Nuvoton
500mA Linear Regulator
NCT3705U Series

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1. GENERAL DESCRIPTION

The NCT3705U is a low supply current and low dropout linear regulator which provides 500mA power for battery-powered application such as notebook computers, cellular phones, and handheld devices. An over current protection and an over-temperature protection circuit were built-in the chip to prevent current and thermal overload. Featured low noise, high PSRR and low dropout make it ideal for audio codec and handheld devices. It comes in a space saving SOT-23-5 package and suitable for handheld applications.

The NCT3705U has two versions for different operation circuits. In fixed mode, the SET pin is connected to ground. The output voltage is a preset value. There is no external component required. When an output other than the preset value is needed, two external resistors should be used as an output voltage divider and operates in adjustable mode. The output voltage can be adjusted by the resistor ratio and regulates from 1.25V to 5.0V.

2. FEATURES

2.1. General

- Guaranteed 500mA Output Current
- Low Ground Current 90uA @ No Load (Typical)
- 70dB PSRR @ 10mA, 100Hz
- Low Dropout Voltage 145mV @ 150mA (V_{OUT} = 5V)
- Low Output Noise 28u Vrms @ 1mA with Bypass Capacitor
- Excellent Load Regulation & Line Regulation
- Short Circuit Protection & Over Current Protection
- Over Temperature Protection
- Stable with Low ESR Capacitor
- 0℃ to 70℃ Ambient Operating Temperature Range

2.2. Package

- SOT23-5 Green Package (Lead Free and Halogen Free)

2.3. Application

- Desktop PCs, Notebooks, and Workstations
- Graphics Card or Add-on Card Low Power Applications
- Set Top Boxes, Digital TVs and Printers
- Digital Still Camera and Camcorders
- Mobile or handheld Devices

