

NCP785B

Product Preview

Wide Input Voltage Range 10 mA Ultra-Low I_q , High PSRR Linear Regulator with Enable Pin

The NCP785B is a high-performance linear regulator, offering a very wide operating input voltage range of up to 450 V DC, with an output current of up to 10 mA.

Ideal for high input voltage applications such as industrial and home metering, home appliances. The NCP785B LDO offers $\pm 5\%$ initial accuracy, extremely high-power supply rejection ratio and ultra-low quiescent current. It is optimized for high-voltage operations, making them ideal for harsh environment applications.

The device is offered in fixed output voltages 3.3 V, 5.0 V, 12 V and 15 V. NCP785B has an Enable pin with internal pull up which allows for easy output voltage ON/OFF control. SOT-223 package option provides good thermal performance as well as helps to minimize the overall solution size.

Features

- Wide Input Voltage Range:
DC: Up to 450 V
AC: 85 V to 260 V (half-wave rectifier and 2.2 μF capacitor)
- 10 mA Guaranteed Output Current
- Ultra Low Quiescent Current: Typ. 15 μA ($V_{\text{OUT}} \leq 5 \text{ V}$)
- $\pm 5\%$ Accuracy Over Full Load, Line and Temperature Variations
- Ultra-high PSRR: 70 dB at 60 Hz, 90 dB at 100 kHz
- Stable with Ceramic Output Capacitor 22 μF MLCC
- Thermal Shutdown and Current Limit Protection
- Available in Thermally Enhanced SOT-223 Package
- This is a Pb-Free Device

Typical Applications

- Industrial Applications, Home Appliances
- Home Metering / Network Application
- Off-line Power Supplies

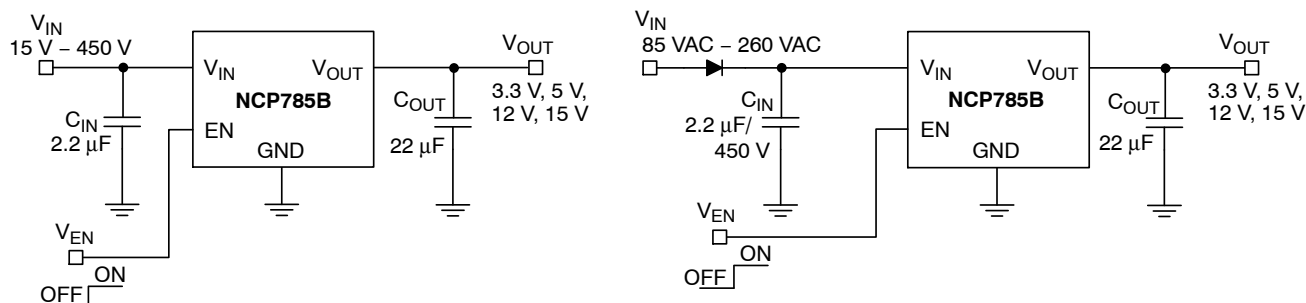


Figure 1. Typical Applications

This document contains information on a product under development. ON Semiconductor reserves the right to change or discontinue this product without notice.



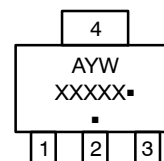
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MARKING DIAGRAMS



SOT-223
S SUFFIX
CASE 318E



(Top View)

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

(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

NCP785B

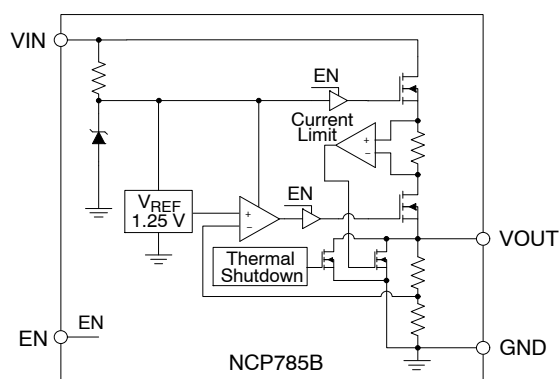


Figure 2. Simplified Internal Block Diagram

Table 1. PIN FUNCTION DESCRIPTION

Pin No. (SOT-223)	Pin Name	Description
1	VIN	Supply Voltage Input. Connect 1 μ F capacitor from VIN to GND.
2	EN	Enable pin. Allows to turn-on/off the Regulator's output voltage. Pulling the EN pin low turns-off the NCP785B. Releasing the EN pin allows the internal pull-up to turn-on the Regulator. This pin should be driven by an open collector output.
3	VOUT	Regulator Output. Connect 10 μ F or higher MLCC capacitor from VOUT to GND.
4 (Tab)	GND	Ground connection.

