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Wide Input Voltage Low Dropout, Ultra-Low Iq Regulator

NCP716BC

The NCP716BC is 150 mA LDO Linear Voltage Regulator. It is a very stable and accurate device with ultra−low ground current consumption (4.7 μA over the full output load range) and a wide input voltage range (up to 24 V). The regulator incorporates several protection features such as Thermal Shutdown and Current Limiting.

Features
- Operating Input Voltage Range: 2.5 V to 24 V
- Fixed Voltage Options Available:
  3.0 V, 3.3 V, 3.45 V and 5.0 V
- Ultra Low Quiescent Current: Max. 4.7 μA over Temperature
- ±2% Accuracy over Full Temperature Range
- Noise: 115 μV_{RMS} from 200 Hz to 100 kHz
- Thermal Shutdown and Current Limit Protection
- Available in TSOP−5 Package
- This is a Pb−Free Device

Typical Applications
- Portable Equipment
- Communication Systems
- Industrial Measurement Systems
- Home Automation Devices

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MARKING DIAGRAM

TSOP−5
CASE 483

XXXAYW■
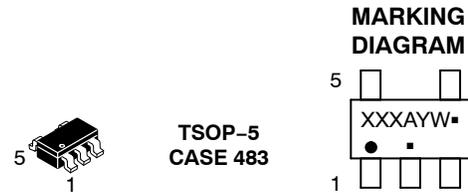
XXX = Specific Device Code
A   = Assembly Location
Y   = Year
W   = Work Week
■   = Pb−Free Package

(Note: Microdot may be in either location)

PIN CONNECTIONS

GND — 1
IN
OUT

N/C — 5
N/C

TSOP−5
(Top View)
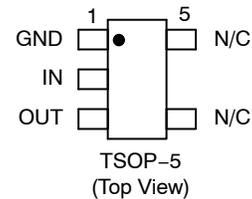
ORDERING INFORMATION

See detailed ordering, marking and shipping information in the package dimensions section on page 8 of this data sheet.

Figure 1. Typical Application Schematic

NCP716BC

Figure 2. Simplified Block Diagram

Table 1. PIN FUNCTION DESCRIPTION

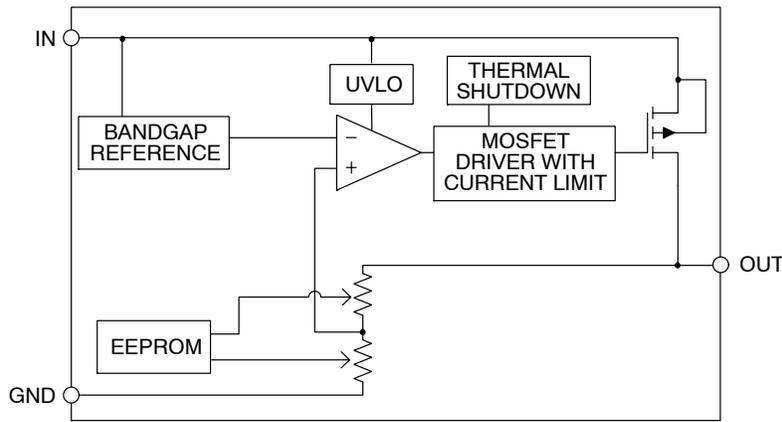| Pin No.	Pin Name	Description
3	OUT	Regulated output voltage pin. A small 1.0 μF ceramic capacitor is needed from this pin to ground to assure stability.
1	GND	Power supply ground.
2	IN	Input pin. A small 1.0 μF ceramic capacitor is needed from this pin to ground to assure stability.
4	N/C	This pin can be tied to ground to improve thermal dissipation or left disconnected.
5	N/C	This pin can be tied to ground to improve thermal dissipation or left disconnected.

Table 2. ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage (Note 1)	V_{IN}	−0.3 to 24	V
Output Voltage	V_{OUT}	−0.3 to 6	V
Output Short Circuit Duration	t_{SC}	Indefinite	s
Maximum Junction Temperature	$T_{J(MAX)}$	150	°C
Storage Temperature	T_{STG}	−55 to 150	°C
ESD Capability, Human Body Model (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. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
2. This device series incorporates ESD protection and is tested by the following methods:
    ESD Human Body Model tested per EIA/JESD22−A114
    ESD Machine Model tested per EIA/JESD22−A115
    ESD Charged Device Model tested per EIA/JESD22−C101E
    Latchup Current Maximum Rating tested per JEDEC standard: JESD78.

