

# NCP785

## Product Preview

# Wide Input Voltage Range 5 mA Ultra-Low Iq, High PSRR Linear Regulator

The NCP785 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 5 mA.

Ideal for high input voltage applications such as industrial and home metering, home appliances. The NCP785 family offers  $\pm 5\%$  initial accuracy, extremely high-power supply rejection ratio and ultra-low quiescent current. The NCP785 family is optimized for high-voltage line and load transients, making them ideal for harsh environment applications.

The NCP785 is offered in fixed output voltage options 3.3 V and 5.0 V.

SOT-223 and SOT-89 packages offer good thermal performance and help 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  $\mu\text{F}$  capacitor)
- 5 mA Guaranteed Output Current
- Ultra Low Quiescent Current: Typ. 6  $\mu\text{A}$  ( $V_{\text{OUT}} \leq 5 \text{ V}$ )
- $\pm 5\%$  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  $\mu\text{F}$  MLCC
- Thermal Shutdown and Current Limit Protection
- Available in Thermally Enhanced SOT89-3, SOT-223 Packages
- This is a Pb-Free Device

### Typical Applications

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

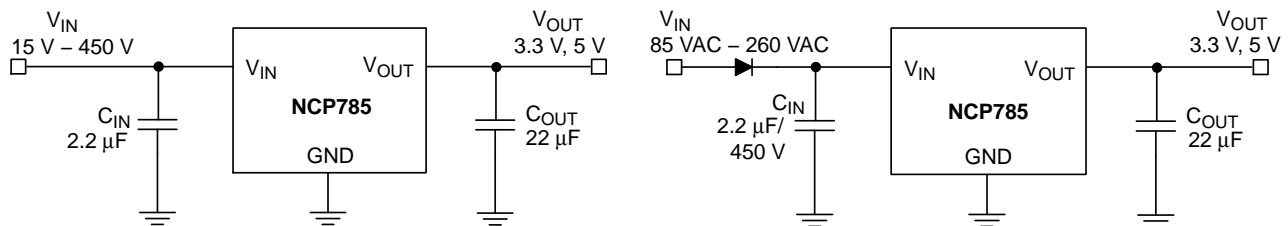


Figure 1. Typical Applications

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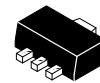
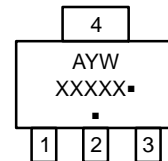
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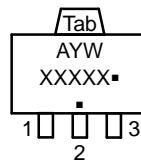
### MARKING DIAGRAMS



SOT-223  
S SUFFIX  
CASE 318E



SOT-89  
H SUFFIX  
CASE 1213



(Top Views)

(Tab is connected to Pin 2)

- 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 4 of this data sheet.

# NCP785

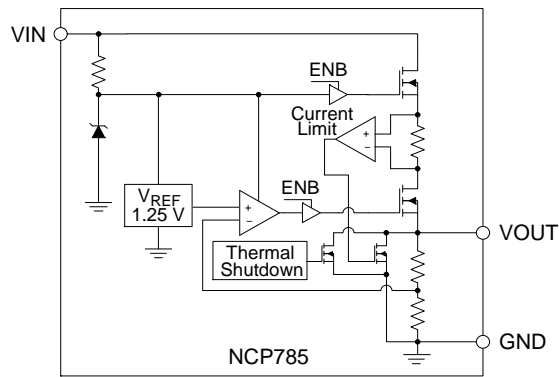


Figure 2. Simplified Internal Block Diagram

Table 1. PIN FUNCTION DESCRIPTION

Pin No. (SOT-223)	Pin No. (SOT89-3)	Pin Name	Description
1	1	VIN	Supply Voltage Input. Connect 2.2 $\mu$ F capacitor from VIN to GND.
2	-	NC	This pin is not internally connected to the IC
3	3	VOUT	Regulator Output. Connect 22 $\mu$ F or larger MLCC capacitor from VOUT to GND.
4	2,4	GND	Ground connection.