3. BLOCK DIAGRAM

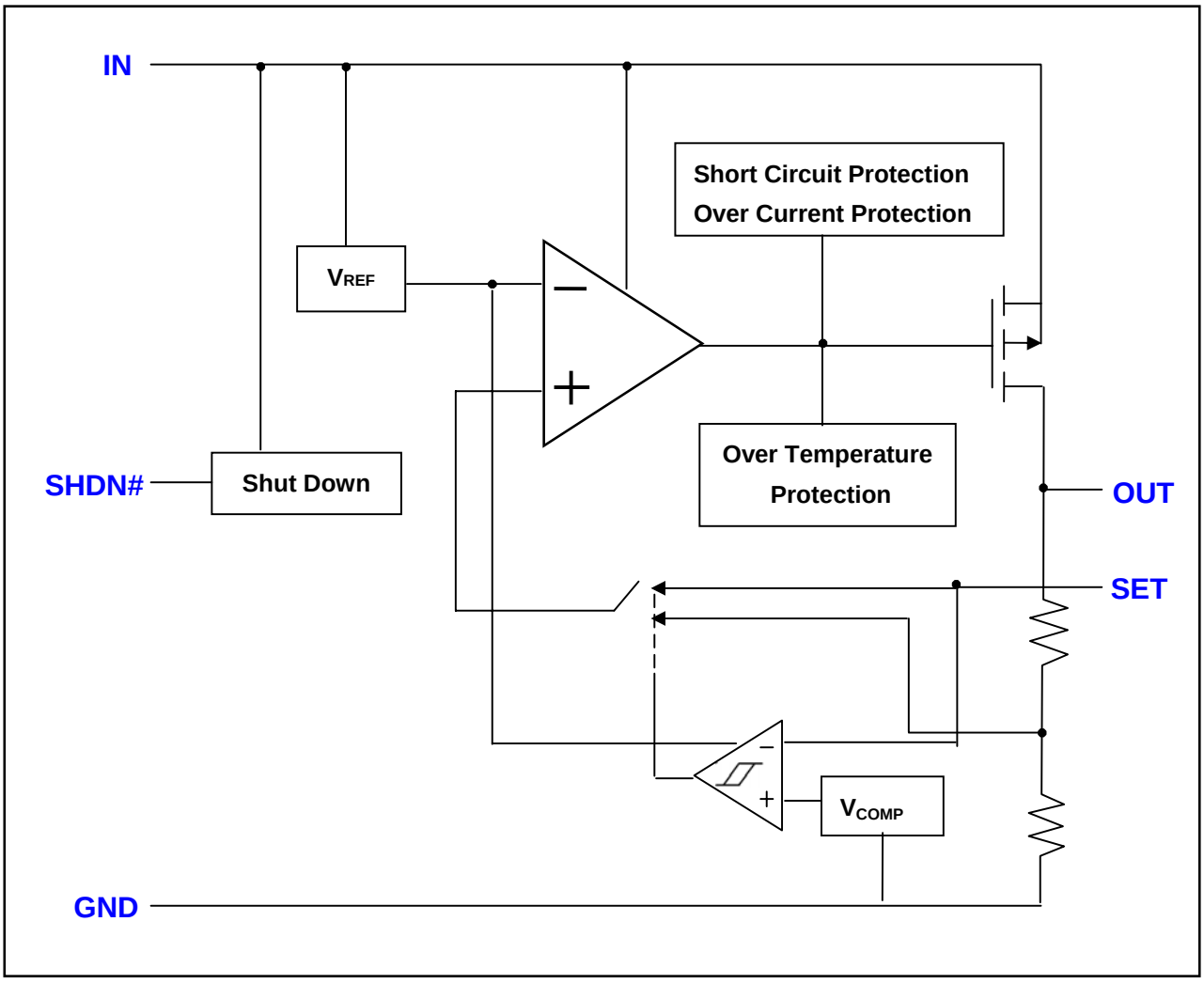


Figure1. Adjustable Mode

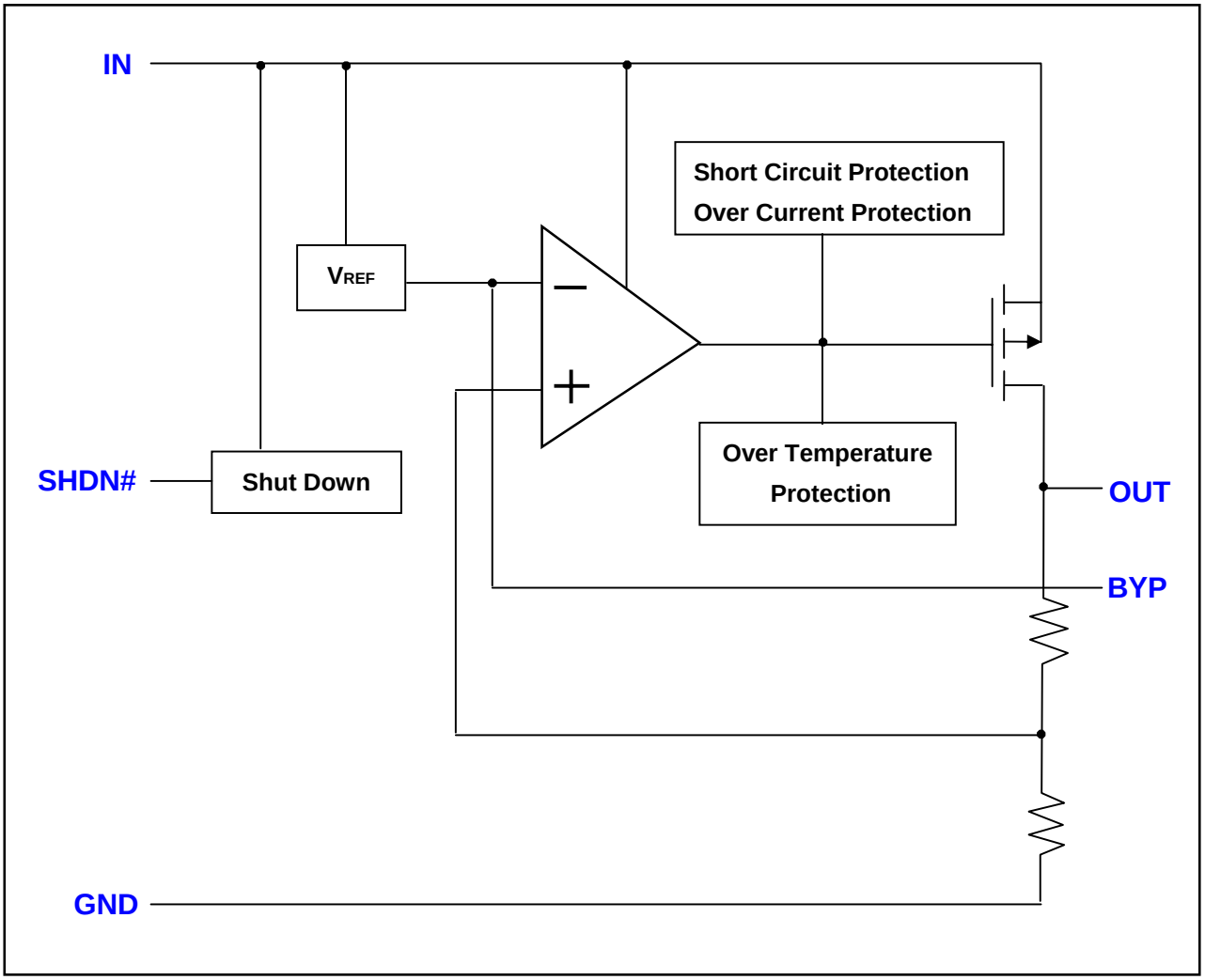


Figure2. Fixed Mode

4. PIN CONFIGURATION AND TYPICAL APPLICATION CIRCUIT

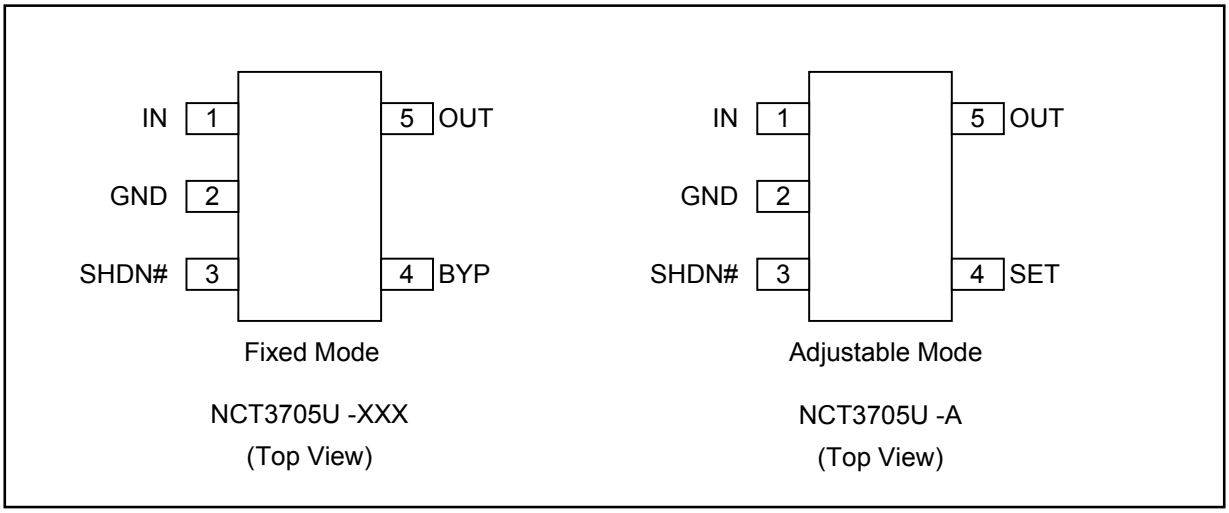


Figure3. Pin Configuration

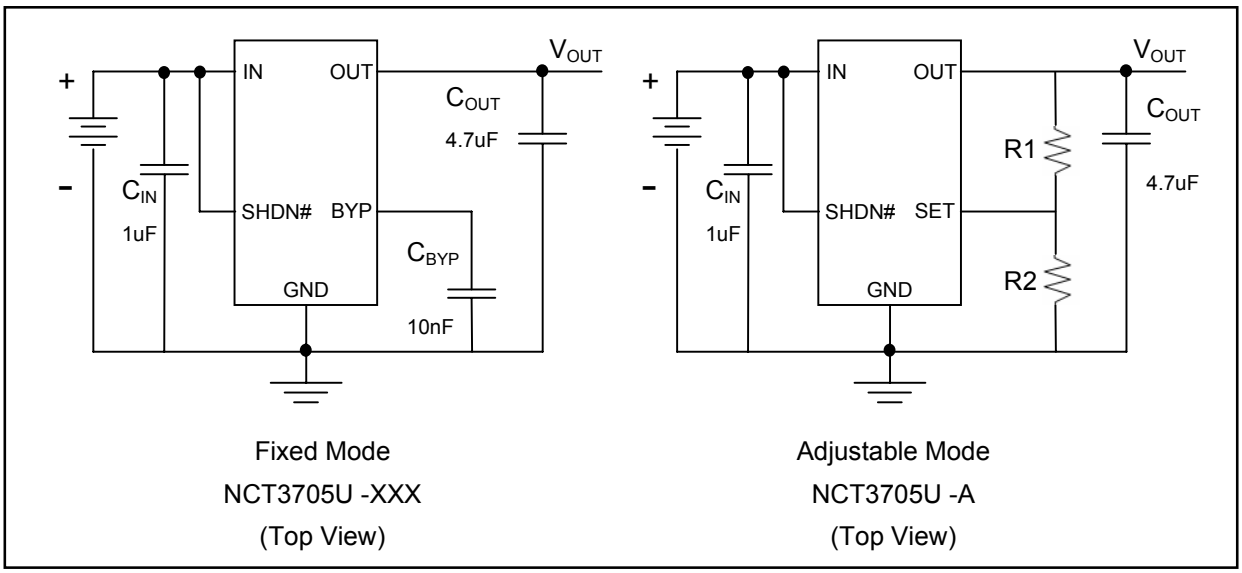


Figure4. Typical Application Circuits

5. PIN DESCRIPTION

NAME	PIN		I/O	FUNCTION
	NCT3705U-A	NCT3705U-XXX		
IN	1		I	Regulator input voltage. Supply voltage can range from 2.5V to 6.0V.
GND	2			Ground
SHDN#	3		I	Active-Low shutdown input pin. A logic low reduces the supply current to 1uA. Connect to IN for normal operation.
BYP		4	O	This is a reference bypass pin. It should connect an external capacitor to GND to reduce output noise.
SET	4		I	Feedback input for setting the output voltage. Connect to GND to set the output voltage to the preset output voltage. Connect to an external resistor divider for adjustable-output operation.
OUT	5			Regulator output. Fixed or adjustable from 1.25V to 5.0V with sourcing current which up to 500mA.

