Nuvoton
4 Times Linear Fan Driver
NCT3941S/S-A

Table of Content-

1. GENERAL DESCRIPTION

The NCT3941S/S-A is a simply linear fan driver. It is designed for noise-sensitive or power-sensitive applications that require system cooling. The NCT3941S/S-A is a low quiescent current, low dropout linear regulator which is designed with a P-channel MOSFET to power a DC fan and delivers output current up to 500mA. The output voltage follows the 4 times on the voltage of VSET pin to dynamic adjust the DC fan speed. NCT3941S supports enable pin to control the output voltage. NCT3941S-A supports fully turn-on function. NCT3941S/S-A is available in SOP8-EP package.

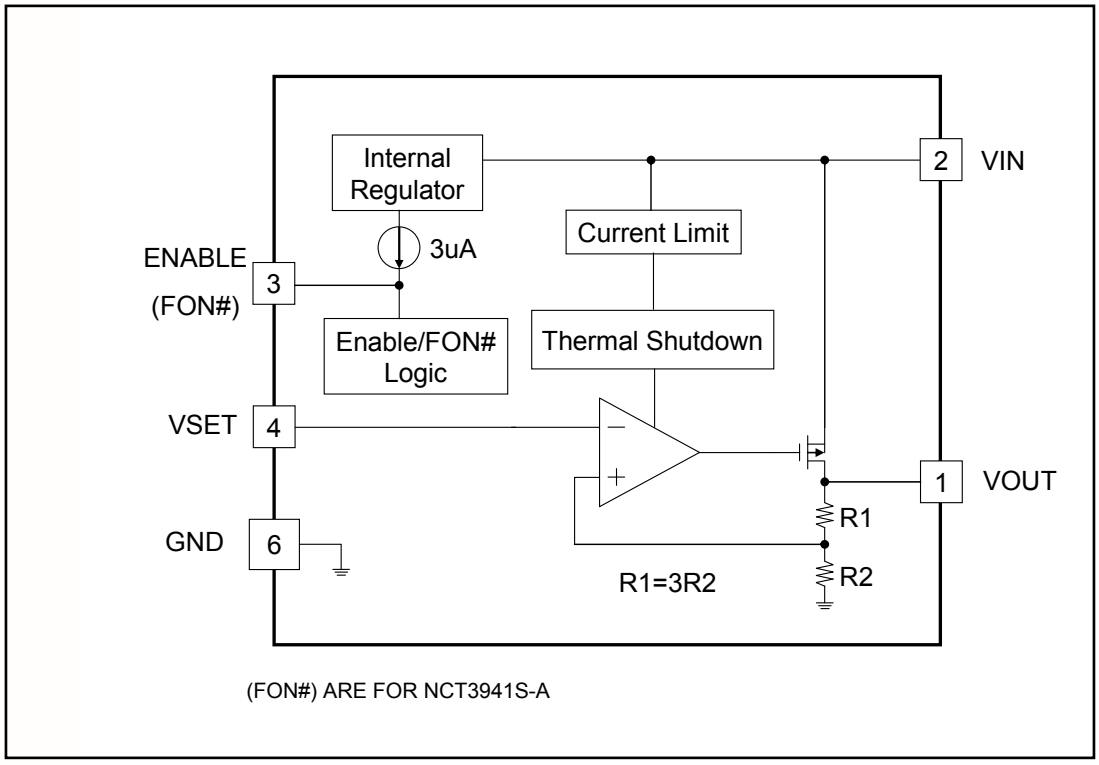
2. FEATURES

- VOUT Follows 4 Times of VSET
- 0.5V Dropout @ 0.5A Output Current
- Continues current up to 500mA, current limit trip threshold 1.6A
- Enable Function (NCT3941S)
- Full Turn On Function (NCT3941S-A)
- Short Circuit and Over Temperature Protections
- Low External Component Count
- Low Cost and Easy to Use
- SOP8 150mil with Exposed Pad Package
- Green Package (Lead Free and Halogen Free)