Table 3. THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Characteristics, TSOP−5 Thermal Resistance, Junction−to−Air	$R_{\theta JA}$	250	°C/W

Table 4. ELECTRICAL CHARACTERISTICS Voltage version 3.0 V

−40°C ≤ T_J ≤ 125°C; V_{IN} = 4.0 V; I_{OUT} = 1 mA, C_{IN} = C_{OUT} = 1.0 μF, unless otherwise noted. Typical values are at T_J = +25°C. (Note 5)

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
Operating Input Voltage			V_{IN}	2.5		24	V
Output Voltage Accuracy	−40°C ≤ T_J ≤ 125°C		V_{OUT}	2.94	3.0	3.06	V
Line Regulation	V_{OUT} + 1 V ≤ V_{IN} ≤ 24 V, I_{OUT} = 0.1 mA		Reg_{LINE}		4	20	mV
Load Regulation	I_{OUT} = 0.1 mA to 150 mA		Reg_{LOAD}		0.0013	0.008	%/mA
Dropout Voltage (Note 3)	V_{OUT} = 0.97 $V_{OUT(NOM)}$, I_{OUT} = 150 mA		V_{DO}		700	1100	mV
Maximum Output Current	(Note 6)		I_{OUT}	150			mA
Ground Current	I_{OUT} = 0 mA, −40 < T_A < 125°C		I_{GND}		3.2	4.7	μA
Power Supply Rejection Ratio	V_{IN} = 4.0 V + 200 mVpp modulation I_{OUT} = 1 mA, C_{OUT} =10 μF	f = 1 kHz	PSRR		55		dB
Output Noise Voltage	V_{OUT} = 3.0 V, I_{OUT} = 150 mA f = 100 Hz to 100 kHz		V_{NOISE}		80		μV$_{rms}$
Thermal Shutdown Temperature (Note 4)	Temperature increasing from T_J = +25°C		T_{SD}		180		°C
Thermal Shutdown Hysteresis (Note 4)	Temperature falling from T_{SD}		T_{SDH}	−	10	−	°C

3. Characterized when V_{OUT} falls 3% below the nominal V_{OUT} = 3.0 V
4. Guaranteed by design and characterization.
5. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at T_J = T_A = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
6. Please follow the Safe Operating Area.

Table 5. ELECTRICAL CHARACTERISTICS Voltage version 3.3 V

−40°C ≤ T_J ≤ 125°C; V_{IN} = 4.3 V; I_{OUT} = 1 mA, C_{IN} = C_{OUT} = 1.0 μF, unless otherwise noted. Typical values are at T_J = +25°C. (Note 9)

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
Operating Input Voltage			V_{IN}	2.5		24	V
Output Voltage Accuracy	−40°C ≤ T_J ≤ 125°C		V_{OUT}	3.234	3.30	3.366	V
Line Regulation	V_{OUT} + 1 V ≤ V_{IN} ≤ 24 V, I_{OUT} = 0.1 mA		Reg_{LINE}		4	20	mV
Load Regulation	I_{OUT} = 0.1 mA to 150 mA		Reg_{LOAD}		0.0013	0.008	%/mA
Dropout Voltage (Note 7)	V_{OUT} = 0.97 $V_{OUT(NOM)}$, I_{OUT} = 150 mA		V_{DO}		685	1080	mV
Maximum Output Current	(Note 10)		I_{OUT}	150			mA
Ground Current	I_{OUT} = 0 mA, −40 < T_A < 125°C		I_{GND}		3.2	4.7	μA
Power Supply Rejection Ratio	V_{IN} = 4.3 V + 200 mVpp modulation I_{OUT} = 1 mA, C_{OUT} =10 μF	f = 1 kHz	PSRR		54		dB
Output Noise Voltage	V_{OUT} = 3.3 V, I_{OUT} = 150 mA f = 100 Hz to 100 kHz		V_{NOISE}		86		μV$_{rms}$
Thermal Shutdown Temperature (Note 8)	Temperature increasing from T_J = +25°C		T_{SD}		180		°C
Thermal Shutdown Hysteresis (Note 8)	Temperature falling from T_{SD}		T_{SDH}	−	10	−	°C

7. Characterized when V_{OUT} falls 3% below the nominal V_{OUT} = 3.3 V
8. Guaranteed by design and characterization.
9. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at T_J = T_A = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
10. Please follow the Safe Operating Area.

