

# NCP4688

## Voltage Regulator - Low Noise, LDO Linear

### 150 mA

The NCP4688 is a CMOS 150 mA LDO linear voltage regulator with high output voltage accuracy which features a low noise output voltage and high ripple rejection. The low level of output noise 10  $\mu$ Vrms typically is kept at any output voltage. The very common SOT23-5 package and small  $\mu$ DFN 1x1 package are suitable for industrial applications, portable communication equipments and RF modules.

#### Features

- Operating Input Voltage Range: 2 V to 5.25 V
- Output Voltage Range: 1.2 to 4.8 V (available in 0.1 V steps)
- $\pm 1\%$  Output Voltage Accuracy
- Output Noise: 10  $\mu$ Vrms
- Line Regulation: 0.02%/V
- Current Limit Circuit
- High PSRR: 80 dB at 1 kHz, 75 dB at 10 kHz
- Available in SOT-23-5 and  $\mu$ DFN 1.0 x 1.0 mm Package
- These are Pb-Free Devices

#### Typical Applications

- Home Appliances, Industrial Equipment
- Cable Boxes, Satellite Receivers, Entertainment Systems
- Car Audio Equipment, Navigation Systems
- Notebook Adaptors, LCD TVs, Cordless Phones and Private LAN Systems
- RF Modules

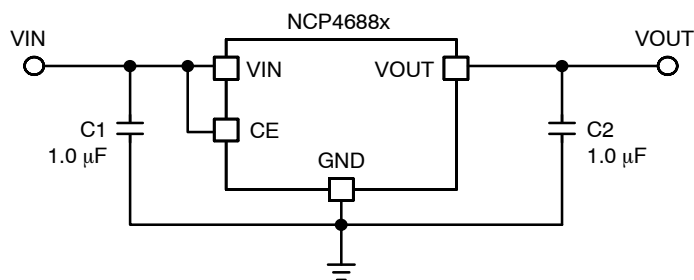


Figure 1. Typical Application Schematic



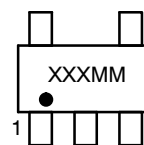
**ON Semiconductor**<sup>TM</sup>

<http://onsemi.com>

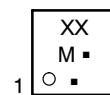
#### MARKING DIAGRAMS



SOT-23-5  
CASE 1212



UDFN-4  
CASE 517BR



(Top Views)

XX, XXX = Specific Device Code

M, MM = Date 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 12 of this data sheet.

# NCP4688

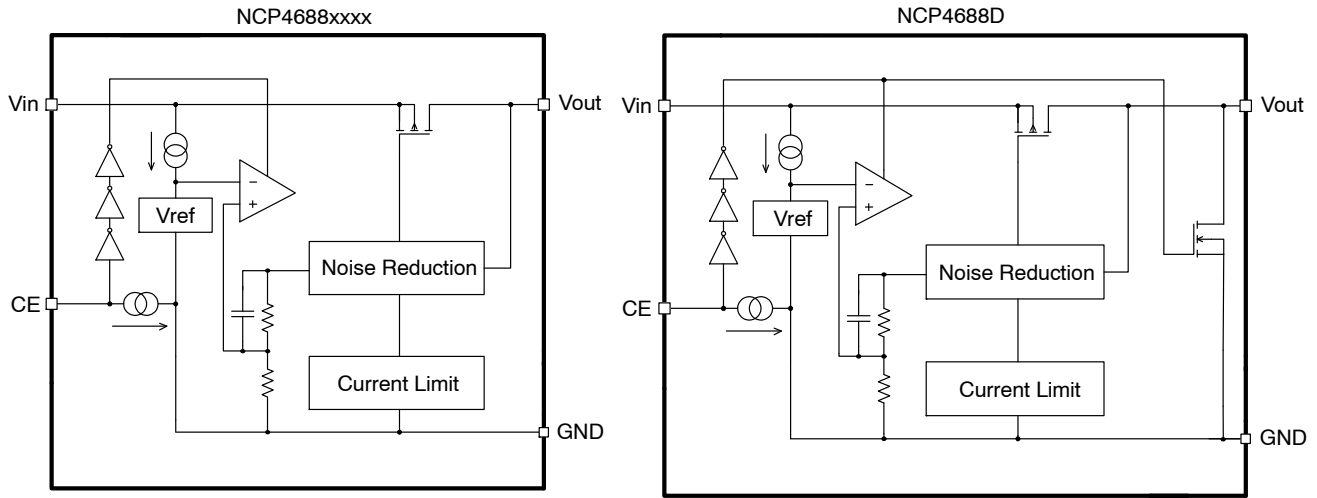


Figure 2. Simplified Schematic Block Diagram

Table 1. PIN FUNCTION DESCRIPTION

| Pin No.<br>SOT-23-5 | Pin No.<br>DFN 1x1 | Pin Name | Description                                    |
|---------------------|--------------------|----------|------------------------------------------------|
| 1                   | 4                  | VIN      | Input pin                                      |
| 2                   | 2                  | GND      | Ground pin                                     |
| 3                   | 3                  | CE       | Chip enable pin ("H" active)                   |
| 4                   |                    | NC       | Non connected                                  |
| 5                   | 1                  | VOUT     | Output pin                                     |
|                     | *EP                | EP       | Exposed Pad (leave floating or connect to GND) |

Table 2. ABSOLUTE MAXIMUM RATINGS

| Rating                                    | Symbol      | Value                  | Unit |
|-------------------------------------------|-------------|------------------------|------|
| Input Voltage                             | $V_{IN}$    | 0 – 6 V                | V    |
| Output Voltage                            | $V_{OUT}$   | -0.3 to $V_{IN} + 0.3$ | V    |
| Chip Enable Input                         | $V_{CE}$    | 0 – 6 V                | V    |
| Power Dissipation SOT-23-5                | $P_D$       | 420                    | mW   |
| Power Dissipation $\mu$ DFN 1.0 x 1.0 mm  |             | 400                    |      |
| Junction Temperature                      | $T_J$       | -40 to 150             | °C   |
| Storage Temperature                       | $T_{STG}$   | -55 to 125             | °C   |
| ESD Capability, Human Body Model (Note 1) | $ESD_{HBM}$ | 2000                   | V    |
| ESD Capability, Machine Model (Note 1)    | $ESD_{MM}$  | 200                    | V    |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