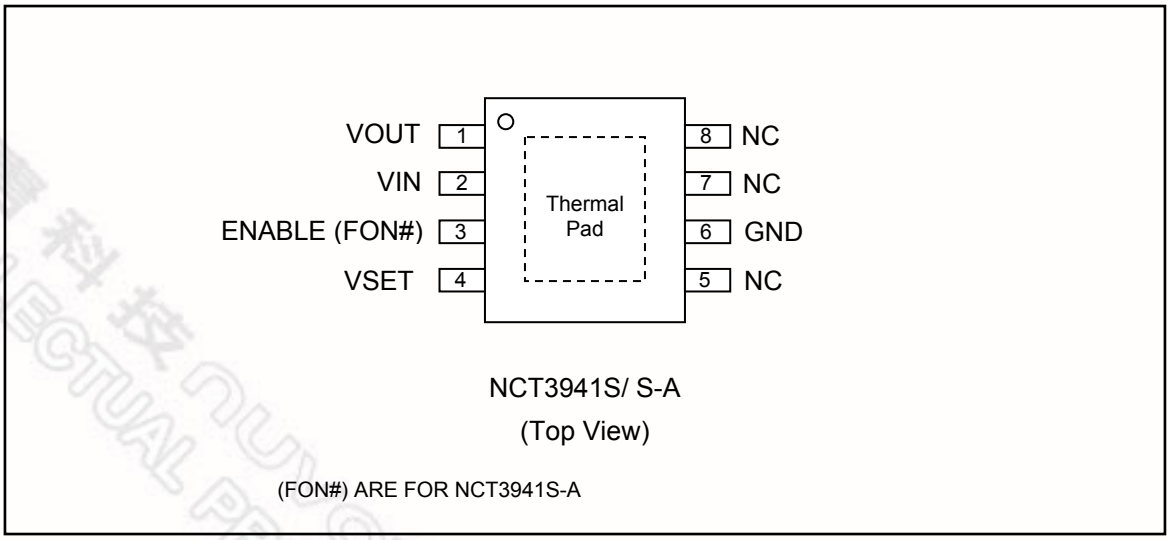
3. APPLICATION

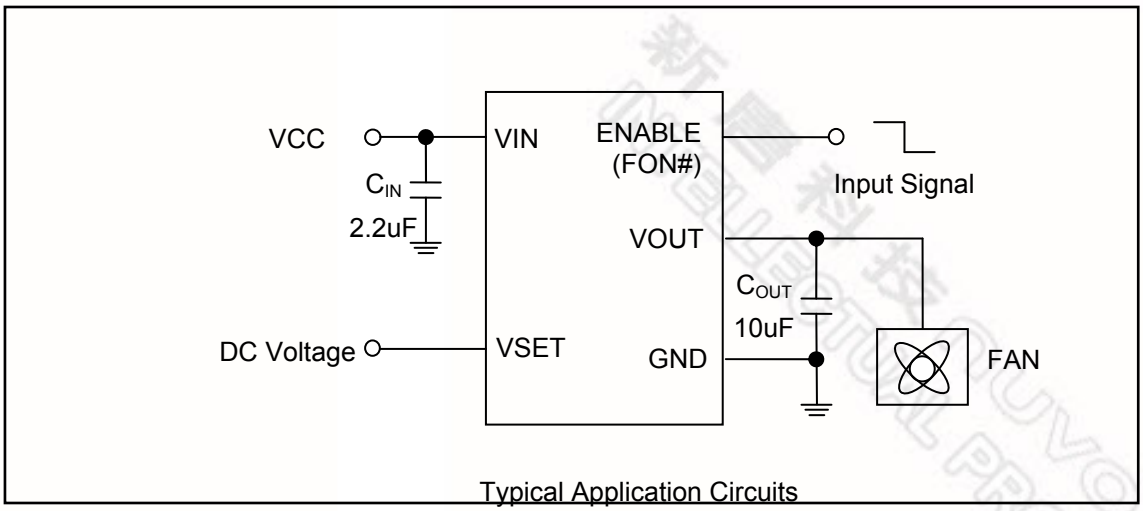
- Projectors
- Peripheral Add-in Cards
- Motherboards
- Battery Powered Systems

4. BLOCK DIAGRAM

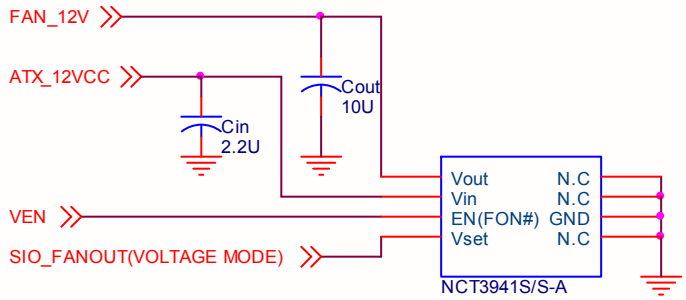


5. PIN CONFIGURATION AND TYPICAL APPLICATION CIRCUIT

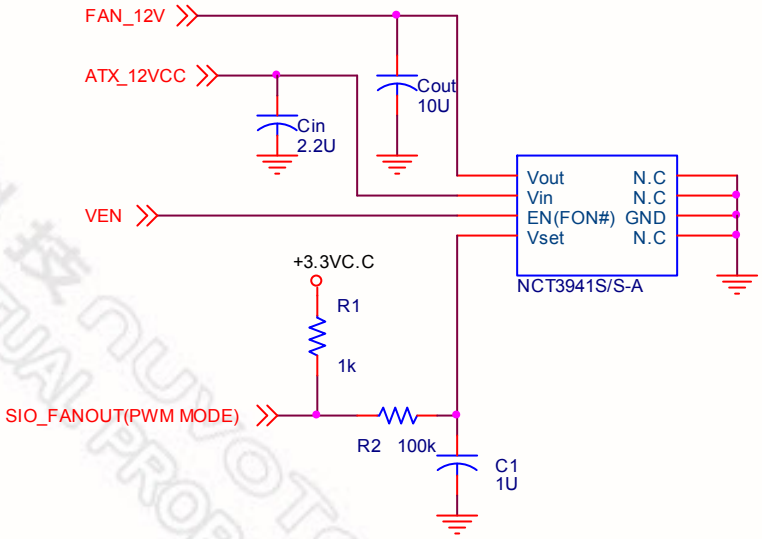




Typical Application Circuits



VOLTAGE MODE (FON#) ARE FOR NCT3941S-A



PWM MODE (FON#) ARE FOR NCT3941S-A

6. PIN DESCRIPTION

PIN NAME	NO		PIN TYPE	DESCRIPTION
	NCT3941S	NCT3941S-A		
VOUT	1	1	AO	Voltage output pin. Connect a low ESR ceramic capacitor (10uF, typically) to ground to assure stability.
VIN	2	2	POWER	DC power supply input. Connect a bypass capacitor (2.2uF, typically) is recommended.
ENABLE	3		I	Enable pin. Output voltage follows 4 times of VSET pin voltage when ENABLE pin at high level. Internal pull high is implemented.
FON#		3	I	Full On mode selection pin. Output voltage follows 4 times of VSET pin voltage when FON# pin at high level. The internal power MOSFET full turns on when FON# pin at low level. Internal pull high is implemented.
VSET	4	4	AIN	Output voltage setting pin. The inputs could be DC voltage. The input voltage must be larger that 1V.
GND	6	6	GROUND	Power supply ground.
NC	5, 7, 8	5, 7, 8		No internal connection.

PIN TYPE	PIN Attribute
AO	Output pin (Analog)
AIN	Input pin (Analog)
I	Input pin (Digital)
POWER	Positive power supply input
GROUND	Power supply ground

7. FUNCTIONAL DESCRIPTION

7.1 VSET Setting

The output voltage is 4 times of VSET pin voltage. When the VSET voltage exceeds 1V, the output voltage will follow 4 times of VSET voltage.