Table 6. ELECTRICAL CHARACTERISTICS Voltage version 3.45 V

$-40°C \leq T_J \leq 125°C$; V_{IN} = 4.45 V; I_{OUT} = 1 mA, C_{IN} = C_{OUT} = 1.0 μF, unless otherwise noted. Typical values are at T_J = +25°C. (Note 13)

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
Operating Input Voltage			V_{IN}	2.5		24	V
Output Voltage Accuracy	$-40°C \leq T_J \leq 125°C$		V_{OUT}	3.381	3.45	3.519	V
Line Regulation	V_{OUT} + 1 V $\leq V_{IN} \leq$ 24 V, I_{OUT} = 0.1 mA		Reg_{LINE}		4	20	mV
Load Regulation	I_{OUT} = 0.1 mA to 150 mA		Reg_{LOAD}		0.0013	0.008	%/mA
Dropout Voltage (Note 11)	V_{OUT} = 0.97 $V_{OUT(NOM)}$, I_{OUT} = 150 mA		V_{DO}		680	1070	mV
Maximum Output Current	(Note 14)		I_{OUT}	150			mA
Ground Current	I_{OUT} = 0 mA, $-40 < T_A < 125°C$		I_{GND}		3.2	4.7	μA
Power Supply Rejection Ratio	V_{IN} = 4.45 V + 200 mVpp modulation I_{OUT} = 1 mA, C_{OUT} =10 μF	f = 1 kHz	PSRR		54		dB
Output Noise Voltage	V_{OUT} = 4.45 V, I_{OUT} = 150 mA f = 100 Hz to 100 kHz		V_{NOISE}		88		μV$_{rms}$
Thermal Shutdown Temperature (Note 12)	Temperature increasing from T_J = +25°C		T_{SD}		180		°C
Thermal Shutdown Hysteresis (Note 12)	Temperature falling from T_{SD}		T_{SDH}	–	10	–	°C

11. Characterized when V_{OUT} falls 3% below the nominal V_{OUT} = 3.45 V
12. Guaranteed by design and characterization.
13. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at $T_J = T_A$ = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
14. Please follow the Safe Operating Area.

Table 7. ELECTRICAL CHARACTERISTICS Voltage version 5.0 V

$-40°C \leq T_J \leq 125°C$; V_{IN} = 6.0 V; I_{OUT} = 1 mA, C_{IN} = C_{OUT} = 1.0 μF, unless otherwise noted. Typical values are at T_J = +25°C. (Note 17)

Parameter	Test Conditions		Symbol	Min	Typ	Max	Unit
Operating Input Voltage			V_{IN}	2.5		24	V
Output Voltage Accuracy	$-40°C \leq T_J \leq 125°C$		V_{OUT}	4.90	5.0	5.10	V
Line Regulation	V_{OUT} + 1 V $\leq V_{IN} \leq$ 24 V, I_{OUT} = 0.1 mA		Reg_{LINE}		4	20	mV
Load Regulation	I_{OUT} = 0.1 mA to 150 mA		Reg_{LOAD}		0.0013	0.008	%/mA
Dropout Voltage (Note 15)	V_{OUT} = 0.97 $V_{OUT(NOM)}$, I_{OUT} = 150 mA		V_{DO}		600	955	mV
Maximum Output Current	(Note 18)		I_{OUT}	150			mA
Ground Current	I_{OUT} = 0 mA, $-40 < T_A < 125°C$		I_{GND}		3.2	4.7	μA
Power Supply Rejection Ratio	V_{IN} = 6.0 V + 200 mVpp modulation I_{OUT} = 1 mA, C_{OUT} =10 μF	f = 1 kHz	PSRR		53		dB
Output Noise Voltage	V_{OUT} = 5.0 V, I_{OUT} = 150 mA f = 100 Hz to 100 kHz		V_{NOISE}		115		μV$_{rms}$
Thermal Shutdown Temperature (Note 16)	Temperature increasing from T_J = +25°C		T_{SD}		180		°C
Thermal Shutdown Hysteresis (Note 16)	Temperature falling from T_{SD}		T_{SDH}	–	10	–	°C

15. Characterized when V_{OUT} falls 3% below the nominal V_{OUT} = 5.0 V
16. Guaranteed by design and characterization.
17. Performance guaranteed over the indicated operating temperature range by design and/or characterization production tested at $T_J = T_A$ = 25°C. Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
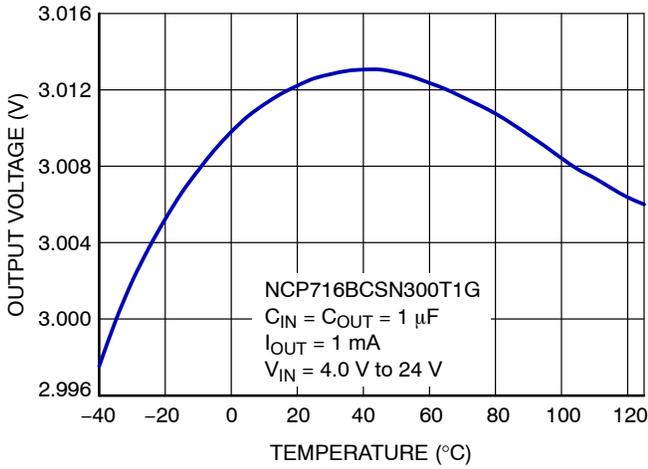18. Please follow the Safe Operating Area.