6. FUNCTIONAL DESCRIPTION

6.1 Output Voltage and Dropout voltage

The output voltage of NCT3705U-A can be adjusted by the resistive divider between OUT, SET and GND pins. The internal V_{REF} is 1.25V and the output voltage is given by the following equation:

$V_{OUT} = V_{REF} (1+R1/R2) = 1.25(1+R1/R2)$

For the reasons of reducing power dissipation and loop stability, R2 is chosen to be 120KΩ.

Alternatively, the relationship between R1 and R2 is given by:

$R1 = R2 (V_{OUT} /1.25 - 1)$

A regulator's minimum input-output voltage differential (or dropout voltage) determines the lowest usable supply voltage. NCT3705U uses a P-channel MOSFET pass transistor, it's dropout voltage is a function of $R_{DS(ON)}$ multiplied by the load current. Dropout voltage is defined as the input-output voltage differential at which output 100mV below the standard of output voltage. The NCT3705U has a very low dropout voltage 280 mV (typical at V_{OUT} = 5V) with 500mA of output current.

6.2 Noise

Noise is specified in two–spot noise or output noise density is the RMS (root means square) sum of all noise source, measured at the regulator output , at a specific frequency from 10Hz~100KHz,this type of frequency. Total output noise or Broad-Band Noise is the RMS sum of spot noise over specified bandwidth, usually several decades of frequencies. Total output noise is measured in μV (rms).

With the 10nF capacitor at the BYP pin can reduce the noise significantly and is required for loop stability. The bandgap is noise source in the NCT3705U LDO that will generates 32uVrms in the 10HZ to 100KHZ bandwidth. It will be increased following the loop gain as below equation:

Vnoise = 32uVrms *(VO/VREF) μV

6.3 PSRR

PSRR (Power Supply Rejection Ratio) can be improved by C_{BYP} capacitor selection. It's the key of LDO anti-interference capability. With the increasing value of $C_{BYP,}$ the PSRR will be better.

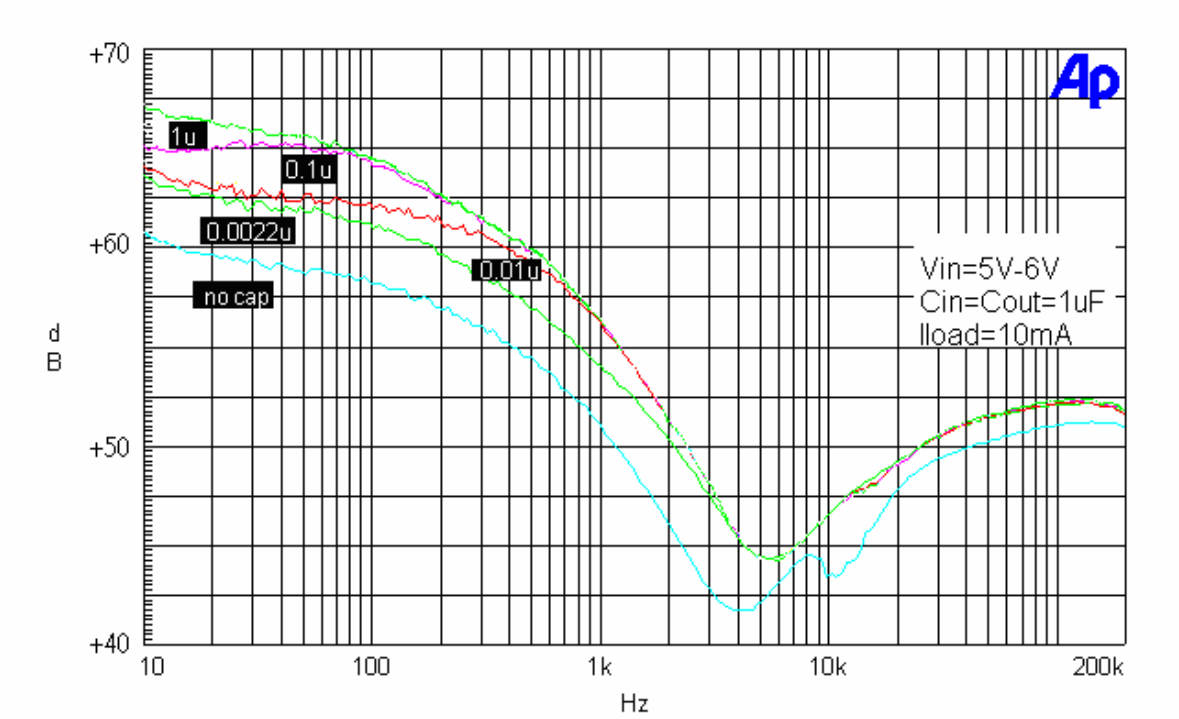


Figure5. Select a C_{BYP} for NCT3705 Circuits

6.4 Load Regulation Consideration

Load regulation will be affected by the length of trace. The impendence of the trace (RLine1 & RLine2) will have influence on the V_{OUT}. The output voltage is given by the following equation:

$V_{OUT} = V_{OUT} -[I_{Load} * (RLine1 + RLine2)]$ (Figure 6)

The best method/layout is making terminals of VOUT & R1, R2 & GND as close as possible to reduce the trace impedance. It will have the better load regulation of the circuits. (Figure7)

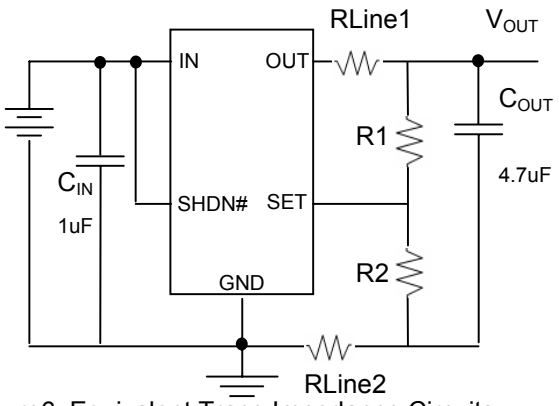


Figure6. Equivalent Trace Impedance Circuits

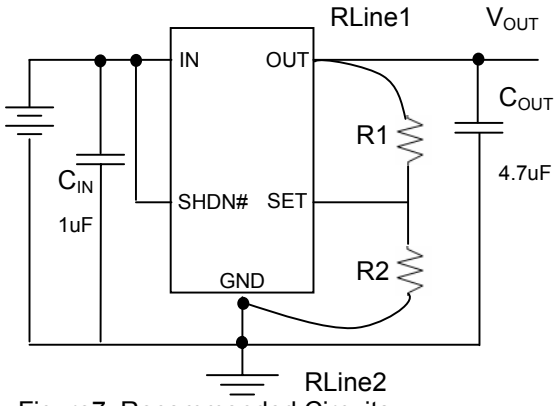


Figure7. Recommended Circuits

6.5 Current Limit Protection

The NCT3705U uses a current sense-resistor to monitor the output current. Once the output current exceeds limit threshold, NCT3705U would be protected with a limited output current. Further more, when the output is short to ground (<0.7V), the output current would be folded-back to a less limit and less thermal accumulation.

6.6 V_{IN} & V_{OUT} Capacitor Selection

When operating from batteries, or in applications with long line length (> 10 inches) between the input source and the LDO, some input capacitance is recommended. A minimum of 1.0μF to 4.7μF is recommended for most applications.

For applications that have output step load requirements, the input capacitance of the LDO is very important. The input capacitance provides the LDO with a good local low-impedance source to pull the transient currents from in order to respond quickly to the output load step.