Table 2. ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage (Note 1)	V_{IN}	-0.3 to 700	V
Output Voltage	V_{OUT}	-0.3 to 18	V
Enable Pin Voltage	V_{EN}	-0.3 to 5.5	V
Maximum Junction Temperature	$T_{J(MAX)}$	150	$^{\circ}$ C
Storage Temperature	T_{STG}	-55 to 150	$^{\circ}$ C
ESD Capability, Human Body Model (All pins except HV pin no.1) (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. Peak 650 V max 1 ms non repeated for 1 s
2. This device series incorporates ESD protection and is tested by the following methods:
 ESD Human Body Model tested per AEC-Q100-002 (EIA/JESD22-A114)
 ESD Machine Model tested per AEC-Q100-003 (EIA/JESD22-A115)
 Latch-up Current Maximum Rating tested per JEDEC standard: JESD78.

Table 3. THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, SOT-223 Thermal Resistance, Junction-to-Air	$R_{\theta JA}$	73	$^{\circ}$ C/W

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Table 4. ELECTRICAL CHARACTERISTICS, $V_{OUT} = 3.3\text{ V}$ ($-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$; $V_{IN} = 340\text{ V}$; $I_{OUT} = 100\text{ }\mu\text{A}$, $C_{IN} = 1\text{ }\mu\text{F}$, $C_{OUT} = 22\text{ }\mu\text{F}$, 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 DC		V_{IN}	23		450	V
Output Voltage Accuracy	$T_J = 25^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $23\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	3.1515	3.3	3.4485	V
	$-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $23\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	3.135	3.3	3.465	V
Line Regulation	$23\text{ V} \leq V_{IN} \leq 450\text{ V}$, $I_{OUT} = 100\text{ }\mu\text{A}$	Reg_{LINE}	-0.5	0.2	+0.5	%
Load Regulation	$100\text{ }\mu\text{A} \leq I_{OUT} \leq 10\text{ mA}$, $V_{IN} = 23\text{ V}$	Reg_{LOAD}	-1.0	0.6	+1.0	%
Maximum Output Current (Note 4)	$23\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_{OUT}	11.5			mA
Quiescent Current	$I_{OUT} = 0$, $23\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_Q		15	26	μA
Ground Current (Note 4)	$23\text{ V} \leq V_{IN} \leq 450\text{ V}$ $0 < I_{OUT} \leq 10\text{ mA}$	I_{GND}			27	μA
EN Pin High Threshold EN Pin Low Threshold	V_{EN} Voltage increasing V_{EN} Voltage decreasing	V_{EN_HI} V_{EN_LO}	1.4		0.8	V
EN Pin Pull up Current (Note 5)	$V_{IN} = 450\text{ V}_{DC}$	I_{EN}		5		μA
EN Pin Voltage (Note 6)	$V_{IN} = 450\text{ V}_{DC}$	V_{EN}		3.0	3.3	V
Power Supply Rejection Ratio	$V_{IN} = 340\text{ V}_{DC} + 1\text{ V}_{pp}$ modulation, $I_{OUT} = 100\text{ }\mu\text{A}$	$f = 1\text{ kHz}$ PSRR		70		dB
Output Noise	$f = 10\text{ kHz to } 100\text{ kHz}$ $V_{IN} = 340\text{ V}_{DC}$, $I_{OUT} = 100\text{ }\mu\text{A}$	V_{NOISE}		280		μV_{rms}
Thermal Shutdown Temperature (Note 5)	Temperature increasing from $T_J = +25^{\circ}\text{C}$	T_{SD}		145		$^{\circ}\text{C}$
Thermal Shutdown Hysteresis (Note 5)	Temperature falling from T_{SD}	T_{SDH}	-	10	-	$^{\circ}\text{C}$

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.
- A proper heatsinking and/or low duty cycle pulse techniques are used to operate the device within the Safe Operating Area.
- Guaranteed by design
- Voltage present at the EN pin in case that this pin is left floating. It is generated by the internal EN Pin Pull-up Current.