Table 2. PIN ASSIGNMENT

Pin No:	SOT223	SOT89-3
1	VIN	VIN
2	N/C	GND
3	VOUT	VOUT
4	GND	-
Tab	It is recommended that the Tab is connected to the ground plane on the PCB or otherwise is left open.	GND

Table 3. 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
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.

- Peak 650 V max 1 ms non repeated for 1 s
- 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 4. THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, SOT-223 Thermal Resistance, Junction-to-Air	$R_{\theta JA}$	73	$^{\circ}$ C/W
Thermal Characteristics, SOT89-3 Thermal Resistance, Junction-to-Air	$R_{\theta JA}$	79	$^{\circ}$ C/W

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**Table 5. ELECTRICAL CHARACTERISTICS,  $V_{OUT} = 3.3\text{ V}$**  ( $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$ ;  $V_{IN} = 340\text{ V}$ ;  $I_{OUT} = 100\ \mu\text{A}$ ,  $C_{IN} = 1\ \mu\text{F}$ ,  $C_{OUT} = 22\ \mu\text{F}$ , 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		$V_{IN}$	14		450	V
Output Voltage Accuracy	$T_J = 25^{\circ}\text{C}$ , $I_{OUT} = 100\ \mu\text{A}$ , $14\text{ V} \leq V_{IN} \leq 450\text{ V}$	$V_{OUT}$	3.1515	3.3	3.4485	V
	$-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$ , $I_{OUT} = 100\ \mu\text{A}$ , $14\text{ V} \leq V_{IN} \leq 450\text{ V}$	$V_{OUT}$	3.135	3.3	3.465	V
Line Regulation	$14\text{ V} \leq V_{IN} \leq 450\text{ V}$ , $I_{OUT} = 100\ \mu\text{A}$	$\text{Reg}_{LINE}$	-0.5	0.2	+0.5	%
Load Regulation	$100\ \mu\text{A} \leq I_{OUT} \leq 6\text{ mA}$ , $V_{IN} = 14\text{ V}$	$\text{Reg}_{LOAD}$	-0.5	0.37	+0.5	%
Maximum Output Current (Note 4)	$14\text{ V} \leq V_{IN} \leq 450\text{ V}$	$I_{OUT}$	6.8			mA
Quiescent Current	$I_{OUT} = 0$ , $14\text{ V} \leq V_{IN} \leq 450\text{ V}$	$I_Q$		5.7	8.4	$\mu\text{A}$
Ground Current (Note 4)	$14\text{ V} \leq V_{IN} \leq 450\text{ V}$ $0 < I_{OUT} \leq 5\text{ mA}$	$I_{GND}$			8.5	$\mu\text{A}$
Power Supply Rejection Ratio	$V_{IN} = 340\text{ V}_{DC} + 1\text{ V}_{pp}$ modulation, $I_{OUT} = 100\ \mu\text{A}$	$f = 1\text{ kHz}$ $\text{PSRR}$		70		dB
Noise	$f = 10\text{ kHz}$ to $100\text{ kHz}$ $V_{IN} = 340\text{ V}_{DC}$ , $I_{OUT} = 100\ \mu\text{A}$	$V_{NOISE}$		280		$\mu\text{V}_{rms}$
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	-	$^{\circ}\text{C}$