For good step response performance, the output capacitor value should be equivalent or higher than the input capacitor. The capacitor should be placed as close to the LDO as possible.

Larger input capacitors will also help reduce any high-frequency noise on the input and output of the LDO and reduce the effects of any inductance that exists between the input source voltage and the input capacitance of the LDO. The recommended value of output capacitor is at least 1uF with low ESR.

6.7 Over Temperature Protection

The NCT3705U LDO has temperature-sensing circuitry to prevent the junction temperature from exceeding approximately 150°C. If the LDO junction temperature does reach 150°C, the LDO output will be turned off until the junction temperature cools to approximately 110°C, at which point the LDO output will automatically resume normal operation. If the internal power dissipation continues to be excessive, the device will again shut off. The junction temperature of the die is a function of power dissipation, ambient temperature and package thermal resistance.

6.8 Layout note

Dropout and load regulation will be deteriorated when C_{OUT}, C_{IN} and NCT3705U distance is too far. The capacitor must be located a distance of not more than 1 inch from the input and return to a clean analog ground.

By putting C_{BYP} close to the NCT3705U, the transient and PSRR will be improved and performs less output noise.

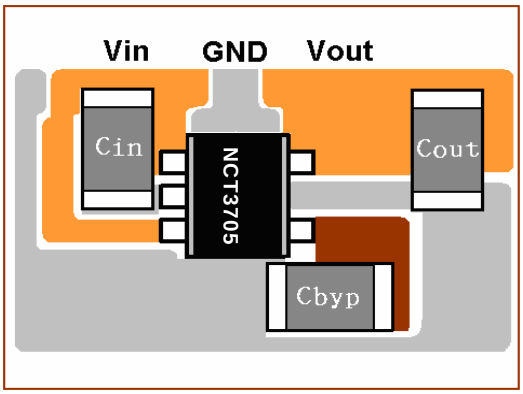


Figure8. Fixed Mode Recommended Layout

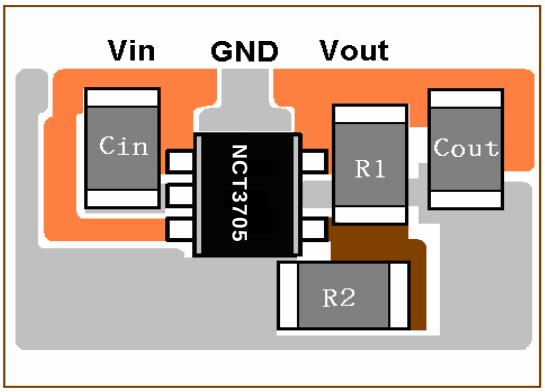


Figure9. Adjustable Mode Recommended Layout

6.9 Thermal Consideration

Different (VIN-VOUT) combinations and ambient temperature play important roles in the thermal dissipation. The maximum power dissipation can be calculated by following formula:

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

Where T_J is the maximum junction temperature.T_A is the ambient temperature. θ_{JA} is the junction to ambient thermal resistance.

For example: NCT3705U at the T_A =25℃.it can calculate $P_{D(MAX)}$ = 520mW = (150℃ -25℃) / 240℃/W

Differential voltage can to explain below：

$(V_{IN} – V_{OUT}) = P_{D(MAX)} / I_{OUT}$

NCT3705U occurs Over Temperature Protection if differential voltage surpasses below Figure10 & Figure11 safe operation range.

Thermal Consideration Area @ Iout=300mA

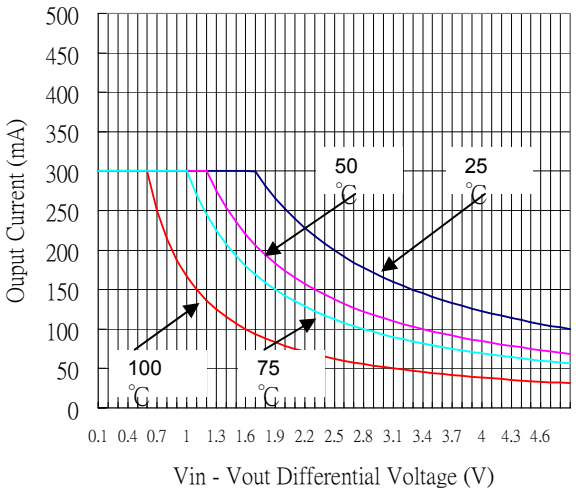


Figure10. Safe Operating Area (IOUT=300mA)

Thermal Consideration Area @ Iout=500mA

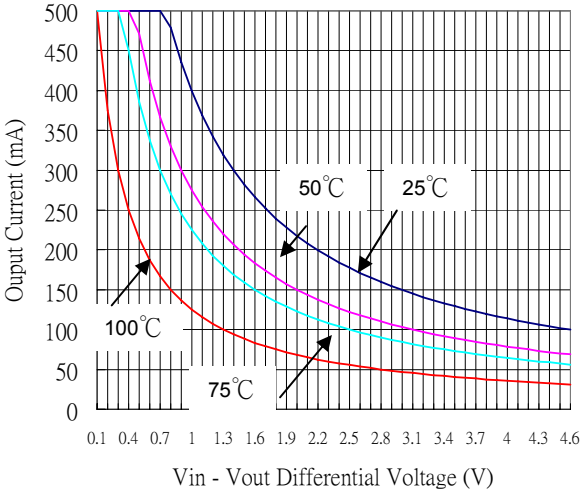


Figure11. Safe Operating Area (IOUT=500mA)

7. ELECTRICAL CHARACTERISTIC

7.1 Absolute Maximum Ratings

ITEM	SYMBOL	RATING	UNIT
Input Voltage	V_{IN}	-0.3 to 7	V
Output Voltage to Ground	V_{OUT}	-0.3 to 7	V
Output Current	I_{OUT}	Internally limited	
Operating Temperature Range	T_{opt}	0 to 70	℃
Electrostatic discharge protection	Human Body Mode	±2	kV
	Machine Mode	±200	V
	Latch-Up	±100	mA

Note: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device and exposure to absolute maximum rating conditions for extended periods may affect device reliability.

7.2 Thermal Information

ITEM	RATING	UNIT
Power Dissipation, P_D @ T_A=25℃	Internal Limited	W
Package Thermal Resistance, SOT23-5, θ_{JA}	240	℃/W

7.3 Recommended operating conditions

ITEM	SYMBOL	MIN	MAX	UNIT
Input Voltage	V_{IN}	2.5	6.0	V
Continuous Output Current	I_{OUT}	0	500	mA
Peak Output Current	I_{PEAK}	0	800	
Operating Temperature Range		0	70	℃
Junction Temperature Range		0	125	℃