TYPICAL CHARACTERISTICS

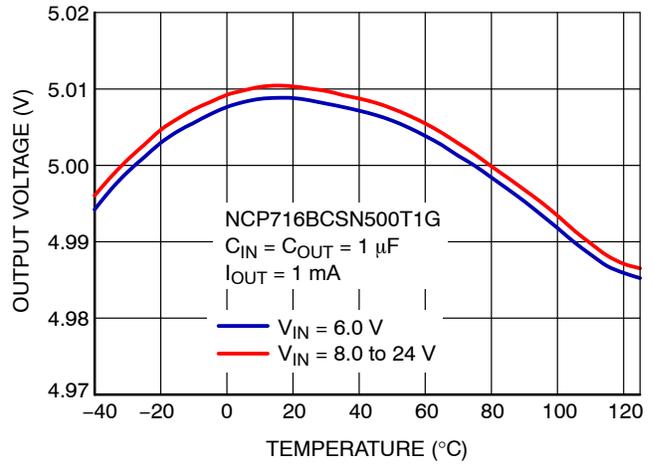Figure 3. Output Voltage vs. Temperature
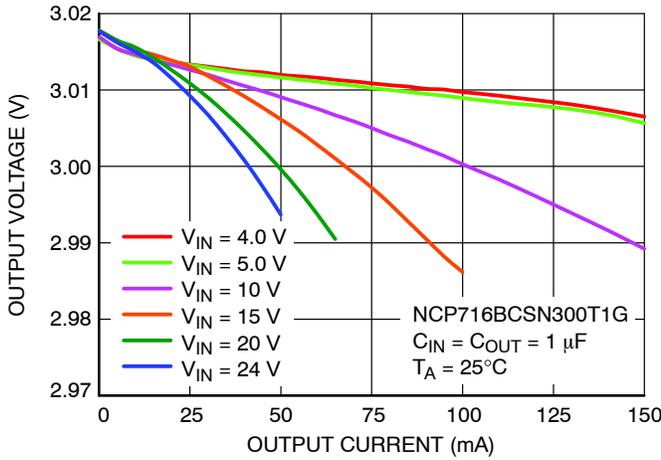
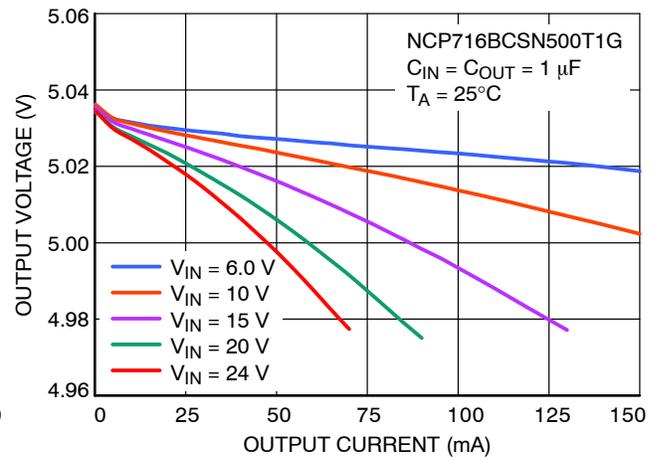Figure 4. Output Voltage vs. Temperature

Figure 5. Output Voltage vs. Output Current
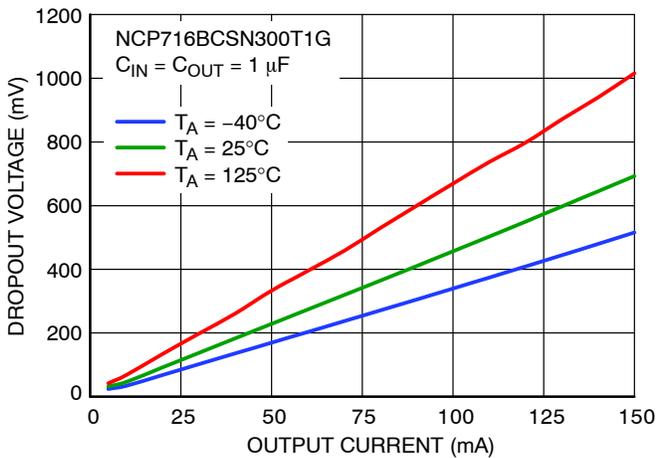
Figure 6. Output Voltage vs. Output Current
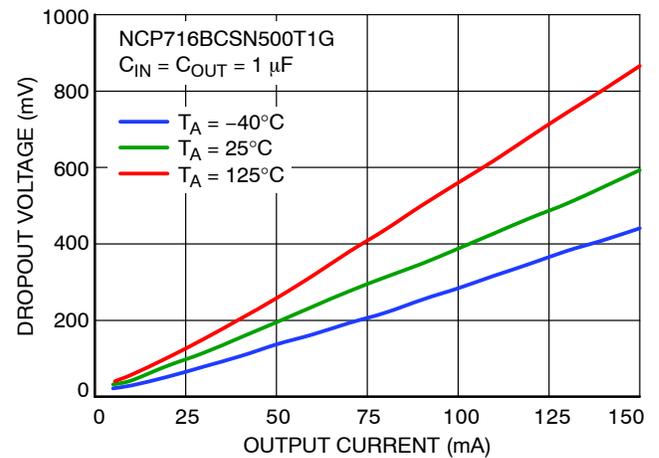
Figure 7. Dropout Voltage vs. Output Current