7.2 Enable Function

This function is for NCT3941S only. The input voltage level of ENABLE pin can control the internal regulator turn on or turn off. When pulling this pin below 0.3V, the regulator will be turned off. When pulling this pin above 1V, the regulator will be turned on.

7.3 Full On Function

This function is for NCT3941S-A only. The input voltage level of FON# can control the internal regulator fully turn on or following 4 times of VSET voltage. When pulling this pin below 0.3V, the regulator will be fully turned on. When pulling this pin above 1.6V, the output voltage will follow 4 times of VSET voltage.

7.4 Short Circuit Current Limit

The NCT3941S/S-A provides a current limit circuitry for short circuit protection, which monitors the output current and controls PMOS gate voltage to limit the output current at 200mA.

7.5 Thermal Consideration

The NCT3941S/S-A 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.

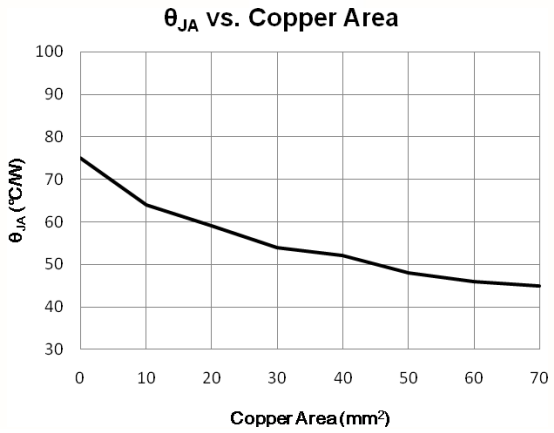


Figure01. Thermal Resistance θ_{JA} vs. Copper Area of ESOP Packages

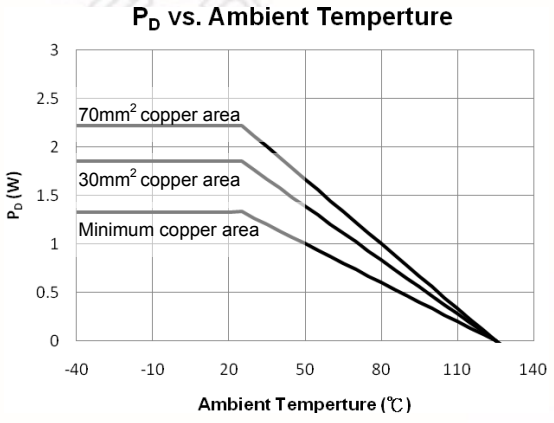


Figure02. Power dissipation vs. ambient temperature

7.6 VIN Decoupling

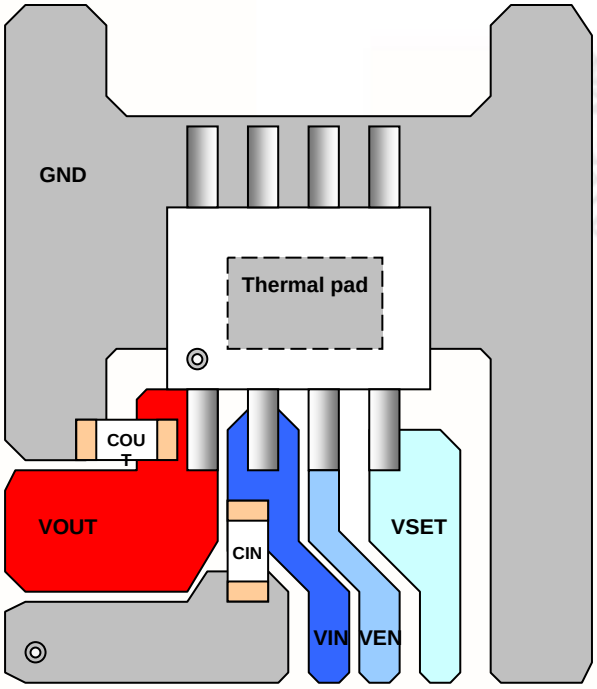
To achieve the best results when using the NCT3941S/S-A, decouple the power supply with a 2.2uF capacitor. Use a high quality ceramic surface mount capacitor if possible. Surface mount components minimize lead inductance, which improves performance, and ceramic capacitors tend to have adequate high frequency response for decoupling applications.

7.7 VOUT Stability

To maintain circuit stability and improve transient response over temperature and current, the NCT3941S/S-A needs a suitable output capacitor. In order to insure the circuit stability, the suitable output capacitor should be larger than 10uF.

7.8 Layout Consideration

Consider the following points before starting the NCT3941S/S-A layout design.



- The input bypass capacitor for VIN should be placed as close as possible to the pin with short and wide connections.
- The output capacitor for VOUT should be placed close to the pin with short and wide connection in order to avoid ESR and/or ESL trace inductance.
- In order to effectively remove heat from the package, properly prepare the thermal land. Apply solder directly to the package's thermal pad. The wide traces of component and the side copper connected to the thermal land pad help to dissipate heat. The thermal land connected to the ground plane could also be used to help dissipation.