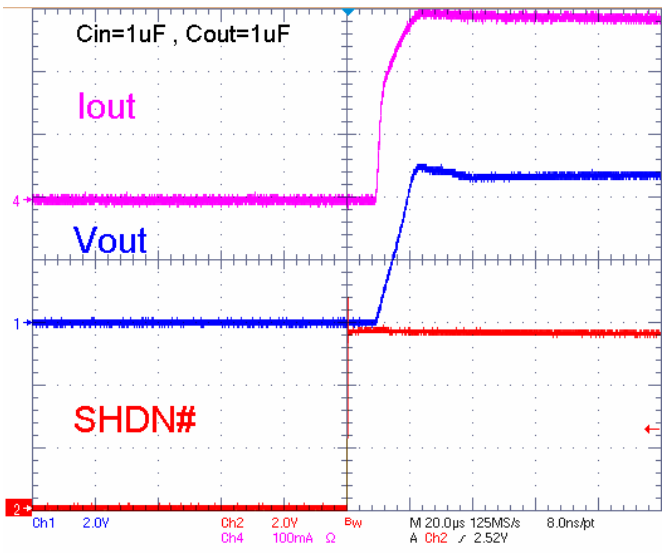
7.4 Electrical Characteristics

PARAMETER	SYMBOL	CONDITION		MIN	TYP	MAX	UNIT
Input Voltage	V_{IN}			2.5	---	6.0	V
Output Voltage Accuracy	V_{OUT}	Variation from specified VOUT, IOUT=1mA		-2	---	2	%
Output Voltage range				1.25	---	5.0	V
Maximum Output Current				500	---	---	mA
Current Limit	I_{LIM}			500	750		mA
Shot Circuit Current	Isc				280		mA
Ground Pin Current	I_Q			---	90	120	µA
Dropout Voltage	V_{DROP}	I_{OUT} = 500mA	V_{OUT} =1.25V	---	1.5	1.8	V
			V_{OUT} =1.80V	---	0.9	1.2	
			V_{OUT} =2.50V	---	0.7	1.0	
			V_{OUT} =2.80V	---	0.7	1.0	
			V_{OUT} =3.30V	---	0.6	0.9	
			V_{OUT} =4.75V	---	0.45	0.75	
			V_{OUT} =5.00V	---	0.40	0.7	
Line Regulation	ΔVLNR	V_{IN}=V(STD)+0.1V to 6.2V, I_{OUT}=10mA		---	0.05	0.1	%/V
Load Regulation	ΔVLDR	I_{OUT}=10mA to 500mA		---	---	0.02	%/mA
Ripple Rejection	PSRR	Freq. =100Hz, I_{OUT}=10mA		---	70	---	dB
Output Voltage Noise	e_n	C_{OUT}=4.7µF,	V_{OUT} =1.25V	---	32	---	µVRMS

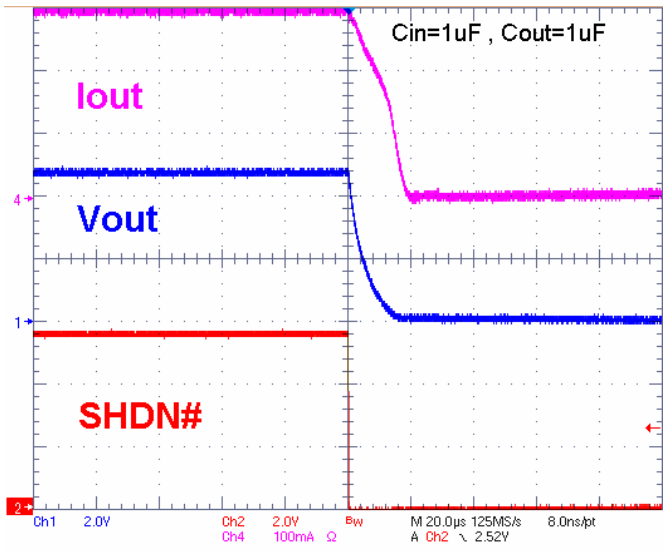
(10Hz to 100kHz)		C_{BYP}=10nF, I_{OUT}=1mA	V_{OUT} =1.80V	---	46	---	
			V_{OUT} =2.50V	---	64	---	
			V_{OUT} =2.80V	---	72	---	
			V_{OUT} =3.30V	---	84	---	
			V_{OUT} =4.75V	---	122	---	
			V_{OUT} =5.00V	---	128	---	
Shutdown Supply Current	I_{SHDN}	V_{OUT} =0V,TA=+25℃		---	---	1	μA
Stable C_{OUT} ESR Range		I_{OUT} =500mA		5m	---	500m	Ω
SHUTDOWN							
SHDN# Input Threshold	V_{IH}	Regulator enabled		1.5	---	---	V
	V_{IL}	Regulator shutdown		---	---	0.4	
SHDN# Input Bias Current	$I_{SHDN\#}$	$V_{SHDN\#}$ = V_{IN}, TA=+25℃		---	---	0.1	μA
	$I_{QSHDN\#}$	$V_{SHDN\#}$ = GND, TA=+25℃		---	---	0.1	
SET INPUT							
SET Reference Voltage	V_{SET}	V_{IN}=2.5V to 5.5V , I_{OUT}=1mA	TA=+25℃	1.225	1.25	1.275	V
			TA=T_{MIN} to T_{MAX}	---	1.25	---	
SET Input Leakage current	I_{SET}	V_{SET} = 1.3V	TA=+25℃	---	5	30	nA
THERMAL PROTECTION							
Thermal Shutdown Temperature	T_{SHDN}			---	150	---	℃
Thermal Shutdown Hysteresis	△T_{SHDN}			---	40	----	℃

8. TYPICAL OPERATING WAVEFORMS (V_{OUT}=4.75V)

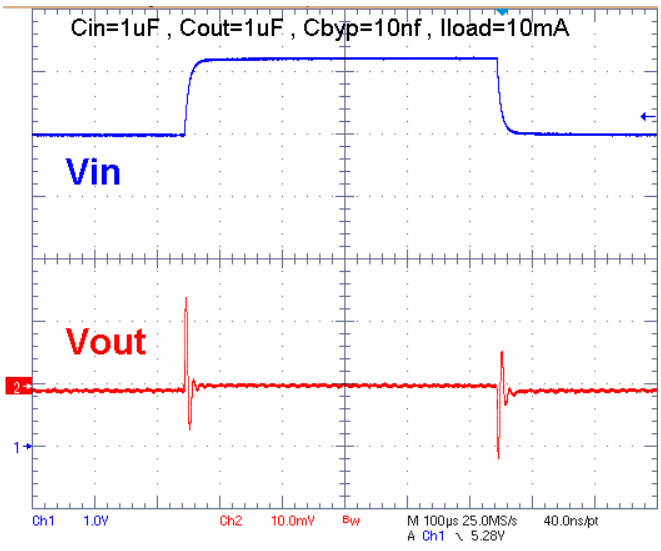
Turn – on time



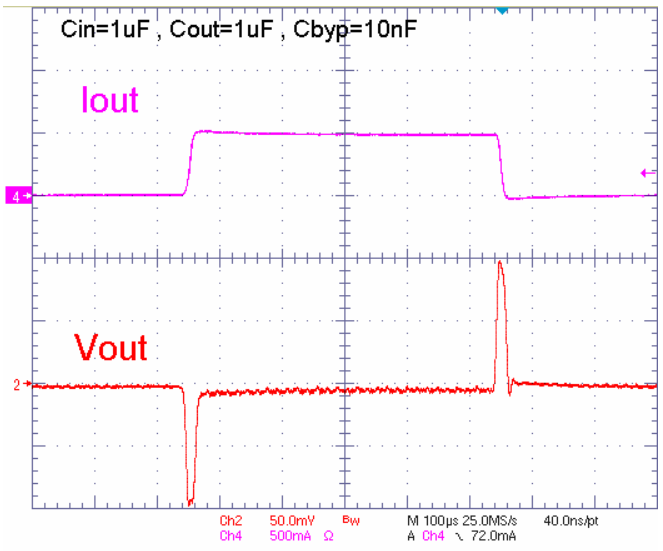
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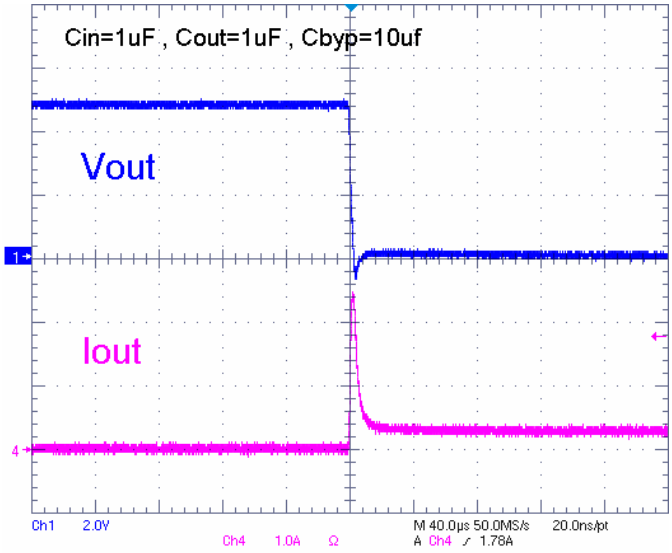
Line Transient