- 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)  
 Latchup Current Maximum Rating tested per JEDEC standard: JESD78

**Table 3. THERMAL CHARACTERISTICS**

| Rating                                                                                      | Symbol          | Value | Unit                 |
|---------------------------------------------------------------------------------------------|-----------------|-------|----------------------|
| Thermal Characteristics, SOT-23-5<br>Thermal Resistance, Junction-to-Air                    | $R_{\theta JA}$ | 238   | $^{\circ}\text{C/W}$ |
| Thermal Characteristics, $\mu\text{DFN } 1 \times 1$<br>Thermal Resistance, Junction-to-Air | $R_{\theta JA}$ | 250   | $^{\circ}\text{C/W}$ |

**Table 4. ELECTRICAL CHARACTERISTICS**

( $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ ;  $C_{IN} = C_{OUT} = 1.0 \mu\text{F}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}\text{C}$ .)

| Parameter                        | Test Conditions                                                                                                                                                                                             |                                  | Symbol              | Min    | Typ  | Max             | Unit              |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------|--------|------|-----------------|-------------------|
| Operating Input Voltage          | 1.2 V < Vout < 4.8 V                                                                                                                                                                                        |                                  | V <sub>IN</sub>     | 2.0    |      | 5.25            | V                 |
| Output Voltage                   | Ta = 25°C, Vout > 2.0 V                                                                                                                                                                                     |                                  | V <sub>OUT</sub>    | x0.99  |      | x1.01           | V                 |
|                                  | −40°C < Ta < 85°C, Vout > 2.0 V                                                                                                                                                                             |                                  |                     | x0.985 |      | x1.015          | V                 |
|                                  | Ta = 25°C, Vout ≤ 2.0 V                                                                                                                                                                                     |                                  |                     | −20    |      | +20             | mV                |
|                                  | −40°C < Ta < 85°C, Vout ≤ 2.0 V                                                                                                                                                                             |                                  |                     | −30    |      | +30             | mV                |
| Output Voltage Temp. Coefficient | −40°C < Ta < 85°C                                                                                                                                                                                           |                                  |                     |        | ±100 |                 | ppm/°C            |
| Line Regulation                  | Set Vout + 0.3 < V <sub>IN</sub> < 5.25 V                                                                                                                                                                   | Vout > 4.1 V                     | Line <sub>Reg</sub> |        | 0.02 | 0.10            | %/V               |
|                                  | Set Vout + 0.5 < V <sub>IN</sub> < 5.0 V                                                                                                                                                                    | 1.7 V ≤ V <sub>OUT</sub> < 4.1 V |                     |        |      |                 |                   |
|                                  | 2.2 < V <sub>IN</sub> < 5.0 V                                                                                                                                                                               | Vout < 1.7 V                     |                     |        |      |                 |                   |
| Load Regulation                  | 1 mA < I <sub>OUT</sub> ≤ 150 mA                                                                                                                                                                            |                                  | Load <sub>Reg</sub> | −14    | 0    | 14              | mV                |
| Dropout Voltage                  | I <sub>OUT</sub> = 150 mA                                                                                                                                                                                   | 1.2 V ≤ V <sub>OUT</sub> < 1.3 V | V <sub>DO</sub>     |        | 0.39 | 0.80            | V                 |
|                                  |                                                                                                                                                                                                             | 1.3 V ≤ V <sub>OUT</sub> < 1.4 V |                     |        | 0.37 | 0.70            |                   |
|                                  |                                                                                                                                                                                                             | 1.4 V ≤ V <sub>OUT</sub> ≤ 1.5 V |                     |        | 0.34 | 0.60            |                   |
|                                  |                                                                                                                                                                                                             | 1.5 V ≤ V <sub>OUT</sub> < 1.7 V |                     |        | 0.32 | 0.50            |                   |
|                                  |                                                                                                                                                                                                             | 1.7 V ≤ V <sub>OUT</sub> < 2.0 V |                     |        | 0.29 | 0.41            |                   |
|                                  |                                                                                                                                                                                                             | 2.0 V ≤ V <sub>OUT</sub> < 2.5 V |                     |        | 0.25 | 0.36            |                   |
|                                  |                                                                                                                                                                                                             | 2.5 V ≤ V <sub>OUT</sub> < 2.8 V |                     |        | 0.22 | 0.31            |                   |
|                                  |                                                                                                                                                                                                             | 2.8 V ≤ V <sub>OUT</sub> ≤ 4.8 V |                     |        | 0.20 | 0.28            |                   |
| Output Current                   |                                                                                                                                                                                                             |                                  | I <sub>OUT</sub>    | 150    |      |                 | mA                |
| Short Current Limit              | V <sub>OUT</sub> = 0 V                                                                                                                                                                                      |                                  | I <sub>SC</sub>     |        | 40   |                 | mA                |
| Quiescent Current                | Iout = 0 mA                                                                                                                                                                                                 | Vout > 4.1 V                     | I <sub>Q</sub>      |        | 80   | 100             | μA                |
|                                  |                                                                                                                                                                                                             | Vout ≤ 4.1 V                     |                     |        | 75   |                 |                   |
| Standby Current                  | V <sub>IN</sub> = V <sub>IN max</sub> , V <sub>CE</sub> = 0 V                                                                                                                                               |                                  | I <sub>STB</sub>    |        | 0.1  | 1.0             | μA                |
| CE Pin Pull–Down Current         |                                                                                                                                                                                                             |                                  | I <sub>PD</sub>     |        | 0.3  | 0.6             | μA                |
| CE Pin Threshold Voltage         | CE Input Voltage “H”                                                                                                                                                                                        |                                  | V <sub>CEH</sub>    | 1.0    |      | V <sub>IN</sub> | V                 |
|                                  | CE Input Voltage “L”                                                                                                                                                                                        |                                  | V <sub>CEL</sub>    |        |      | 0.4             |                   |
| Power Supply Rejection Ratio     | V <sub>OUT</sub> > 4.1 V @ V <sub>IN</sub> = 5.25 V, f = 1 kHz<br>V <sub>OUT</sub> ≤ 4.1 V @ V <sub>IN</sub> = Set V <sub>OUT</sub> + 1.0 V,<br>ΔV <sub>IN_PK-PK</sub> = 0.2 V,<br>I <sub>OUT</sub> = 30 mA | f = 10 kHz                       | PSRR                |        | 80   |                 | dB                |
|                                  |                                                                                                                                                                                                             | f = 100 kHz                      |                     |        | 75   |                 |                   |
|                                  |                                                                                                                                                                                                             |                                  |                     |        | 65   |                 |                   |
| Output Noise Voltage             | I <sub>OUT</sub> = 30 mA, f = 10 Hz to 100 kHz                                                                                                                                                              |                                  | V <sub>NOISE</sub>  |        | 10   |                 | μV <sub>rms</sub> |
| Autodischarge NMOS Resistance    | V <sub>IN</sub> = 4.0 V, V <sub>CE</sub> = 0.0 V                                                                                                                                                            |                                  | R <sub>DSON</sub>   |        | 60   |                 | ohm               |