8. ELECTRICAL CHARACTERISTIC

8.1 Absolute Maximum Ratings

PARAMETER		RATING	UNIT
Power Supply Voltage		-0.3 to 19V	V
Voltage on Other Pins		-0.3 to 7V	V
Storage Temperature		-50 to 150	°C
Soldering Temperature		Refer to IPC/JEDEC J-STD-020 Specification	
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 Thermal Information

ITEM	RATING	UNIT
Power Dissipation, P_D @ T_A=25℃	Internal Limited	W
Package Thermal Resistance, SOP8-EP, θ_{JA}	75	℃/W

8.3 Recommended Operating Conditions

PARAMETER	RATING	UNIT
Operating Temperature	-20 to 85	°C
Junction Temperature	-20 to 125	°C
Supply Voltage, VCC	8 to 17.6	V

8.4 Electrical Characteristics

VIN=13V, VSET=2V, ENABLE=5V, C_{IN}= 2.2uF, C_{OUT}=10uF, Ta= -20~85°C (Typical value are at Ta=25°C)

PARAMETER	SYM.	MIN.	TYP.	MAX.	UNIT	CONDITIONS
Supply Input Voltage						
Supply Input Voltage	V_{IN}	8		17.6	V	
ENABLE / FON# Pin						
ENABLE / FON# Voltage High		1			V	
ENABLE / FON# Voltage Low				0.3	V	
ENABLE / FON# Pin Bias Current			3		uA	ENABLE / FON# = 0V
Supply Input Current						
Quiescent Current	I_Q		3		mA	ENABLE = 5V, VOUT 12V, No Load
Shutdown Current	I_{SD}		100		uA	ENABLE = 0V
Output Voltage						
VOUT Voltage / VSET Voltage		3.88	4	4.12	V/V	VIN = 12V VSET = 1 ~ 3V
Load Regulation(NOTE1)			0.5	2	%	VSET = 3V 10mA≦I_{OUT}≦500mA
Line Regulation(NOTE1)			0.1	0.5	%	Vin = 9V to 14V

Output Resistance			0.7		Ω	I_{OUT} = 500mA VSET = 4V
Output Leakage(NOTE2)			0	1	uA	ENABLE = 0V
VSET Pin						
VSET Voltage	V_{SET}		1	5.5	V	
VSET pin Current			100		nA	
Short Circuit Current Limit Protection						
Output Current Limit	I_{LIM}		0.7		A	
Current Limit Trigger Point	I_{TR}		1.6		A	
Short circuit protection	I_{SH}		0.2		A	
Over Temperature Protection						
Thermal Shutdown Temperature			150		°C	
Thermal Shutdown Hysteresis			30		°C	

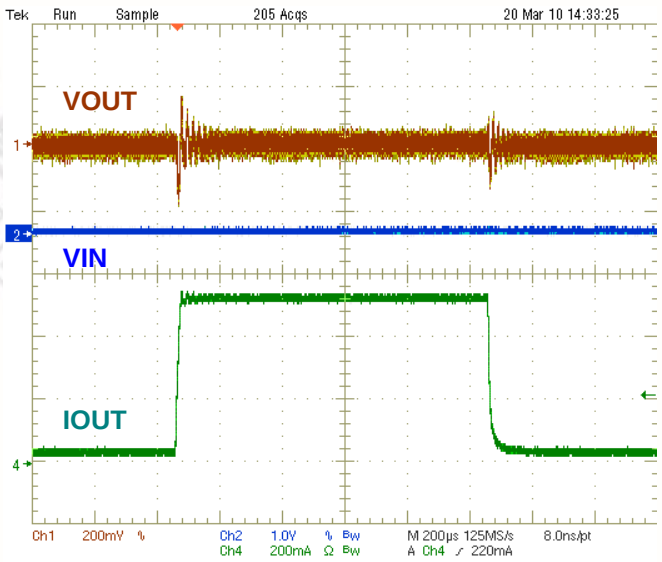
NOTE1 : Slew rate will effect transient response, use $T_{R<}$10us, T_F<10us measurement load regulation and line regulation

NOTE2 : .NCT3941S-A is full-on when enable=0, measurement output leakage current using VSET<0.3V to disable output voltage

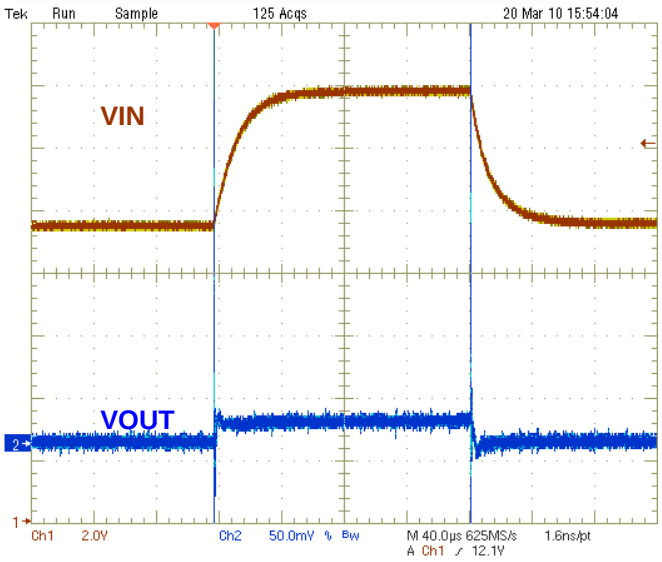
9. OPERATING CHARACTERISTICS

(C_{IN}=2.2uf , C_{out}=10uf , V_{IN}=13V , V_{SET}=2V , V_{EN}=5V , Ta=25°C)