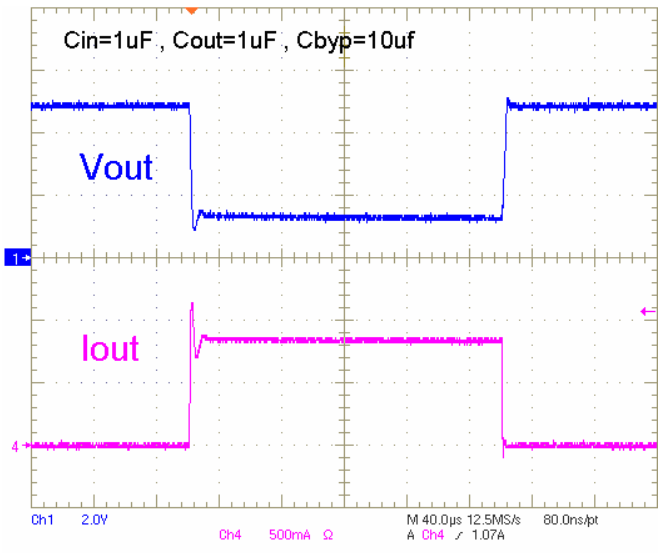
Load Transient



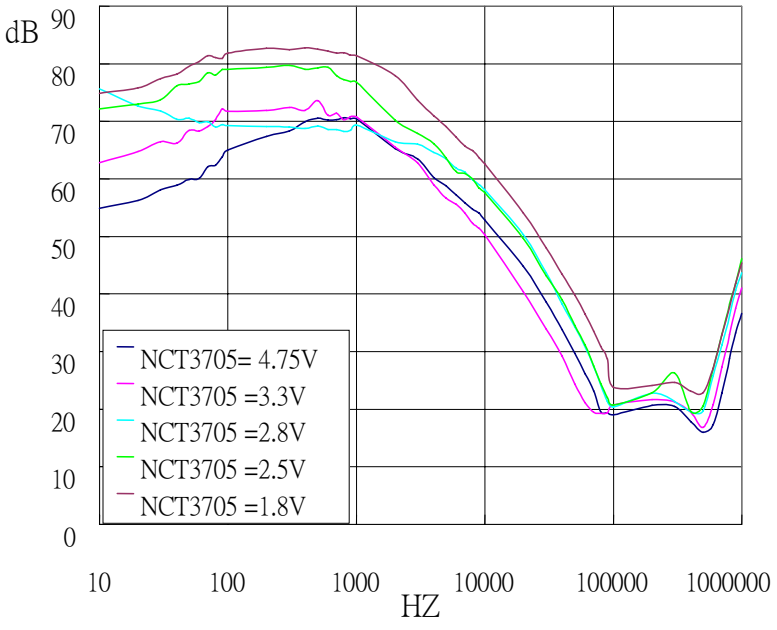
Short Circuit Protection



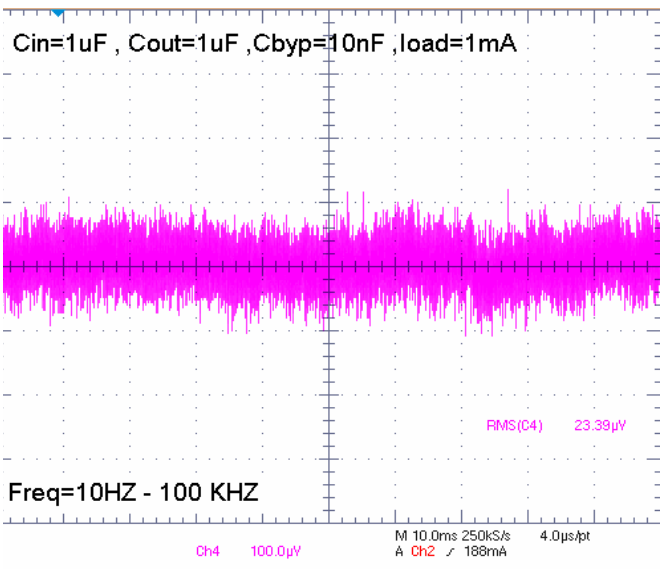
Over Current Protection



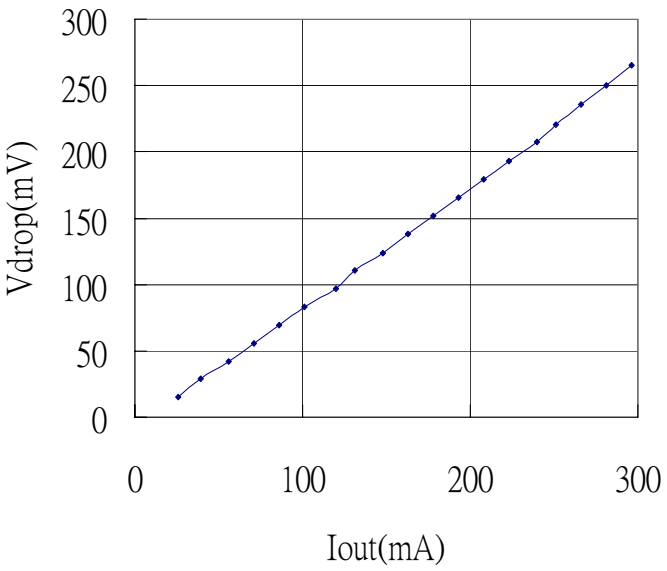
Power Supply Rejection Ratio



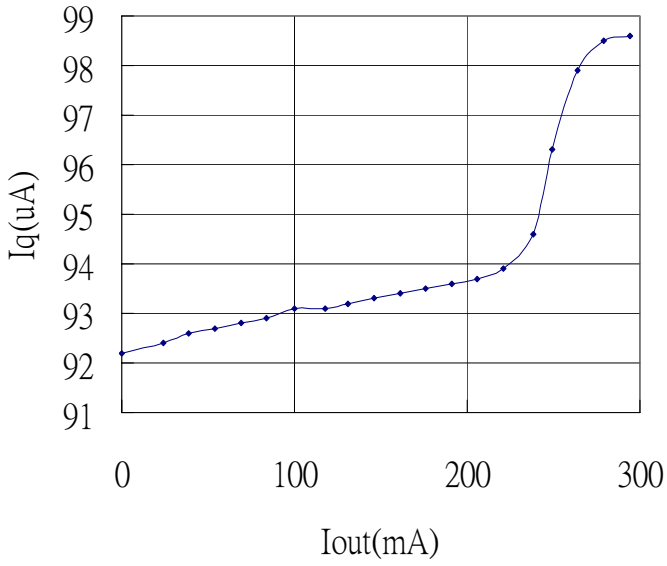
Output Voltage Noise



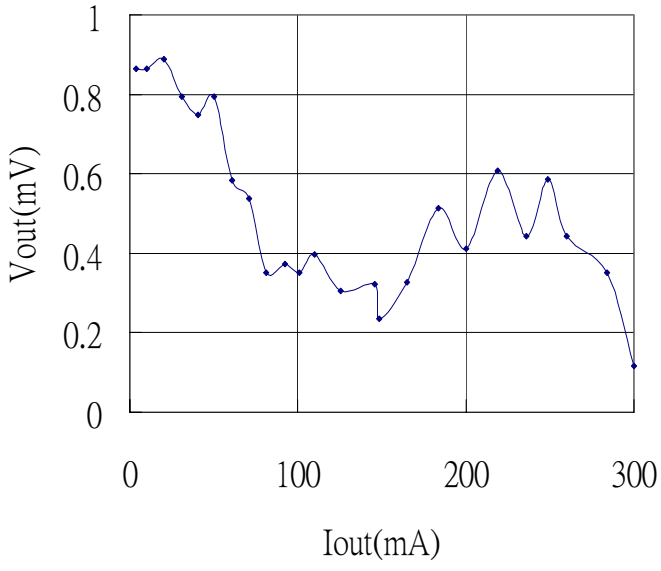
Dropout voltage VS Output Current



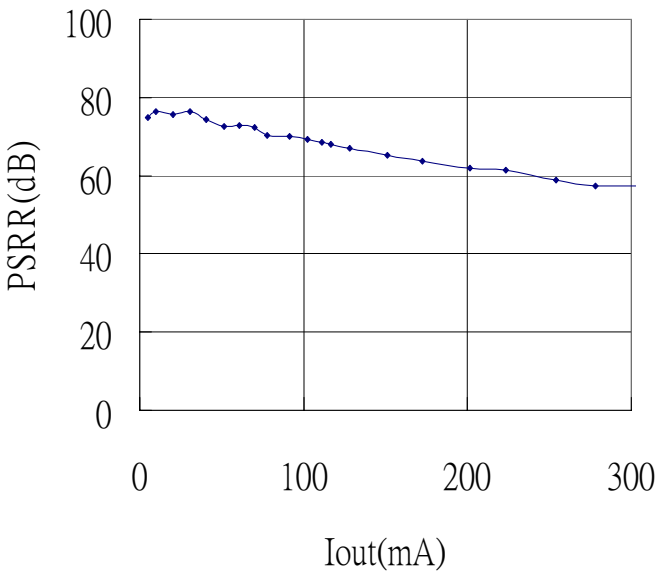
Quiescent current VS Output Current



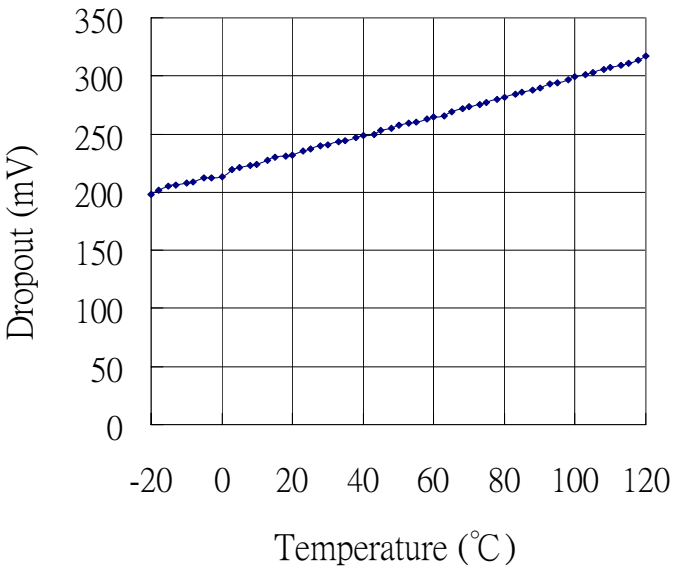
Line Regulation VS Output Current



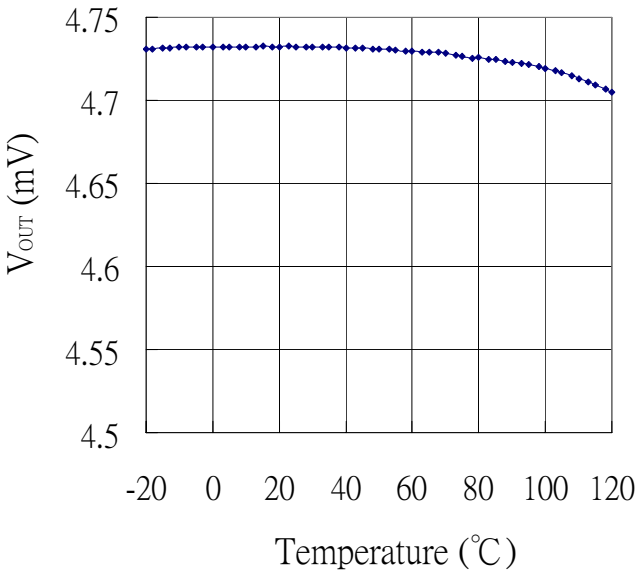
PSRR VS Output Current



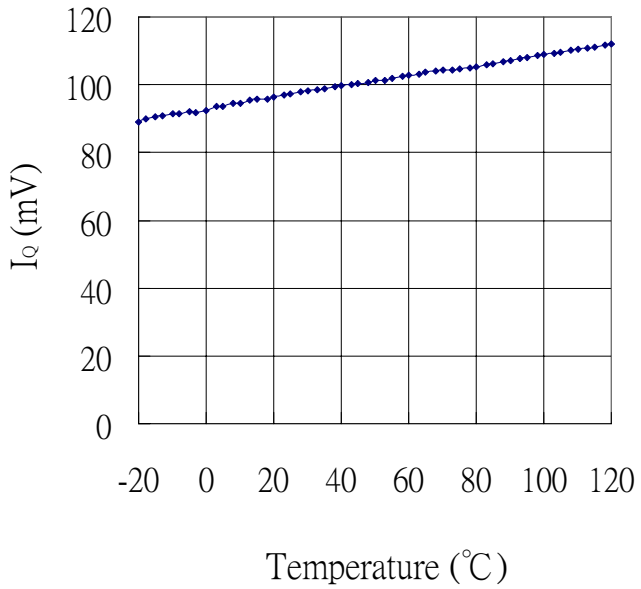
Dropout VS Temperature



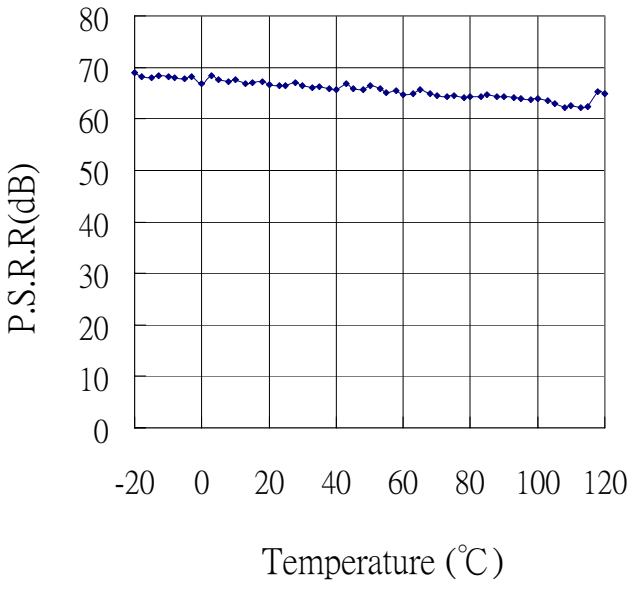
Output Voltage VS Temperature