TYPICAL CHARACTERISTICS

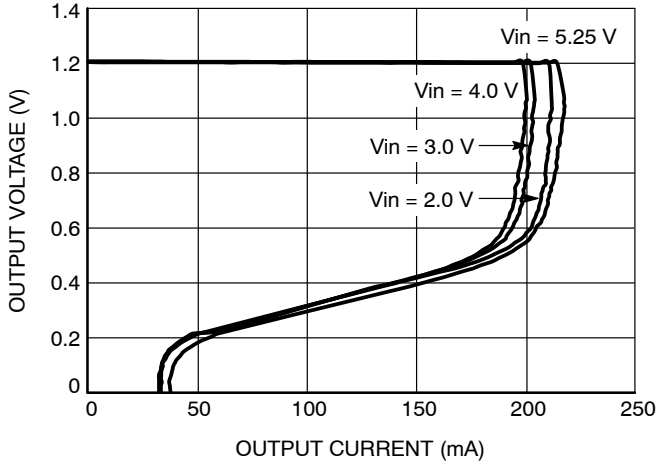


Figure 3. Output Voltage vs. Output Current  
NCP4688xx12

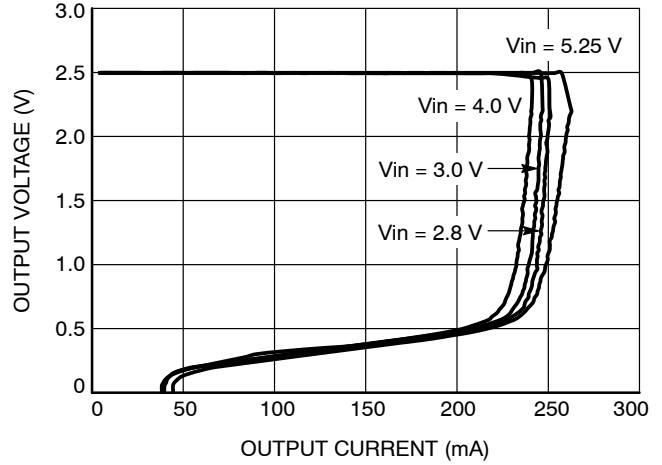


Figure 4. Output Voltage vs. Output Current  
NCP4688xx25

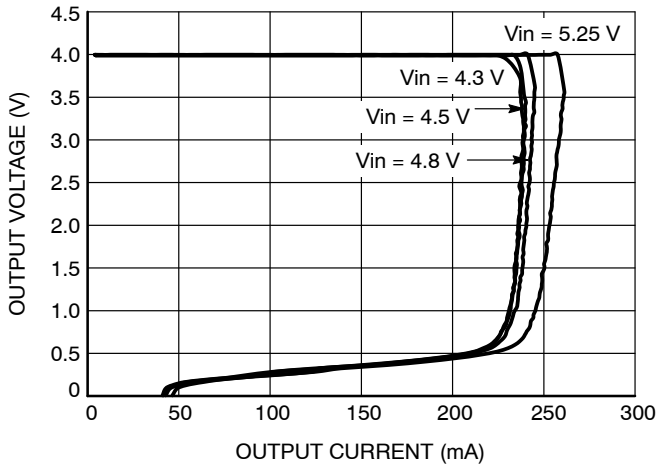


Figure 5. Output Voltage vs. Output Current  
NCP4688xx40

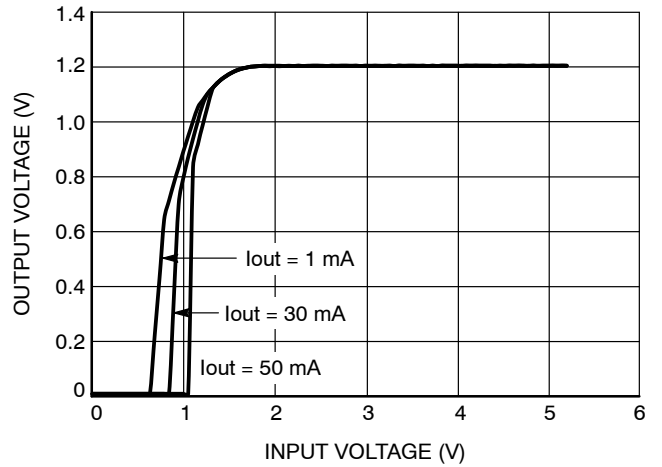


Figure 6. Output Voltage vs. Input Voltage  
NCP4688xx12

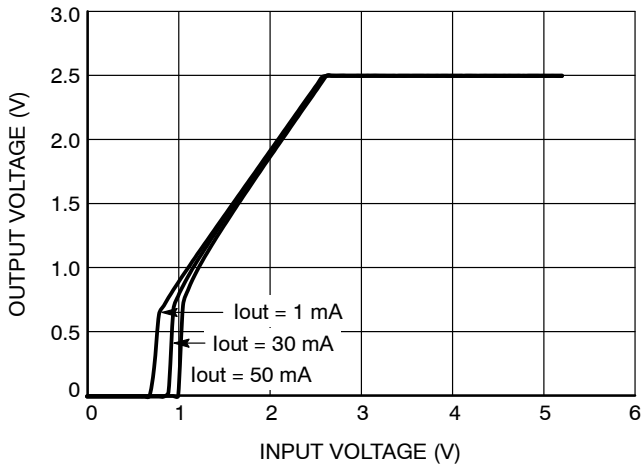


Figure 7. Output Voltage vs. Input Voltage  
NCP4688xx25