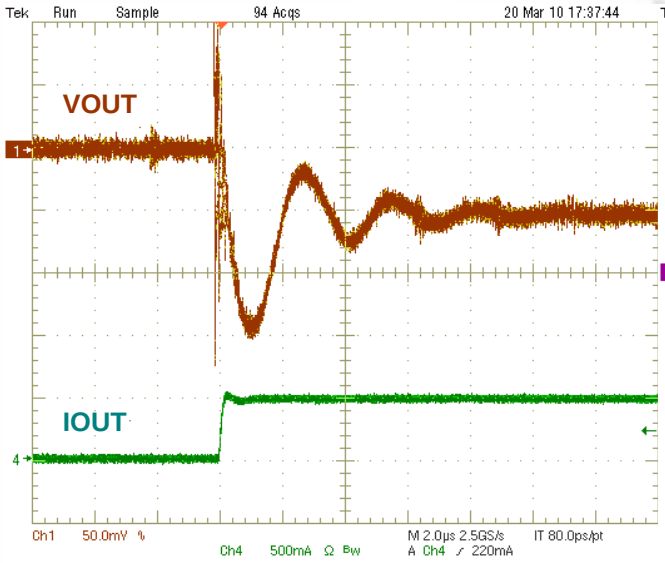
LOAD REGULAION



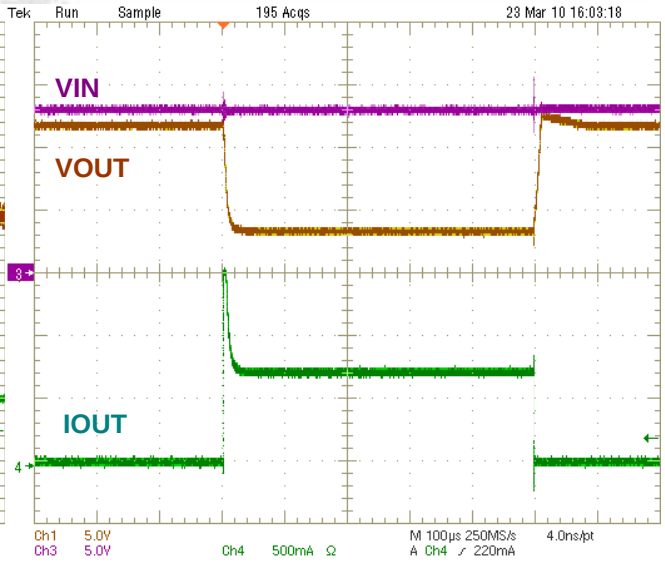
LINE REGULATION



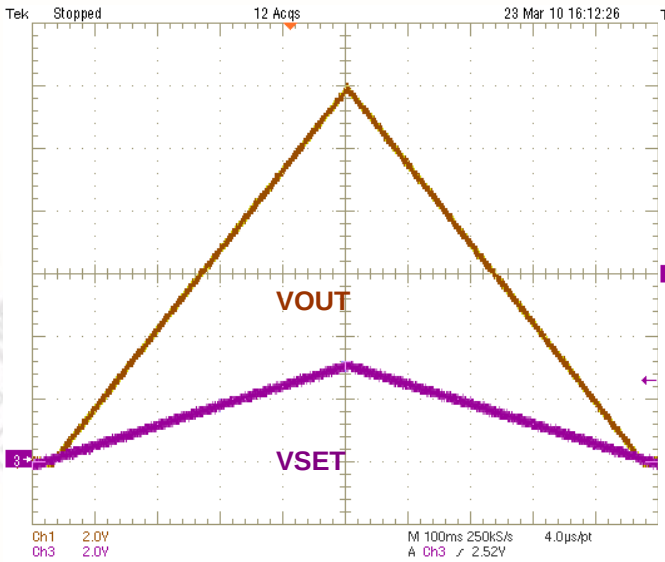
LOAD TRANSIENT



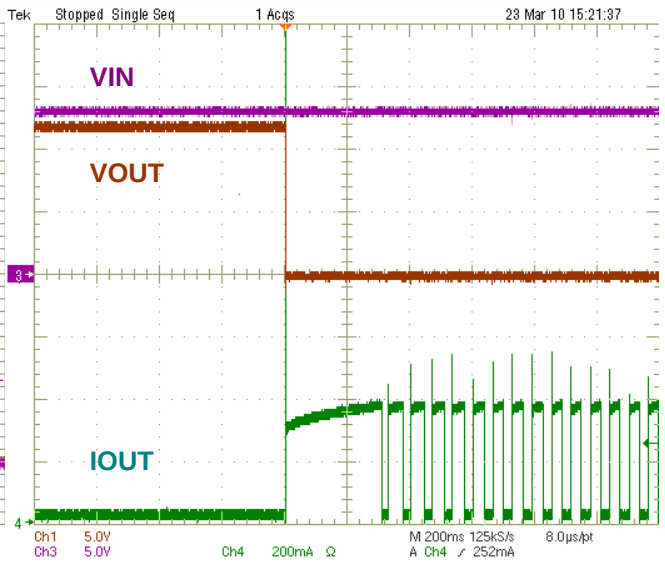
CURRENT LIMIT BEHAVIOR



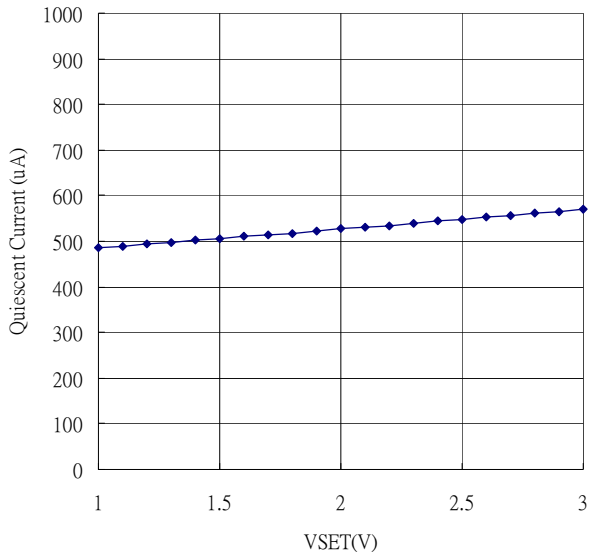
VSET V.S. VOUT



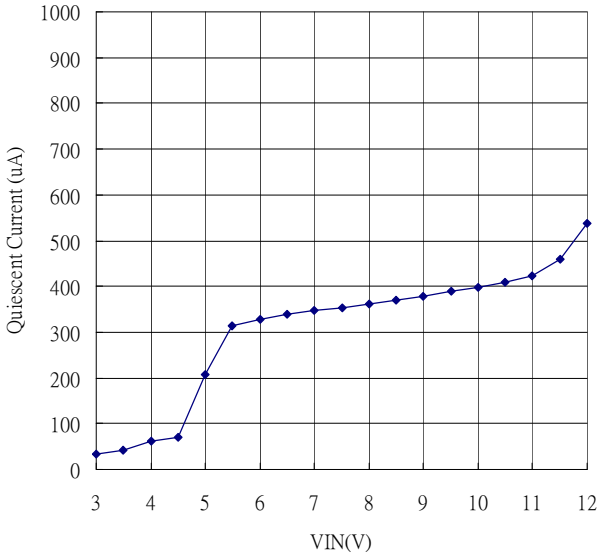
SHORT CIRCUIT BEHAVIOR



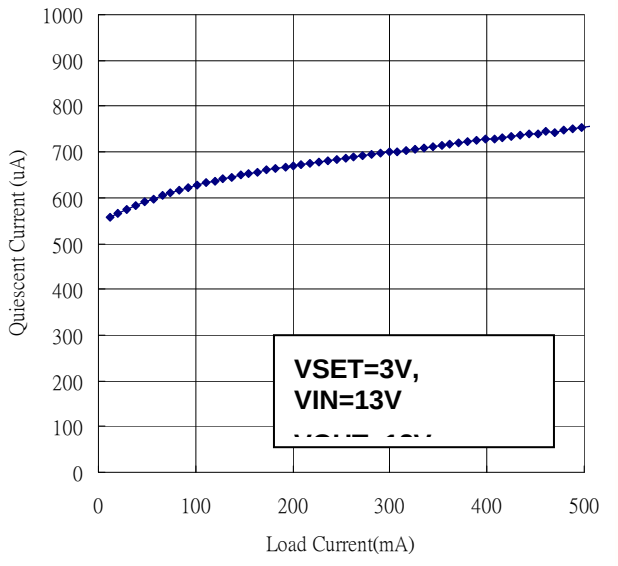
VSET V.S. QUIESCENT CURRENT



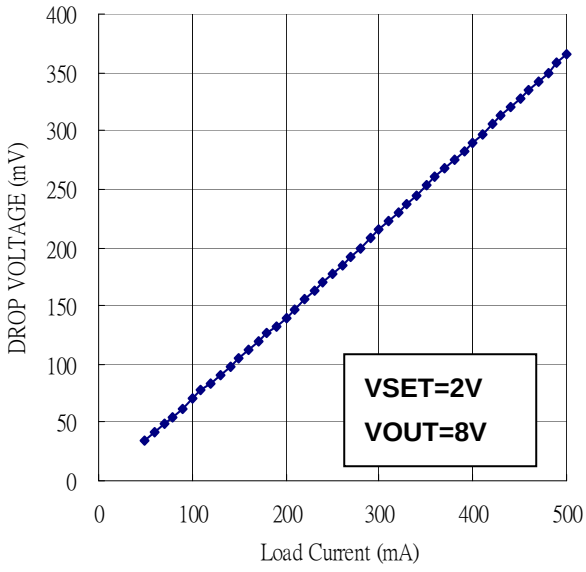
VIN V.S. QUIESCENT CURRENT



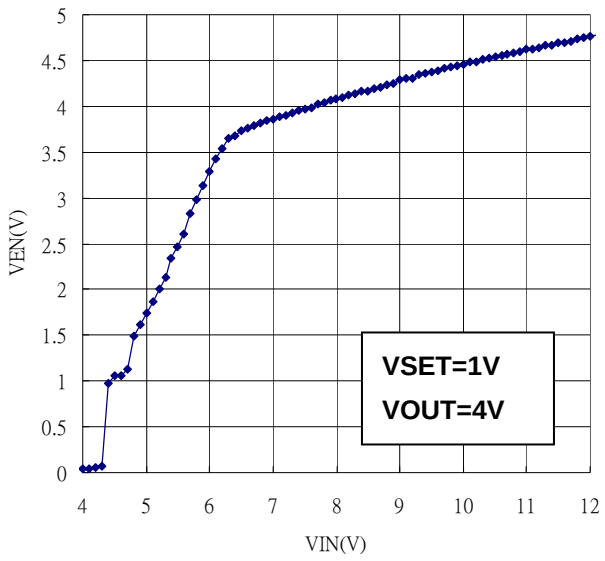