Figure 8. Dropout Voltage vs. Output Current

TYPICAL CHARACTERISTICS

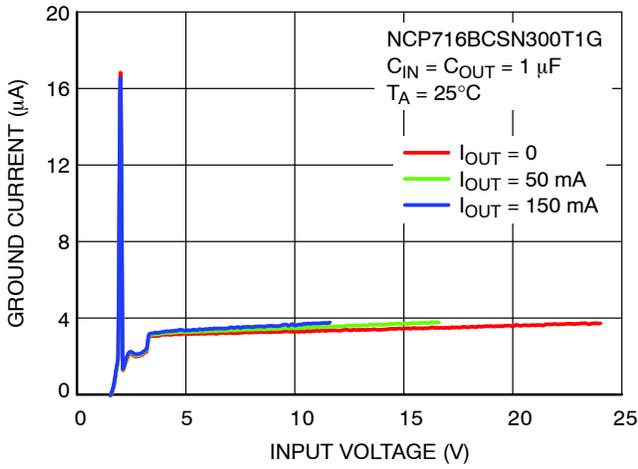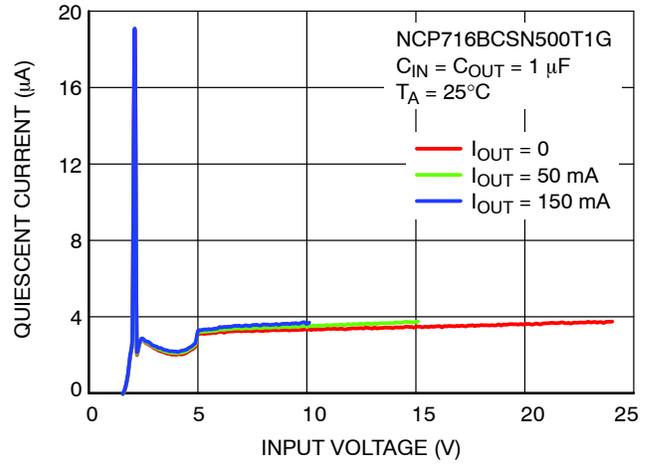**Figure 9. Ground Current vs. Input Voltage**
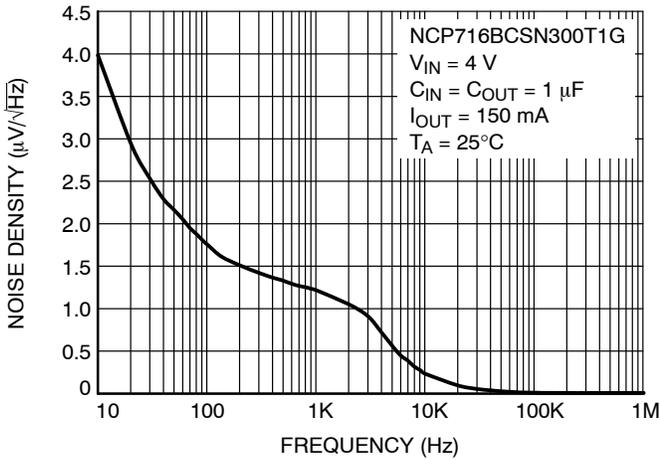