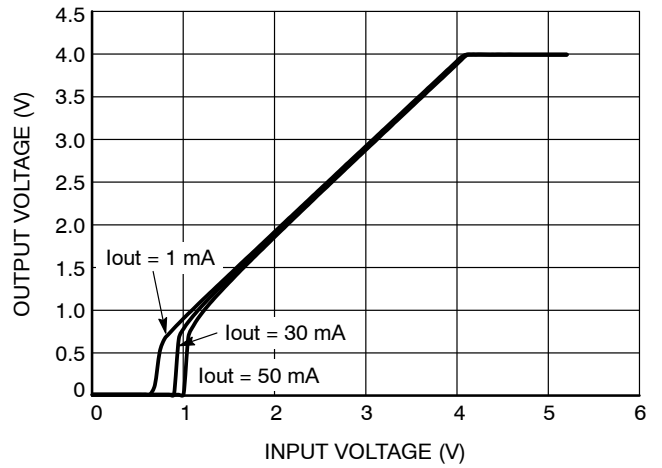


Figure 8. Output Voltage vs. Input Voltage  
NCP4688xx40

TYPICAL CHARACTERISTICS

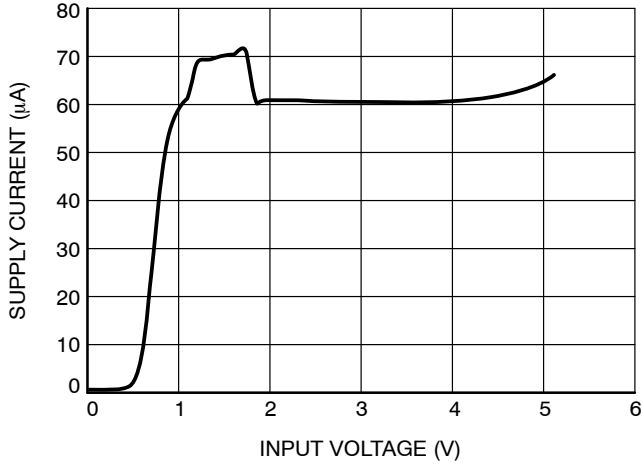


Figure 9. Supply Current vs. Input Voltage  
NCP4688xx12

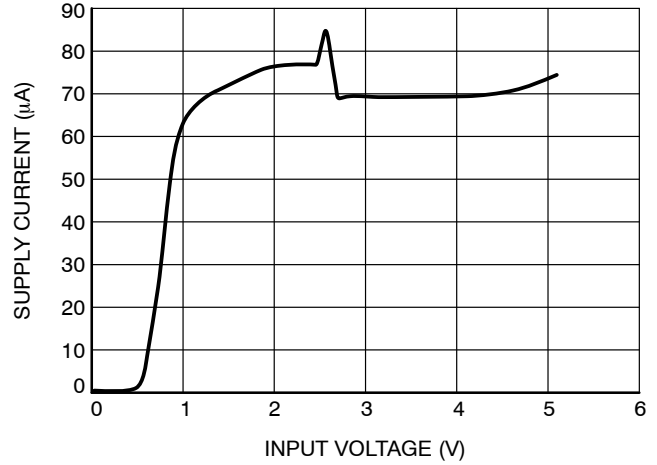


Figure 10. Supply Current vs. Input Voltage  
NCP4688xx25

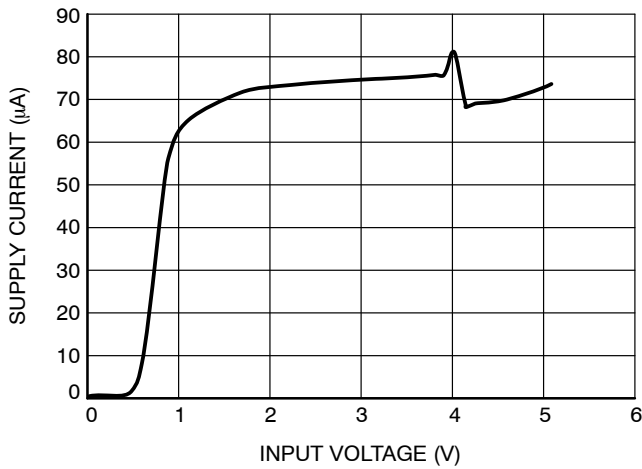


Figure 11. Supply Current vs. Input Voltage  
NCP4688xx40

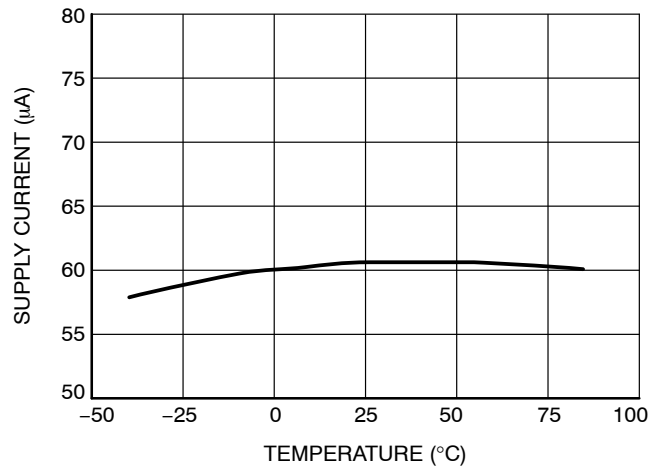


Figure 12. Supply Current vs. Temperature  
NCP4688xx12