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Table 5. ELECTRICAL CHARACTERISTICS, $V_{OUT} = 5.0\text{ V}$ ($-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$; $V_{IN} = 340\text{ V}$; $I_{OUT} = 100\text{ }\mu\text{A}$, $C_{IN} = 1\text{ }\mu\text{F}$, $C_{OUT} = 22\text{ }\mu\text{F}$, unless otherwise noted. Typical values are at $T_J = +25^{\circ}\text{C}$.) (Note 7)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage DC		V_{IN}	24		450	V
Output Voltage Accuracy	$T_J = 25^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $24\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	4.775	5.0	5.225	V
	$-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $24\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	4.75	5.0	5.25	V
Line Regulation	$35\text{ V} \leq V_{IN} \leq 450\text{ V}$, $I_{OUT} = 100\text{ }\mu\text{A}$	Reg_{LINE}	-0.5	0.2	+0.5	%
Load Regulation	$100\text{ }\mu\text{A} \leq I_{OUT} \leq 10\text{ mA}$, $V_{IN} = 35\text{ V}$	Reg_{LOAD}	-1.0	0.62	+1.0	%
Maximum Output Current (Note 8)	$24\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_{OUT}	12.7			mA
Quiescent Current	$I_{OUT} = 0$, $24\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_Q		15	26	μA
Ground Current (Note 8)	$24\text{ V} \leq V_{IN} \leq 450\text{ V}$ $0 < I_{OUT} \leq 10\text{ mA}$	I_{GND}			27	μA
EN Pin High Threshold EN Pin Low Threshold	V_{EN} Voltage increasing V_{EN} Voltage decreasing	V_{EN_HI} V_{EN_LO}	1.4		0.8	V
EN Pin Pull up Current (Note 9)	$V_{IN} = 450\text{ V}_{DC}$	I_{EN}		5		μA
EN Pin Voltage (Note 10)	$V_{IN} = 450\text{ V}_{DC}$	V_{EN}		3.0	3.3	V
Power Supply Rejection Ratio	$V_{IN} = 340\text{ V}_{DC} + 1\text{ V}_{pp}$ modulation, $I_{OUT} = 100\text{ }\mu\text{A}$	$f = 1\text{ kHz}$ PSRR		70		dB
Output Noise	$f = 10\text{ kHz to } 100\text{ kHz}$ $V_{IN} = 340\text{ V}_{DC}$, $I_{OUT} = 100\text{ }\mu\text{A}$	V_{NOISE}		280		μV_{rms}
Thermal Shutdown Temperature (Note 9)	Temperature increasing from $T_J = +25^{\circ}\text{C}$	T_{SD}		145		$^{\circ}\text{C}$
Thermal Shutdown Hysteresis (Note 9)	Temperature falling from T_{SD}	T_{SDH}	-	10	-	$^{\circ}\text{C}$

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.

7. 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.

8. A proper heatsinking and/or low duty cycle pulse techniques are used to operate the device within the Safe Operating Area.

9. Guaranteed by design

10. Voltage present at the EN pin in case that this pin is left floating. It is generated by the internal EN Pin Pull-up Current.