Figure 10. Ground Current vs. Input Voltage

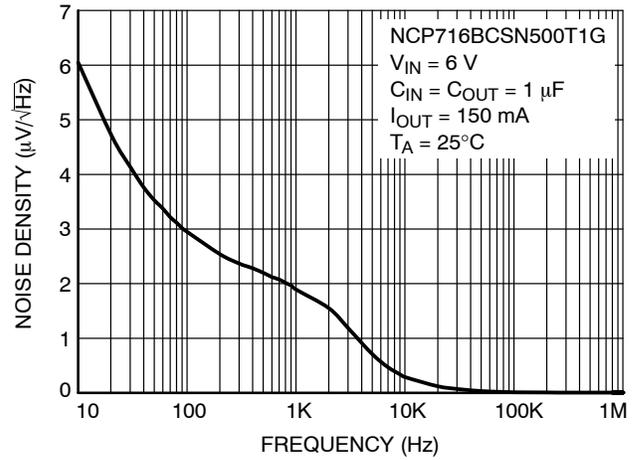**Figure 11. Spectral Noise Density vs. Frequency**
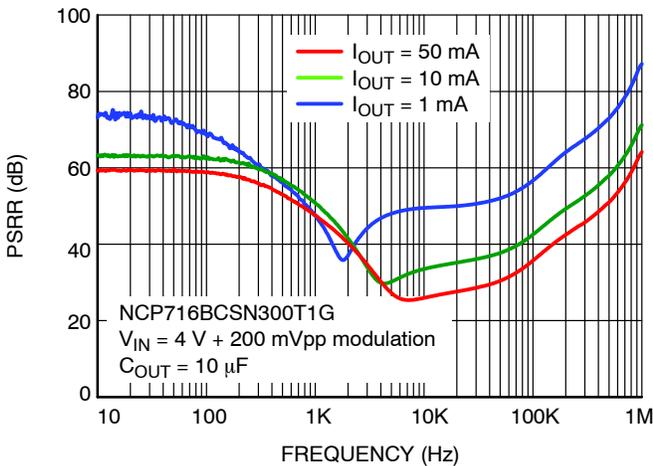

Figure 12. Spectral Noise Density vs. Frequency
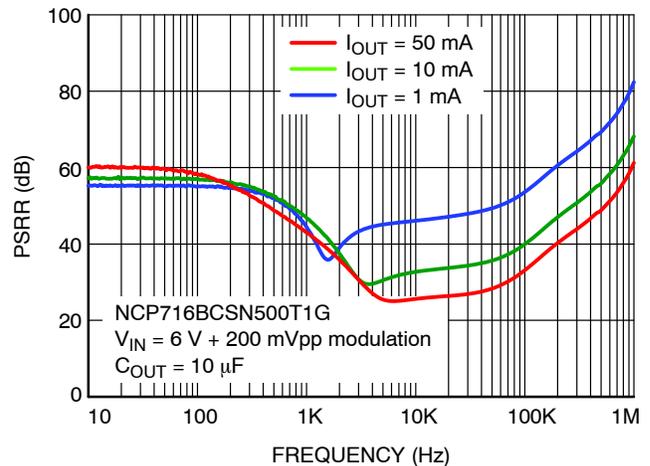