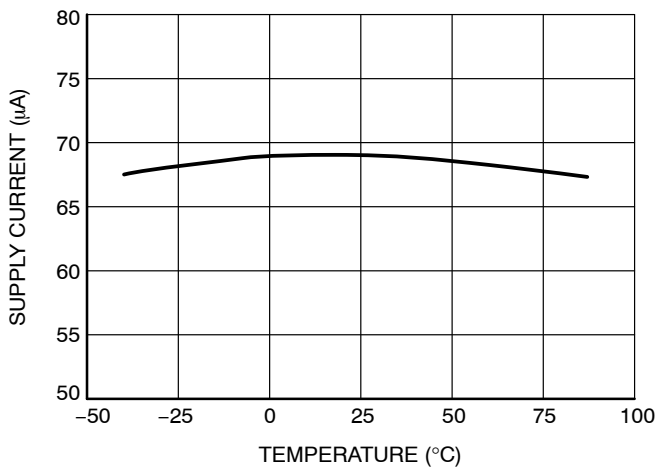


Figure 13. Supply Current vs. Temperature  
NCP4688xx25

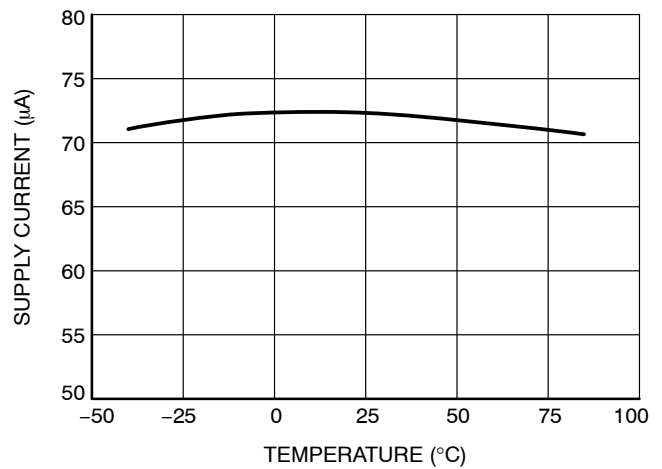


Figure 14. Supply Current vs. Temperature  
NCP4688xx40

TYPICAL CHARACTERISTICS

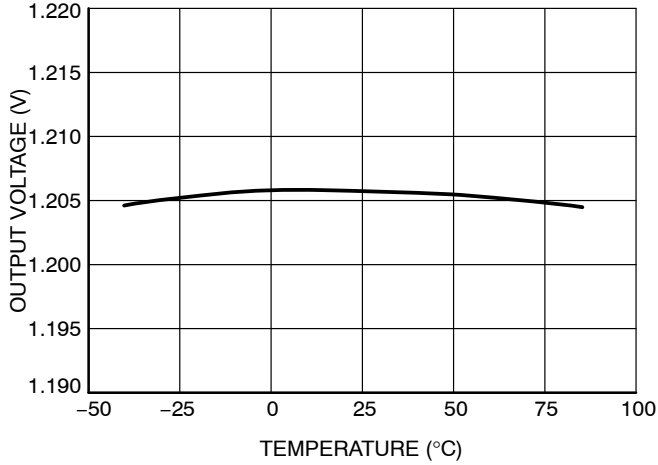


Figure 15. Output Voltage vs. Temperature  
NCP4688xx12

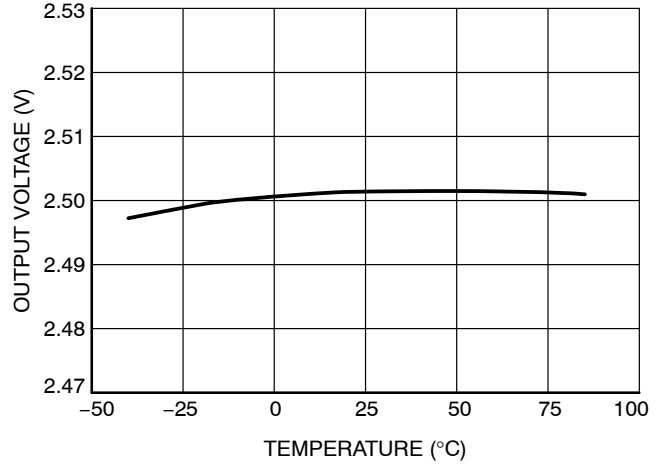


Figure 16. Output Voltage vs. Temperature  
NCP4688xx25

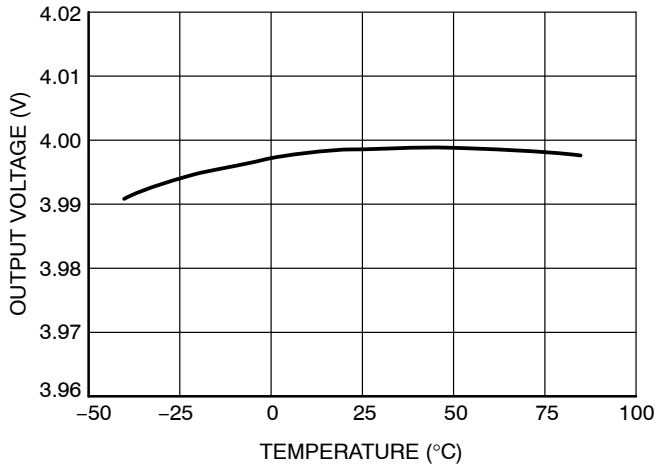


Figure 17. Output Voltage vs. Temperature  
NCP4688xx40