LOAD CURRENT V.S. QUIESCENT CURRENT



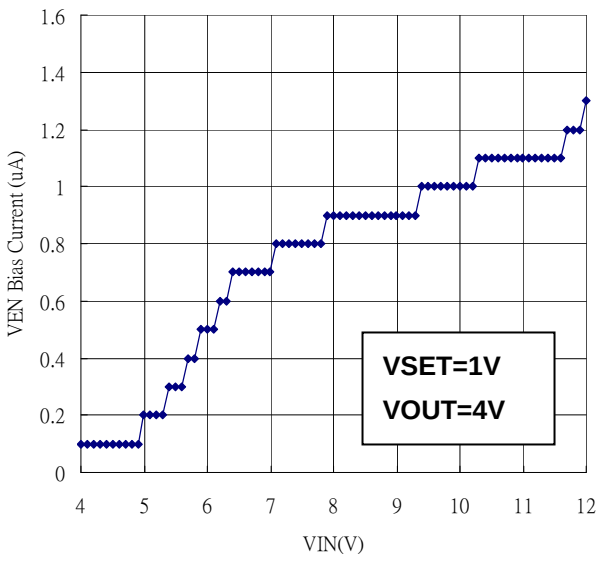
LOAD CURRENT V.S. DROP VOLTAGE



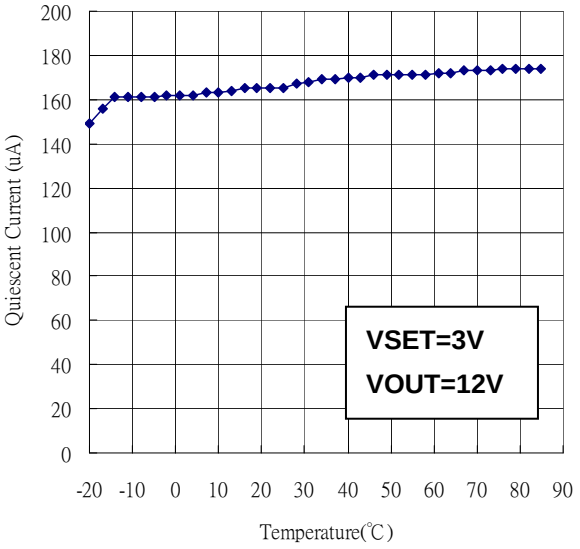
VIN V.S. VEN



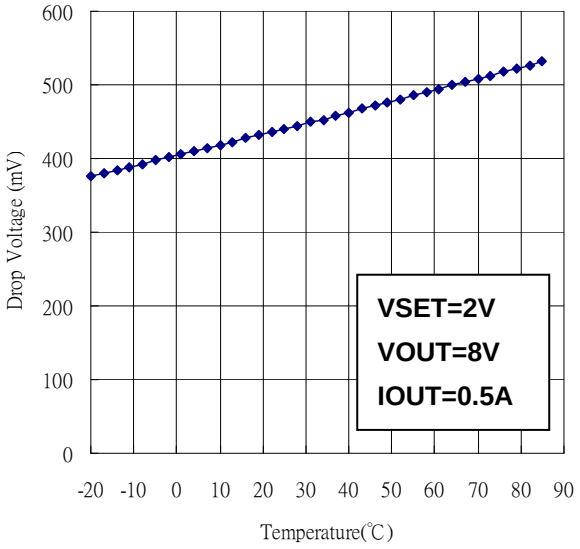
VIN V.S. VEN PIN BIAS CURRENT



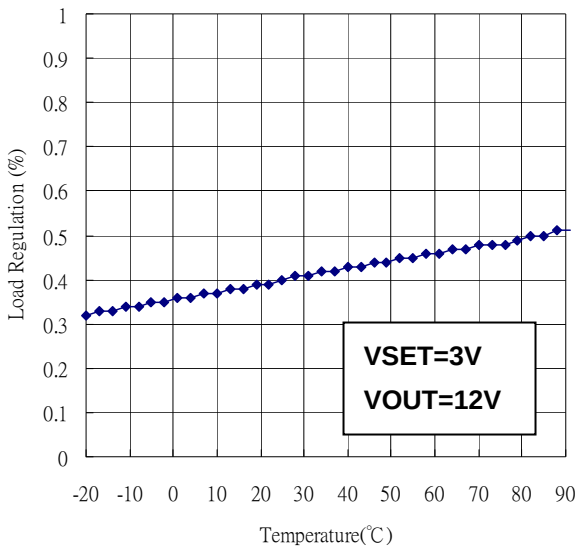
QUIESCENT CURRENT V.S TEMPERATURE



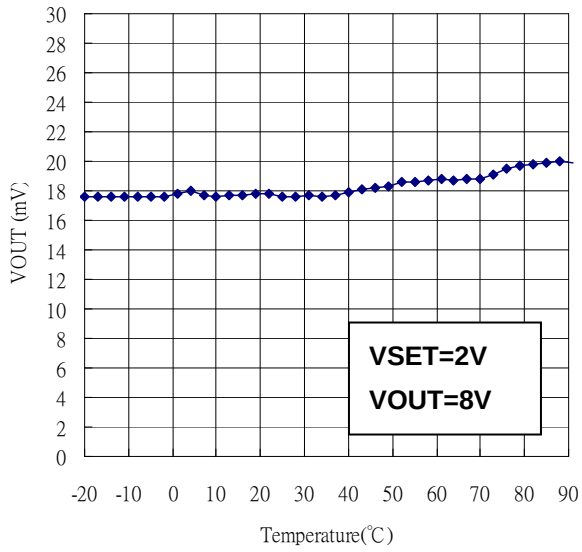
DROP VOLTAGE V.S TEMPERATURE



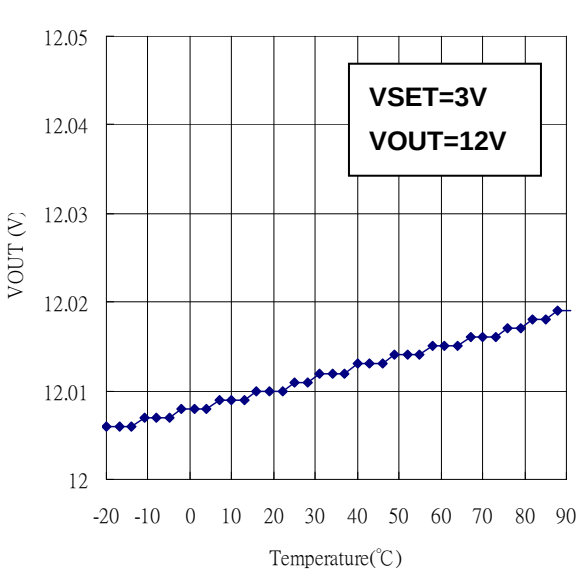
LOAD REGULATION V.S TEMPERATURE



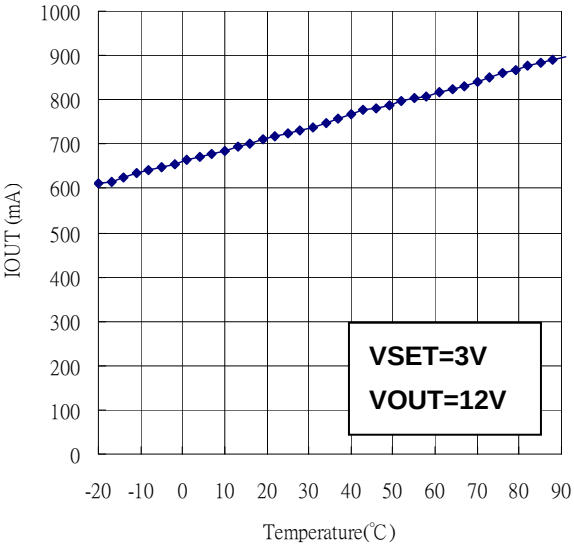
LINE REGULATION V.S TEMPERATURE