Figure 13. PSRR vs. Frequency

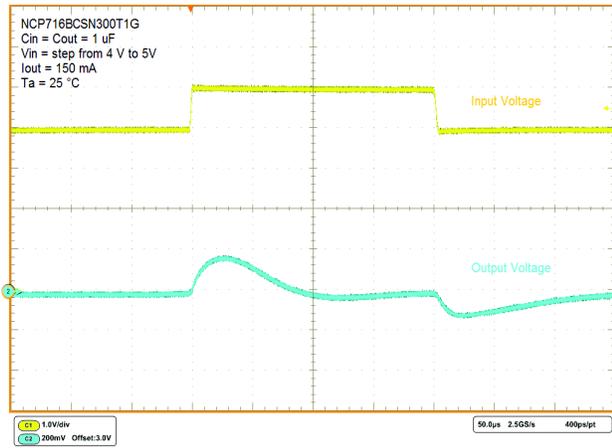**Figure 14. PSRR vs. Frequency**

TYPICAL CHARACTERISTICS

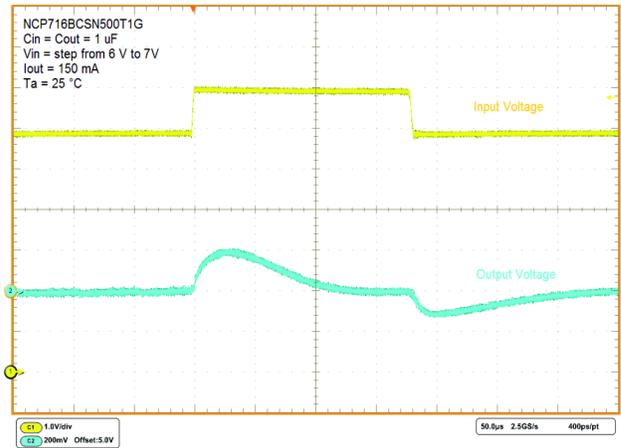Figure 15. Line Transient Response

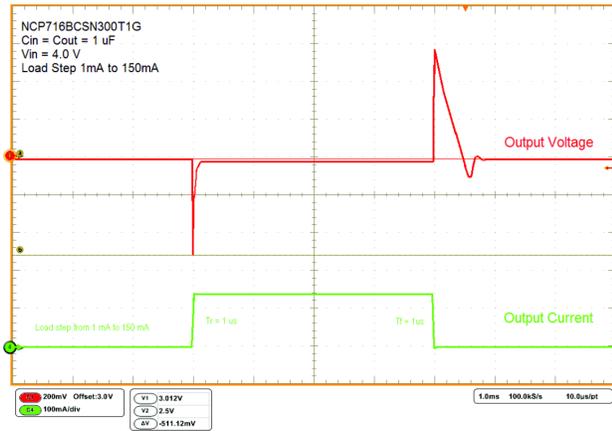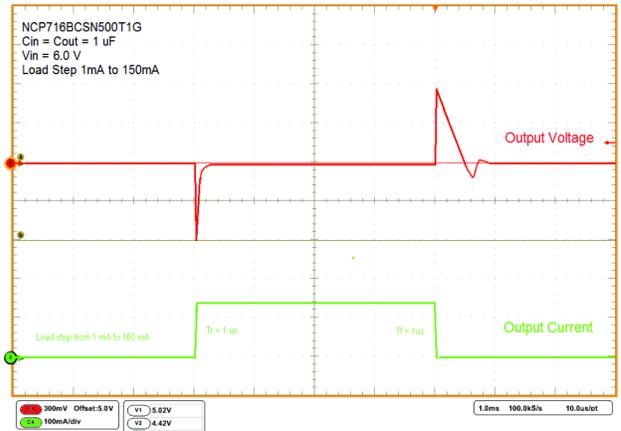Figure 16. Line Transient Response

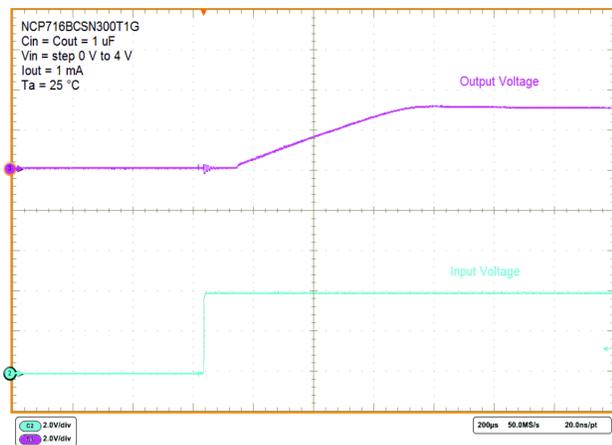Figure 17. Load Transient Response

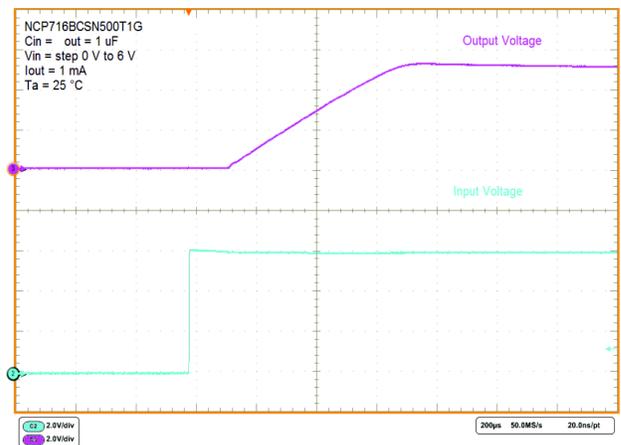Figure 18. Load Transient Response

Figure 19. Turn−On Response

Figure 20. Turn−On Response

APPLICATIONS INFORMATION

The NCP716BC is the member of new family of Wide Input Voltage Range Low Dropout Regulators which delivers Ultra Low Ground Current consumption, Good Noise and Power Supply Rejection Ratio Performance.

Input Decoupling (C_IN)

It is recommended to connect at least $1.0 \, \mu F$ Ceramic X5R or X7R capacitor between IN and GND pin of the device. This capacitor will provide a low impedance path for any unwanted AC signals or Noise superimposed onto constant Input Voltage. The good input capacitor will limit the influence of input trace inductances and source resistance during sudden load current changes.

Higher capacitance and lower ESR Capacitors will improve the overall line transient response.