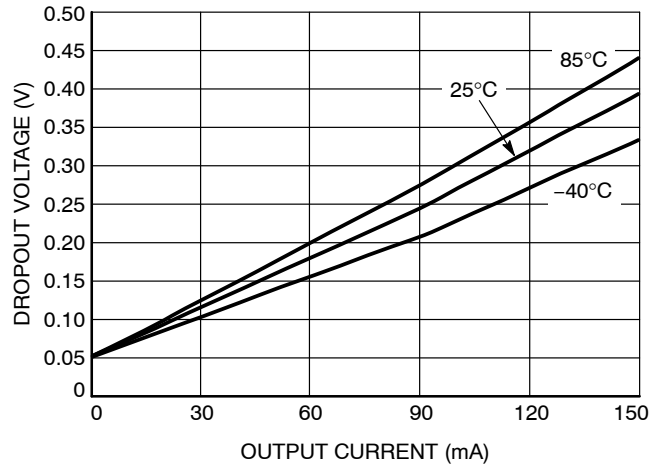


Figure 18. Dropout Voltage vs. Output Current  
NCP4688xx12

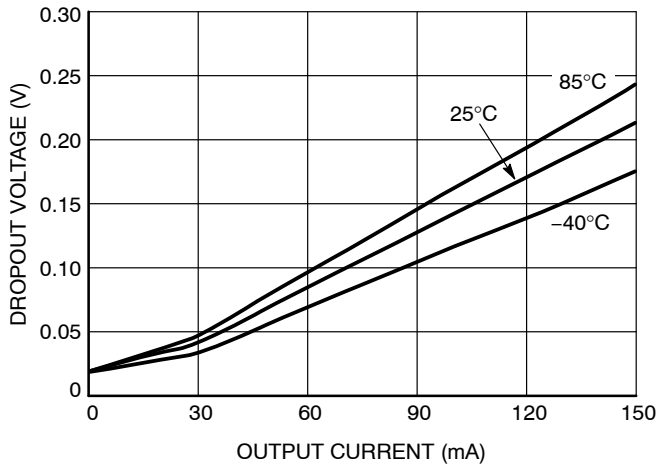


Figure 19. Dropout Voltage vs. Output Current  
NCP4688xx25

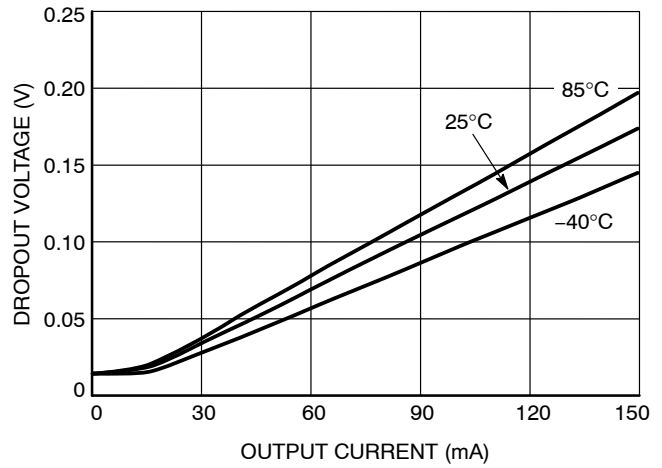


Figure 20. Dropout Voltage vs. Output Current  
NCP4688xx40

TYPICAL CHARACTERISTICS

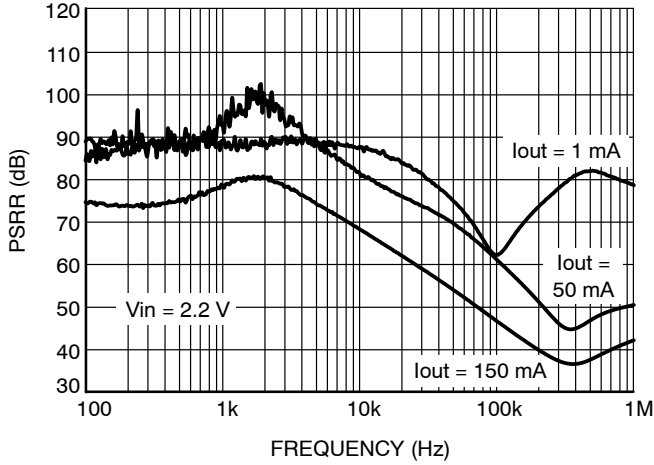


Figure 21. PSRR vs. Frequency NCP4688xx12

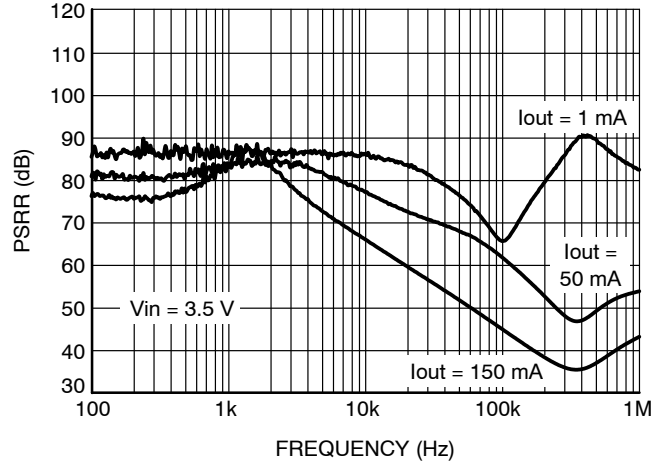


Figure 22. PSRR vs. Frequency NCP4688xx25