Quiescent Current VS Temperature

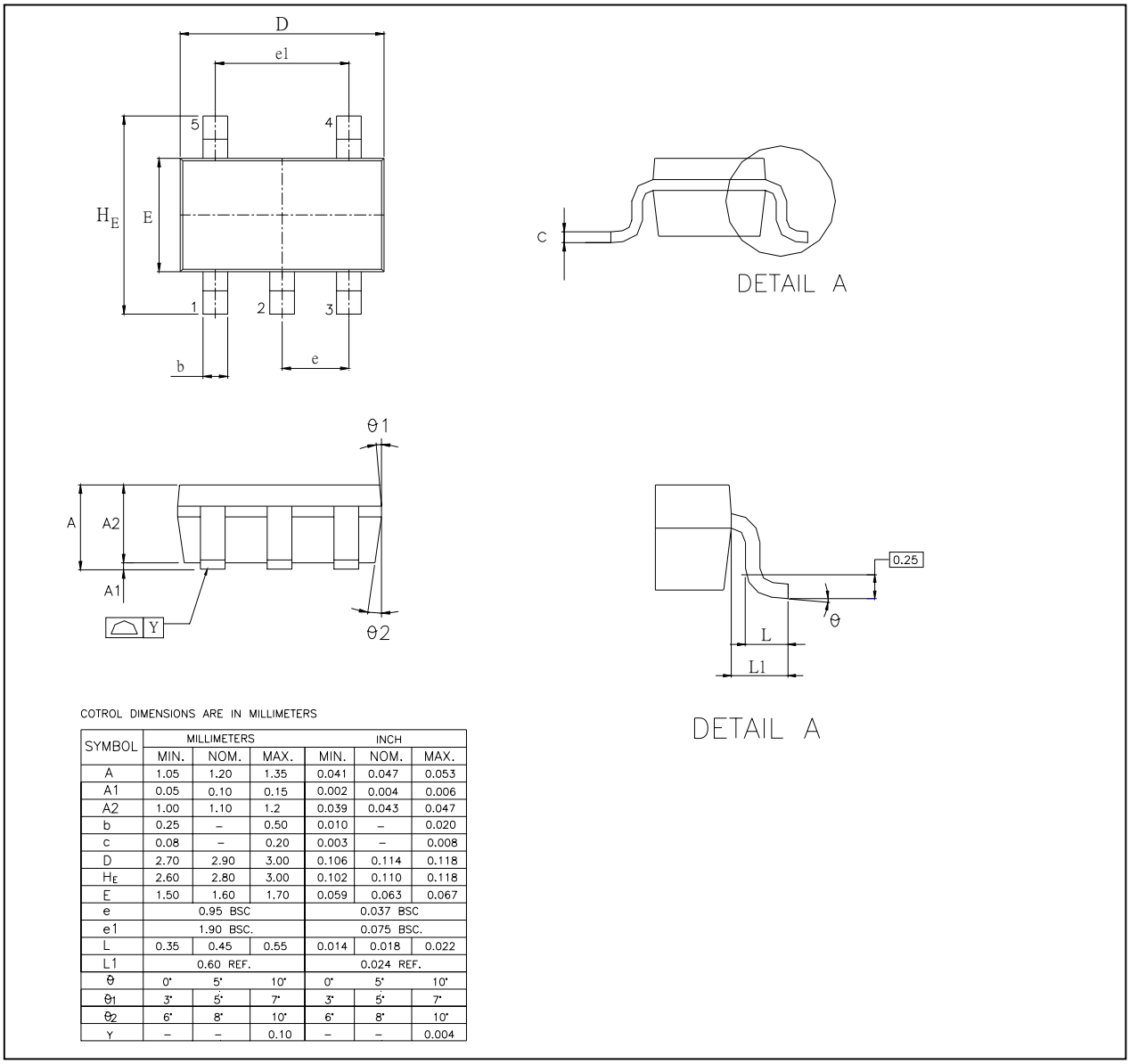


P.S.R.R VS Temperature



9. PACKAGE DIMENSION

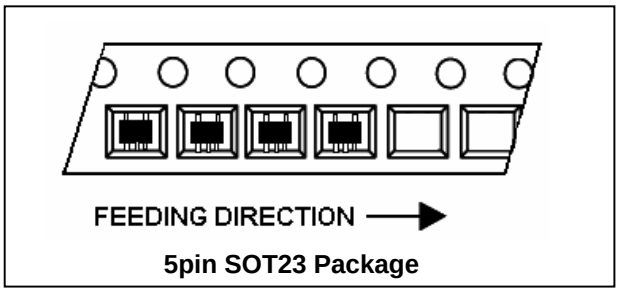
5pin SOT23 Package



COTROL DIMENSIONS ARE IN MILLIMETERS

SYMBOL	MILLIMETERS			INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.05	1.20	1.35	0.041	0.047	0.053
A1	0.05	0.10	0.15	0.002	0.004	0.006
A2	1.00	1.10	1.2	0.039	0.043	0.047
b	0.25	–	0.50	0.010	–	0.020
c	0.08	–	0.20	0.003	–	0.008
D	2.70	2.90	3.00	0.106	0.114	0.118
H_E	2.60	2.80	3.00	0.102	0.110	0.118
E	1.50	1.60	1.70	0.059	0.063	0.067
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC.			0.075 BSC.		
L	0.35	0.45	0.55	0.014	0.018	0.022
L1	0.60 REF.			0.024 REF.		
θ	0°	5°	10°	0°	5°	10°
θ1	3°	5°	7°	3°	5°	7°
θ2	6°	8°	10°	6°	8°	10°
Y	–	–	0.10	–	–	0.004