Output Decoupling (C_OUT)

The NCP716BC does not require a minimum Equivalent Series Resistance (ESR) for the output capacitor. The device is designed to be stable with standard ceramics capacitors with values of $1.0 \, \mu F$ or greater up to $10 \, \mu F$. The X5R and X7R types have the lowest capacitance variations over temperature thus they are recommended.

Power Dissipation and Heat sinking

The maximum power dissipation supported by the device is dependent upon board design and layout. Mounting pad configuration on the PCB, the board material, and the ambient temperature affect the rate of junction temperature rise for the part. The maximum power dissipation the NCP716BC can handle is given by:

$$P_{D(MAX)} = \frac{\left[T_{J(MAX)} - T_A\right]}{R_{\theta JA}} \qquad \text{(eq. 1)}$$

The power dissipated by the NCP716BC for given application conditions can be calculated from the following equations:

$$P_D \approx V_{IN}\left(I_{GND}(I_{OUT})\right) + I_{OUT}\left(V_{IN} - V_{OUT}\right) \quad \text{(eq. 2)}$$

or

$$V_{IN(MAX)} \approx \frac{P_{D(MAX)} + \left(V_{OUT} \times I_{OUT}\right)}{I_{OUT} + I_{GND}} \qquad \text{(eq. 3)}$$

For reliable operation, junction temperature should be limited to $+125°C$ maximum.

Hints

V_{IN} and GND printed circuit board traces should be as wide as possible. When the impedance of these traces is high, there is a chance to pick up noise or cause the regulator to malfunction. Place external components, especially the output capacitor, as close as possible to the NCP716BC, and make traces as short as possible.

ORDERING INFORMATION

Device	Voltage Option	Marking	Package	Shipping†
NCP716BCSN300T1G	3.0 V	7AA	TSOP−5 (Pb−Free)	3000 / Tape & Reel
NCP716BCSN330T1G	3.3 V	7AC	TSOP−5 (Pb−Free)	3000 / Tape & Reel
NCP716BCSN345T1G	3.45 V	7AM	TSOP−5 (Pb−Free)	3000 / Tape & Reel
NCP716BCSN500T1G	5.0 V	7AV	TSOP−5 (Pb−Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# NCP716BC

PACKAGE DIMENSIONS

TSOP−5
CASE 483
ISSUE N
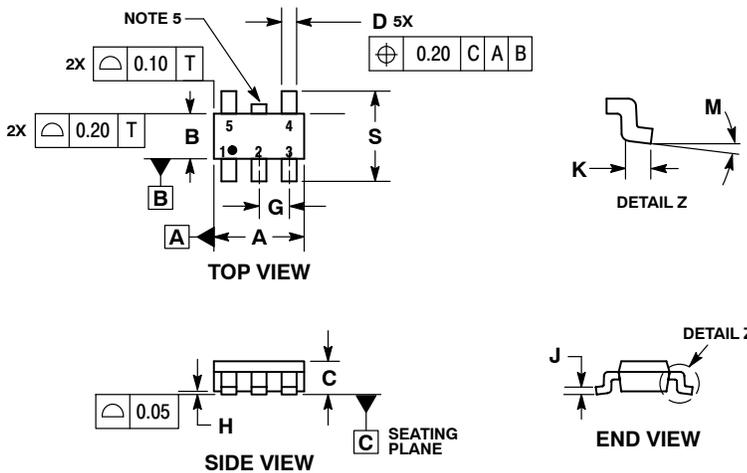
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION A.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

| DIM | MILLIMETERS | |
	MIN	MAX
A	2.85	3.15
B	1.35	1.65
C	0.90	1.10
D	0.25	0.50
G	0.95 BSC	
H	0.01	0.10
J	0.10	0.26
K	0.20	0.60
M	0 °	10 °
S	2.50	3.00

TOP VIEW

SIDE VIEW

END VIEW

DETAIL Z

SOLDERING FOOTPRINT*

SCALE 10:1 (mm/inches)
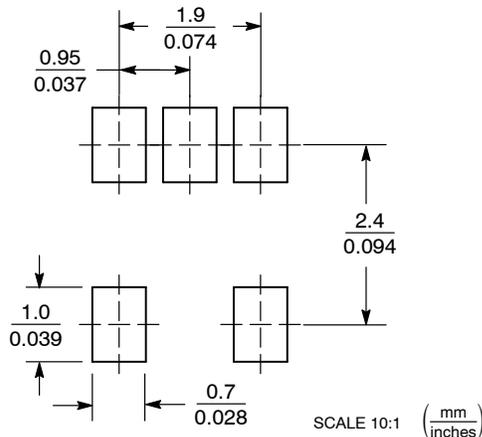
*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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