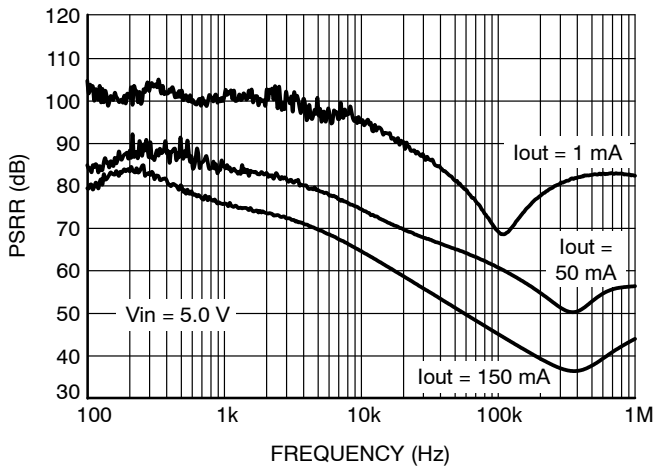


Figure 23. PSRR vs. Frequency NCP4688xx40

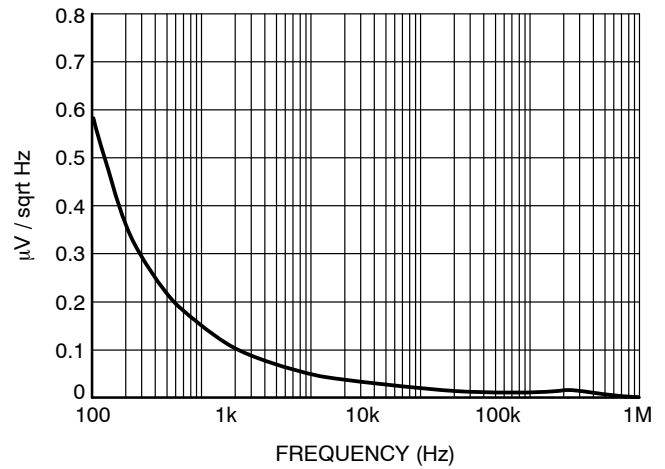


Figure 24. Output Noise Density vs. Frequency NCP4688xx12

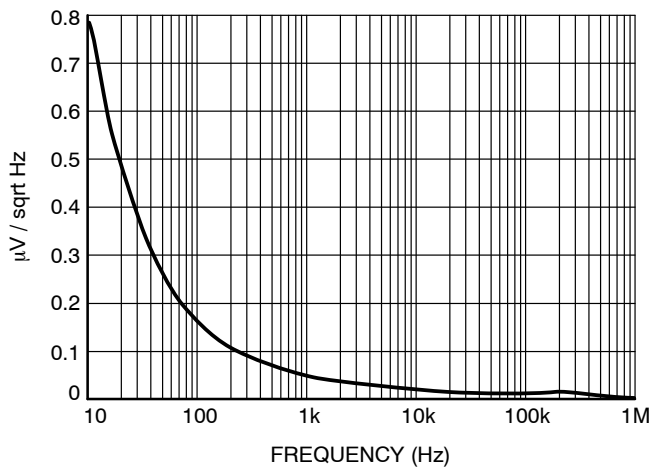


Figure 25. Output Noise Density vs. Frequency NCP4688xx25

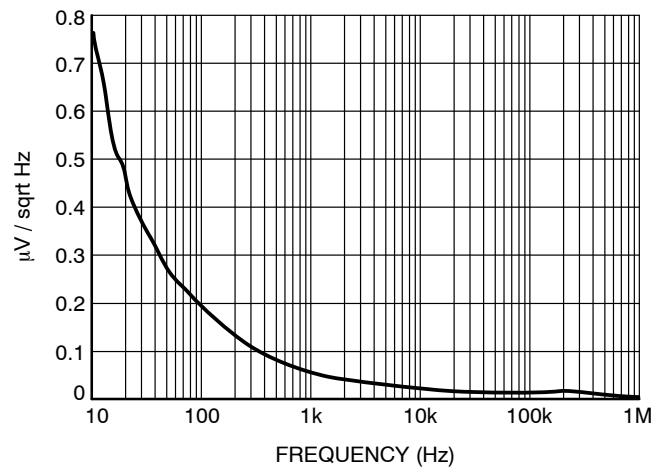


Figure 26. Output Noise Density vs. Frequency NCP4688xx40

TYPICAL CHARACTERISTICS

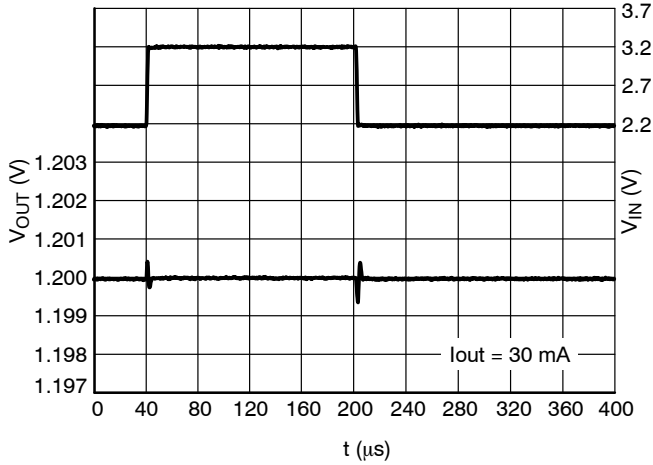


Figure 27. Line Transient Response  
NCP4688xx12

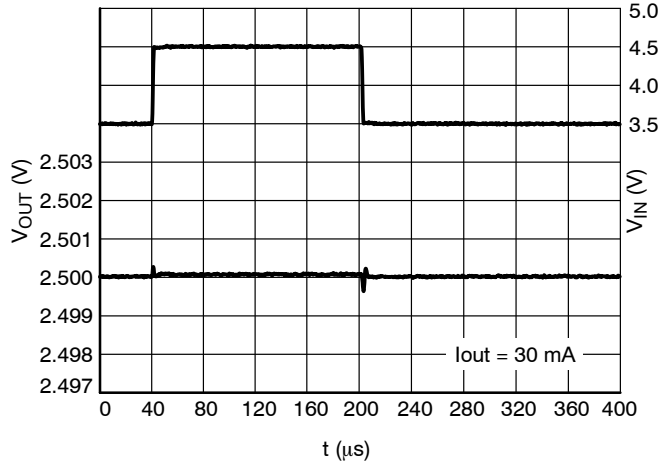


