VOUT = 1.5V
Dropout (mV)
250
200
150
100
50
0
85℃
25℃
-40℃
0 0.5 1 1.5 2 2.5 3
IOUT (A)

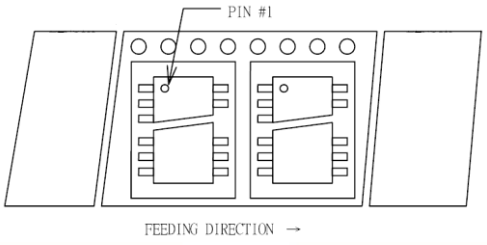
10. PACKAGE DIMENSION

SOP8-EP (150mil)



SYMBOLS	Dimensions In Millimeters		Dimensions In Inched	
	Min	Max	Min	Max
A	1.35	1.75	0.05	0.07
A1	0.05	0.25	0.00	0.01
b	0.31	0.51	0.01	0.02
c	0.1	0.25	0.00	0.01
D	4.7	5.10	0.19	0.2
E	3.8	4.00	0.15	0.16
e	1.27 BASIC		0.05 BASIC	
He	5.8	6.20	0.23	0.24
Y	-	0.10	-	0.00
L	0.4	1.27	0.02	0.05
θ	0°	10°	0°	10°
D1	3.10	3.50	0.12	0.14
E1	2.20	2.60	0.09	0.10

10.1 Taping Specification

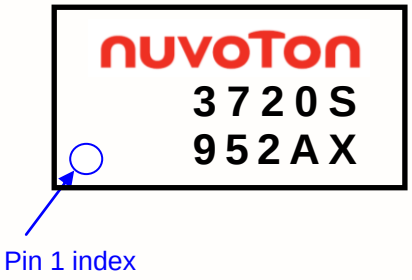


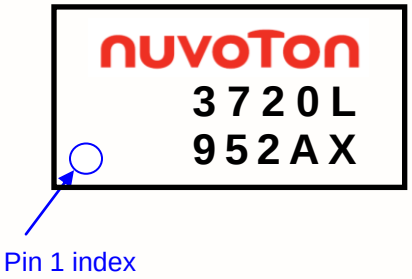
SOP8-EP Package

11. ORDERING INFORMATION

Part Number	Package Type	Supplied as	Production Flow
NCT3720S	SOP8-EP (Green Package)	2,500 units/T&R	Commercial, -40℃ to 85℃
NCT3720S-L	SOP8-EP (Green Package)	2,500 units/T&R	Commercial, -40℃ to 85℃

12. TOP MARKING SPECIFICATION





1st Line: Nuvoton logo

2nd Line: 3720S (Part number NCT3720S); 3720L (Part number NCT3720S-L)

3rd line: Tracking code

- 952: packages assembled in Year 2009, week 52
- A: assembly house ID
- X: internal use only

13. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
A0	09/30/2010	All	New Create
A1	11/26/2010	All	Add NCT3720S-L part number and relative data.
A2	01/18/2011	P12 & P13	Added part numbers and relative data.
A3	01/20/2011	P1, P9, P10, P12 & P13	Added waveform and revised some description. Removed part numbers and relative data.

Important Notice

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Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.