**Table 6. ELECTRICAL CHARACTERISTICS,  $V_{OUT} = 5.0\text{ V}$**  ( $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$ ;  $V_{IN} = 340\text{ V}$ ;  $I_{OUT} = 100\ \mu\text{A}$ ,  $C_{IN} = 1\ \mu\text{F}$ ,  $C_{OUT} = 22\ \mu\text{F}$ , 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		$V_{IN}$	16		450	V
Output Voltage Accuracy	$T_J = 25^{\circ}\text{C}$ , $I_{OUT} = 100\ \mu\text{A}$ , $16\text{ V} \leq V_{IN} \leq 450\text{ V}$	$V_{OUT}$	4.775	5.0	5.225	V
	$-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$ , $I_{OUT} = 100\ \mu\text{A}$ , $16\text{ V} \leq V_{IN} \leq 450\text{ V}$	$V_{OUT}$	4.75	5.0	5.25	V
Line Regulation	$16\text{ V} \leq V_{IN} \leq 450\text{ V}$ , $I_{OUT} = 100\ \mu\text{A}$	$\text{Reg}_{LINE}$	-0.5	0.2	+0.5	%
Load Regulation	$100\ \mu\text{A} \leq I_{OUT} \leq 3.3\text{ mA}$ , $V_{IN} = 16\text{ V}$	$\text{Reg}_{LOAD}$	-0.5	0.38	+0.5	%
Maximum Output Current (Note 4)	$16\text{ V} \leq V_{IN} \leq 450\text{ V}$	$I_{OUT}$	3.3			mA
Quiescent Current	$I_{OUT} = 0$ , $16\text{ V} \leq V_{IN} \leq 450\text{ V}$	$I_Q$		5.7	8.4	$\mu\text{A}$
Ground Current (Note 4)	$16\text{ V} \leq V_{IN} \leq 450\text{ V}$ $0 < I_{OUT} \leq 3.3\text{ mA}$	$I_{GND}$			8.5	$\mu\text{A}$
Power Supply Rejection Ratio	$V_{IN} = 340\text{ V}_{DC} + 1\text{ V}_{pp}$ modulation, $I_{OUT} = 100\ \mu\text{A}$	$f = 1\text{ kHz}$ $\text{PSRR}$		70		dB
Noise	$f = 10\text{ kHz}$ to $100\text{ kHz}$ $V_{IN} = 340\text{ V}_{DC}$ , $I_{OUT} = 100\ \mu\text{A}$	$V_{NOISE}$		280		$\mu\text{V}_{rms}$
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	-	$^{\circ}\text{C}$

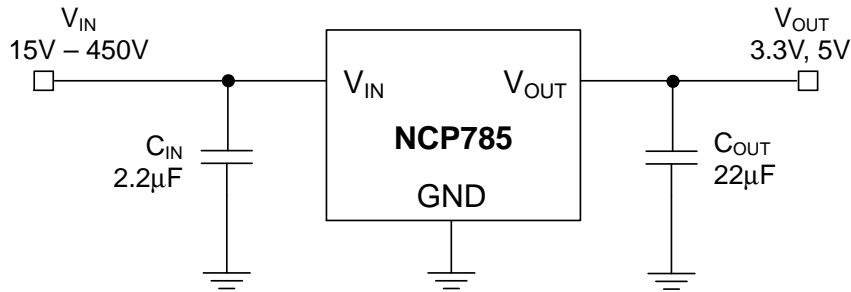
Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

3. 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.
4. A proper heatsinking and/or low duty cycle pulse techniques are used to operate the device within the Safe Operating Area.
5. Guaranteed by design

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## APPLICATION INFORMATION

The typical application circuit for the NCP785 device is shown below.



### Input Decoupling (C1)

A 1  $\mu\text{F}$  capacitor either ceramic or electrolytic is recommended and should be connected close to the input pin of NCP785. Higher value 2.2  $\mu\text{F}$  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 NCP785 is a stable Regulator and does not require any specific Equivalent Series Resistance (ESR). Thus capacitors exhibiting ESRs ranging from a few  $\text{m}\Omega$  up to 0.5  $\Omega$  can be used safely. The minimum decoupling value is 22  $\mu\text{F}$ . 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 the  $V_{\text{IN}}$  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 NCP785 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 NCP785 has good thermal conductivity through the PCB, the junction temperature will be relatively low with high power dissipation applications.