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Table 6. ELECTRICAL CHARACTERISTICS, $V_{OUT} = 12\text{ V}$ ($-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$; $V_{IN} = 340\text{ V}$; $I_{OUT} = 100\text{ }\mu\text{A}$, $C_{IN} = 1\text{ }\mu\text{F}$, $C_{OUT} = 22\text{ }\mu\text{F}$, unless otherwise noted. Typical values are at $T_J = +25^{\circ}\text{C}$.) (Note 11)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage DC		V_{IN}	35		450	V
Output Voltage Accuracy	$T_J = 25^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $35\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	11.46	12	12.54	V
	$-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $35\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	11.4	12	12.6	V
Line Regulation	$35\text{ V} \leq V_{IN} \leq 450\text{ V}$, $I_{OUT} = 100\text{ }\mu\text{A}$	Reg_{LINE}	-0.5	0.1	+0.5	%/V
Load Regulation	$100\text{ }\mu\text{A} \leq I_{OUT} \leq 10\text{ mA}$, $V_{IN} = 35\text{ V}$	Reg_{LOAD}	-1.0	0.66	+1.0	%
Maximum Output Current (Note 12)	$38\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_{OUT}	11.5			mA
Quiescent Current	$I_{OUT} = 0$, $35\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_Q		12	18	μA
Ground Current (Note 12)	$35\text{ V} \leq V_{IN} \leq 450\text{ V}$ $0 < I_{OUT} \leq 10\text{ mA}$	I_{GND}			19	μA
EN Pin High Threshold EN Pin Low Threshold	V_{EN} Voltage increasing V_{EN} Voltage decreasing	V_{EN_HI} V_{EN_LO}	1.4		0.8	V
EN Pin Pull up Current (Note 13)	$V_{IN} = 450\text{ V}_{DC}$	I_{EN}		5		μA
EN Pin Voltage (Note 14)	$V_{IN} = 450\text{ V}_{DC}$	V_{EN}		3.0	3.3	V
Power Supply Rejection Ratio	$V_{IN} = 340\text{ V}_{DC} + 1\text{ V}_{pp}$ modulation, $I_{OUT} = 100\text{ }\mu\text{A}$	$f = 1\text{ kHz}$ PSRR		70		dB
Output Noise	$f = 10\text{ kHz to } 100\text{ kHz}$ $V_{IN} = 340\text{ V}_{DC}$, $I_{OUT} = 100\text{ }\mu\text{A}$	V_{NOISE}		280		μV_{rms}
Thermal Shutdown Temperature (Note 13)	Temperature increasing from $T_J = +25^{\circ}\text{C}$	T_{SD}		145		$^{\circ}\text{C}$
Thermal Shutdown Hysteresis (Note 13)	Temperature falling from T_{SD}	T_{SDH}	-	10	-	$^{\circ}\text{C}$

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.

11. 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.

12. A proper heatsinking and/or low duty cycle pulse techniques are used to operate the device within the Safe Operating Area.

13. Guaranteed by design

14. Voltage present at the EN pin in case that this pin is left floating. It is generated by the internal EN Pin Pull-up Current.

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Table 7. ELECTRICAL CHARACTERISTICS, $V_{OUT} = 15\text{ V}$ ($-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$; $V_{IN} = 340\text{ V}$; $I_{OUT} = 100\text{ }\mu\text{A}$, $C_{IN} = 1\text{ }\mu\text{F}$, $C_{OUT} = 22\text{ }\mu\text{F}$, unless otherwise noted. Typical values are at $T_J = +25^{\circ}\text{C}$.) (Note 15)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage DC		V_{IN}	38		450	V
Output Voltage Accuracy	$T_J = 25^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $38\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	14.325	15	15.675	V
	$-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$, $I_{OUT} = 100\text{ }\mu\text{A}$, $38\text{ V} \leq V_{IN} \leq 450\text{ V}$	V_{OUT}	14.25	15	15.75	V
Line Regulation	$38\text{ V} \leq V_{IN} \leq 450\text{ V}$, $I_{OUT} = 100\text{ }\mu\text{A}$	Reg_{LINE}	-0.5	0.1	+0.5	%
Load Regulation	$100\text{ }\mu\text{A} \leq I_{OUT} \leq 10\text{ mA}$, $V_{IN} = 38\text{ V}$	Reg_{LOAD}	-1.0	0.66	+1.0	%
Maximum Output Current (Note 16)	$38\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_{OUT}	11			mA
Quiescent Current	$I_{OUT} = 0$, $38\text{ V} \leq V_{IN} \leq 450\text{ V}$	I_Q		17	27	μA
Ground Current (Note 16)	$38\text{ V} \leq V_{IN} \leq 450\text{ V}$ $0 < I_{OUT} \leq 10\text{ mA}$	I_{GND}			28	μA
EN Pin High Threshold EN Pin Low Threshold	V_{EN} Voltage increasing V_{EN} Voltage decreasing	V_{EN_HI} V_{EN_LO}	1.4		0.8	V
EN Pin Pull up Current (Note 17)	$V_{IN} = 450\text{ V}_{DC}$	I_{EN}		5		μA
EN Pin Voltage (Note 18)	$V_{IN} = 450\text{ V}_{DC}$	V_{EN}		3.0	3.3	V
Power Supply Rejection Ratio	$V_{IN} = 340\text{ V}_{DC} + 1\text{ V}_{pp}$ modulation, $I_{OUT} = 100\text{ }\mu\text{A}$	$f = 1\text{ kHz}$ PSRR		70		dB
Output Noise	$f = 10\text{ kHz to } 100\text{ kHz}$ $V_{IN} = 340\text{ V}_{DC}$, $I_{OUT} = 100\text{ }\mu\text{A}$	V_{NOISE}		280		μV_{rms}
Thermal Shutdown Temperature (Note 17)	Temperature increasing from $T_J = +25^{\circ}\text{C}$	T_{SD}		145		$^{\circ}\text{C}$
Thermal Shutdown Hysteresis (Note 17)	Temperature falling from T_{SD}	T_{SDH}	-	10	-	$^{\circ}\text{C}$