➢ TAPING SPECIFICATION

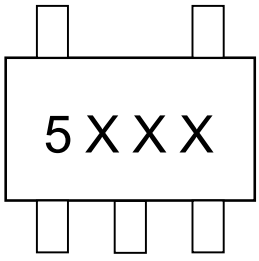


5pin SOT23 Package

10. ORDERING INFORMATION

PART NUMBER	MARKING	V_{OUT}	SUPPLIED AS	PACKAGE TYPE	PRODUCTION FLOW
NCT3705U-**A**	**5A00**	ADJ	T Shape: 3,000 units/T&R	5 PIN SOT23 (Green package)	Commercial, 0℃ to +70℃
NCT3705U-**12**	**5120**	1.2V			
NCT3705U-**15**	**5150**	1.5V			
NCT3705U-**18**	**5180**	1.8V			
NCT3705U-**25**	**5250**	2.5V			
NCT3705U-**28**	**5250**	2.8V			
NCT3705U-**33**	**5330**	3.3V			
NCT3705U-**475**	**5475**	4.75V			
NCT3705U-**50**	**5500**	5.0V			

11. TOP MARKING SPECIFICATION



1st Line: 3XXX

- 5: 500mA (NCT3705U)
- XXX : Please check ordering information

12. REVISION HISTORY

VERSION	DATE	PAGE	DESCRIPTION
A1	03/18/2009	All	New Create

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