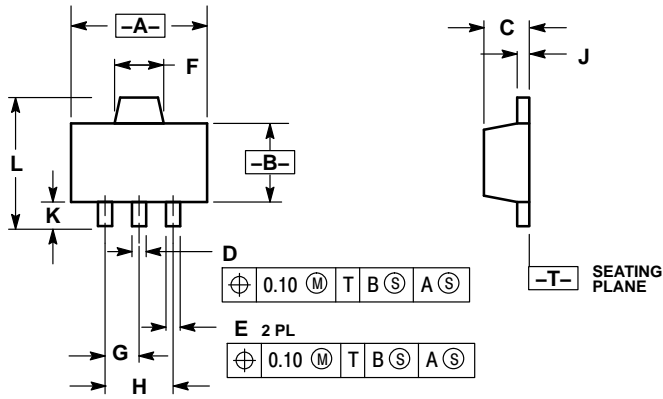
### ORDERING INFORMATION:

Part Number	Output Voltage	Case	Package	Marking	Shipping
NCP785H33T1G	3.3 V	TBD	SOT89-3	TBD	
NCP785H50T1G	5 V	TBD	SOT89-3	TBD	
NCP785ST33T3G	3.3 V	TBD	SOT223-4	HVA	
NCP785ST50T3G	5 V	TBD	SOT223-4	HVC	

# NCP785

## PACKAGE DIMENSIONS

### SOT-89 (3-LEAD) CASE 1213-02 ISSUE C



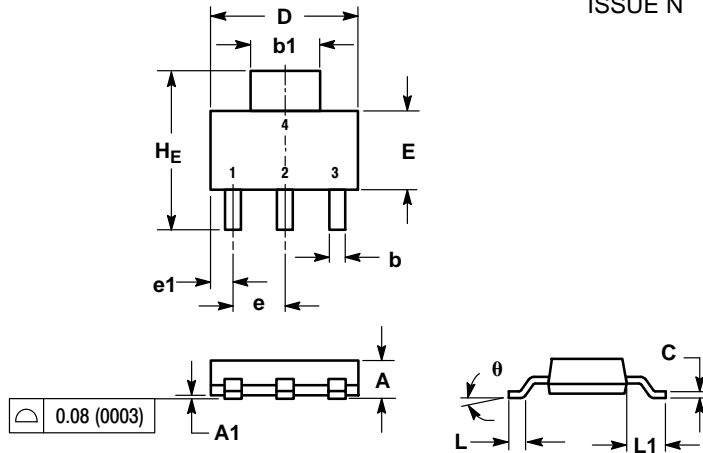
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETERS
  3. 1213-01 OBSOLETE, NEW STANDARD 1213-02.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.40	4.60	0.173	0.181
B	2.40	2.60	0.094	0.102
C	1.40	1.60	0.055	0.063
D	0.37	0.57	0.015	0.022
E	0.32	0.52	0.013	0.020
F	1.50	1.83	0.059	0.072
G	1.50 BSC		0.059 BSC	
H	3.00 BSC		0.118 BSC	
J	0.30	0.50	0.012	0.020
K	0.80	---	0.031	---
L	---	4.25	---	0.167

# NCP785

## PACKAGE DIMENSIONS

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

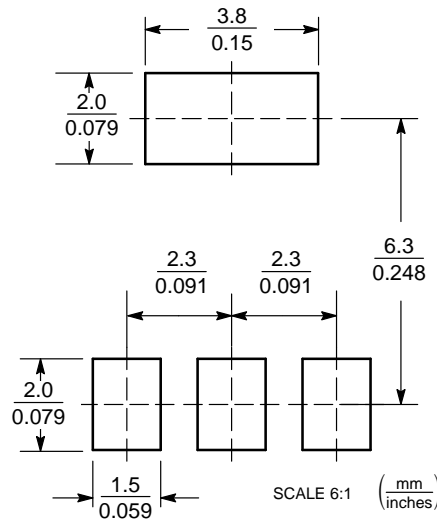


NOTES:  
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.  
2. CONTROLLING DIMENSION: INCH.

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
HE	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

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