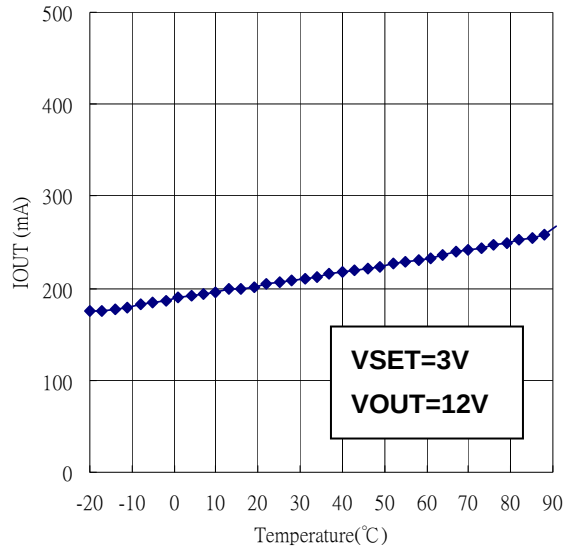
VOUT V.S TEMPERATURE



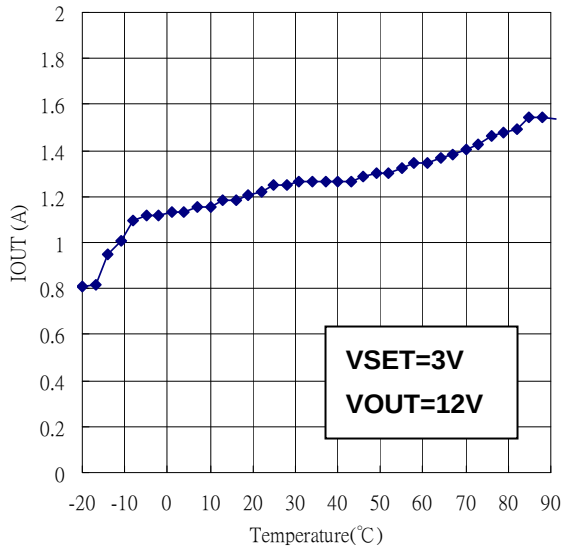
OVER CURRENT LIMIT V.S. TEMPERATURE



SHORT CIRCUIT LIMIT V.S. TEMPERATURE

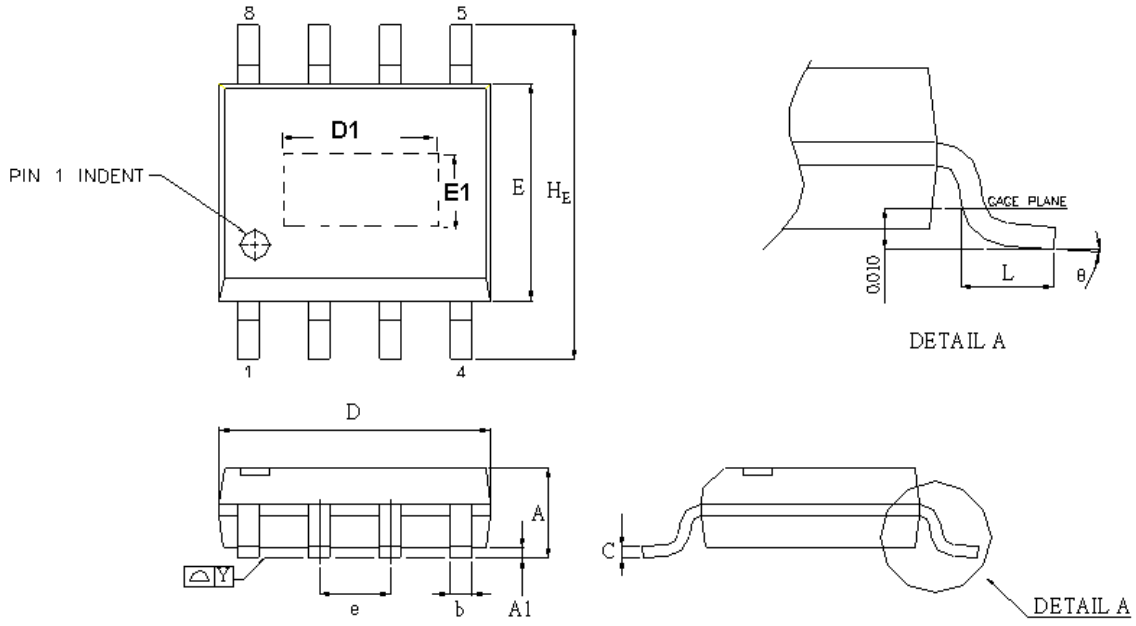


OVER CURRENT TRIGGER POINT V.S. TEMPERATURE



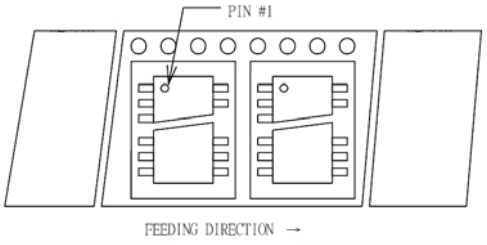
10. PACKAGE DIMENSION

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
NCT3941S	SOP8-EP (Green Package)	T Shape: 2,500 units/T&R	Commercial, -20°C to + 85°C
NCT3941S-A			

12. TOP MARKING SPECIFICATION

Pin 1 index

Pin 1 index

1st Line: Nuvoton logo

2nd Line: 3941S (NCT3941S), 3941S-A (NCT3941S-A)

3rd line: Tracking code

- 846: packages assembled in Year 2008, week 46
- A: assembly house ID.
- X: IC version. (A means A; B means B and C means C…etc.

13. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
A1	04/01/2010	All	New Create
A2	05/05/2010	P.5	Adding thermal consideration
A3	05/06/2010	P.7	Revised Maximum supply voltage.
A4	25/08/2010	P.1, P.12	Modify description of feature and waveform

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

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.