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.

15. 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.

16. A proper heatsinking and/or low duty cycle pulse techniques are used to operate the device within the Safe Operating Area.

17. Guaranteed by design

18. Voltage present at the EN pin in case that this pin is left floating. It is generated by the internal EN Pin Pull-up Current.

APPLICATION INFORMATION

The typical application circuit for the NCP785B device is shown below.

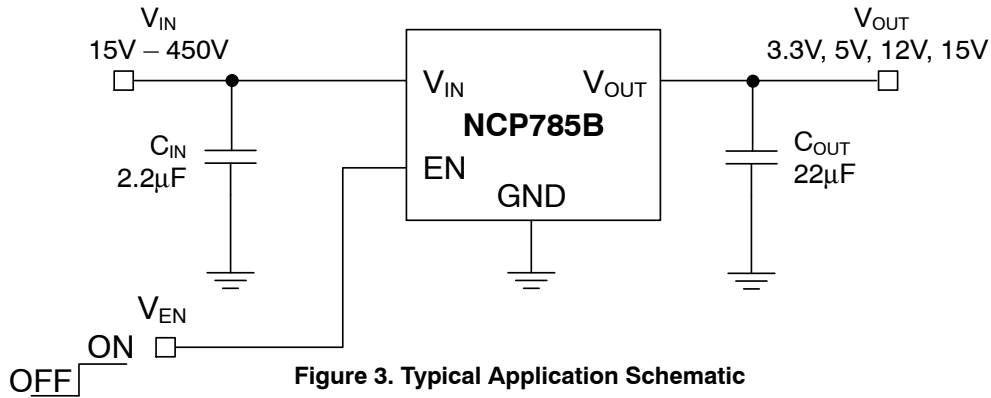


Figure 3. Typical Application Schematic

Input Decoupling (C1)

A 1 µF capacitor either ceramic or electrolytic is recommended and should be connected close to the input pin of NCP785B. Higher value 2.2 µF is necessary to keep the input voltage above the required minimum input voltage at full load for AC voltage as low as 85 V with half wave rectifier.

Output Decoupling (C2)

The NCP785B Regulator does not require any specific Equivalent Series Resistance (ESR). Thus capacitors exhibiting ESRs ranging from a few mΩ up to 0.5 Ω can be used safely. The minimum decoupling value is 22 µF. The regulator accepts ceramic chip capacitors as well as tantalum devices or low ESR electrolytic capacitors. Larger values improve noise rejection and load transient response.

Layout Recommendations

Please be sure that the VIN and GND lines are sufficiently wide. When the impedance of these lines is high, there is a chance to pick up noise or to cause the malfunction of regulator.

Set external components, especially the output capacitor, as close as possible to the circuit, and make leads as short as possible.

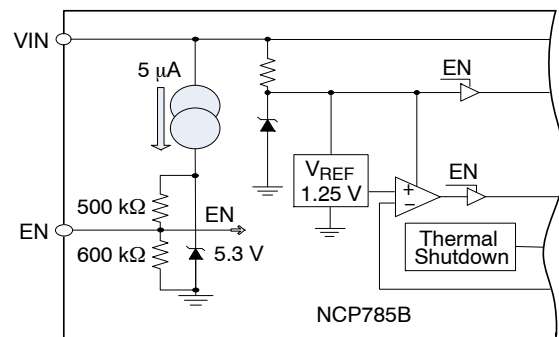
Thermal

As power across the NCP785B increases, it might become necessary to provide some thermal relief. The maximum power dissipation supported by the device is dependent

upon board design layout and used package. 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 NCP785B has good thermal conductivity through the PCB, the junction temperature will be relatively low with high power dissipation applications.

ENABLE Operation

The enable pin EN of the NCP785B will turn on or off the regulator's output. The threshold limits are covered in the electrical specification section of this data sheet. If the enable function is not used then the EN pin should be left disconnected. An internal current source pulls this pin high to a voltage given by the internal resistor divider. The limit of this voltage is mentioned in the electrical specification section of this data sheet. Maximum applicable external voltage at this pin from external source is limited to 5.0 V.



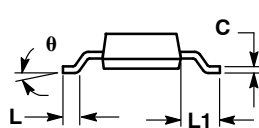
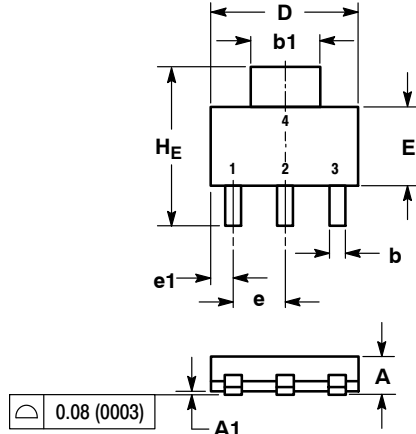
ORDERING INFORMATION:

Part Number	Output Voltage	Case	Package	Marking	Shipping	Released PN	Marking
NCP785BST33T3G	3.3 V	TBD	SOT223-4	HVH	TBD	PCP785BST33T3G	XAH
NCP785BST50T3G	5 V	TBD	SOT223-4	HVJ	TBD	PCP785BST50T3G	XAJ
NCP785BST120T3G	12 V	TBD	SOT223-4	HVK	TBD	PCP785BST120T3G	XAK
NCP785BST150T3G	15 V	TBD	SOT223-4	HVL	TBD	PCP785BST150T3G	XAL

NCP785B

PACKAGE DIMENSIONS

SOT-223 (TO-261)
CASE 318E-04
ISSUE N

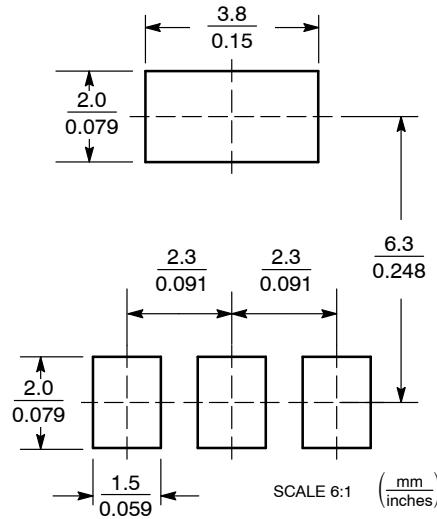


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCH.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.50	1.63	1.75	0.060	0.064	0.068
A1	0.02	0.06	0.10	0.001	0.002	0.004
b	0.60	0.75	0.89	0.024	0.030	0.035
b1	2.90	3.06	3.20	0.115	0.121	0.126
c	0.24	0.29	0.35	0.009	0.012	0.014
D	6.30	6.50	6.70	0.249	0.256	0.263
E	3.30	3.50	3.70	0.130	0.138	0.145
e	2.20	2.30	2.40	0.087	0.091	0.094
e1	0.85	0.94	1.05	0.033	0.037	0.041
L	0.20	---	---	0.008	---	---
L1	1.50	1.75	2.00	0.060	0.069	0.078
H_E	6.70	7.00	7.30	0.264	0.276	0.287
θ	0°	---	10°	0°	---	10°

STYLE 11:
PIN 1. MT 1
2. MT 2
3. GATE
4. MT 2

SOLDERING FOOTPRINT



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