Figure 28. Line Transient Response  
NCP4688xx25

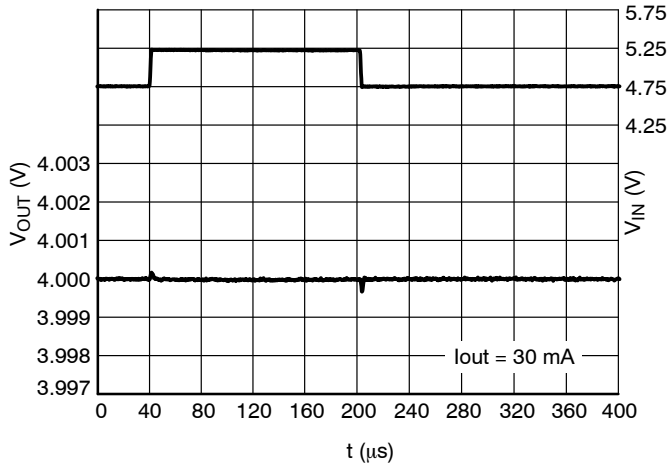


Figure 29. Line Transient Response  
NCP4688xx40

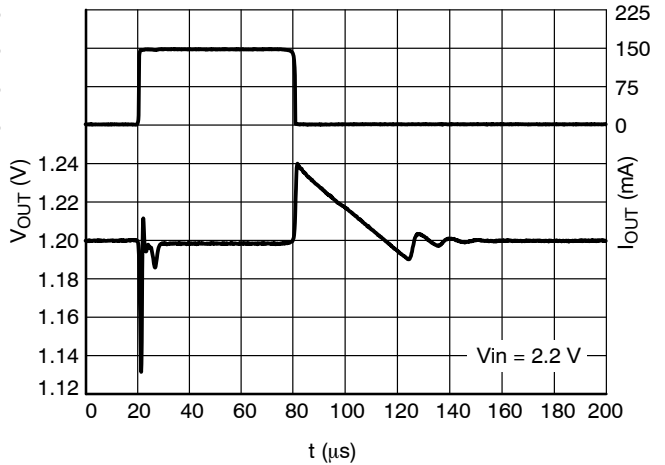


Figure 30. Load Transient Response Load  
Step 1 mA to 150 mA NCP4688xx12

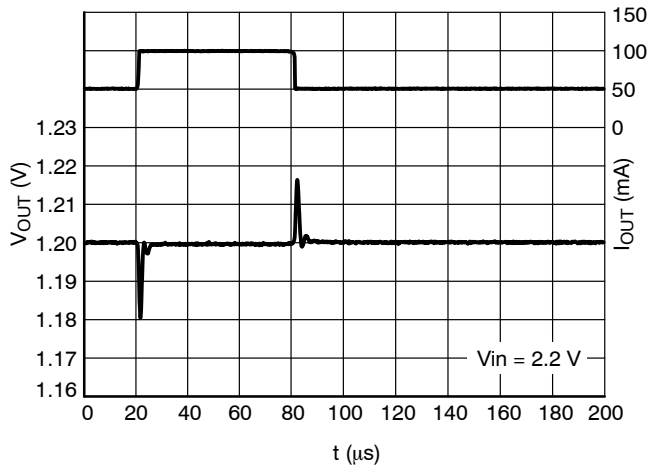


Figure 31. Load Transient Response Load  
Step 50 mA to 100 mA NCP4688xx12

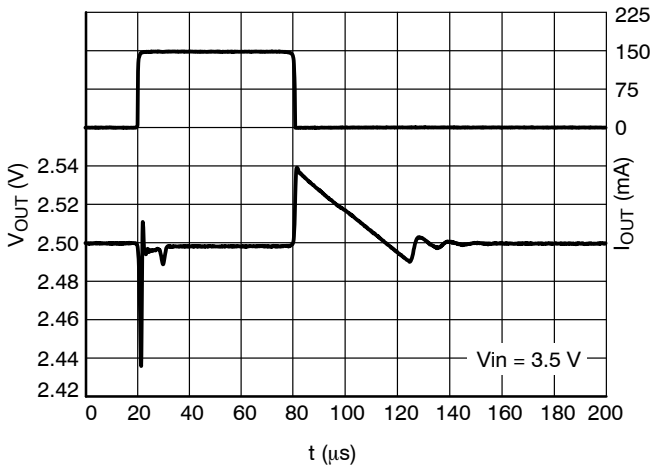


Figure 32. Load Transient Response Load  
Step 1 mA to 150 mA NCP4688xx25

TYPICAL CHARACTERISTICS

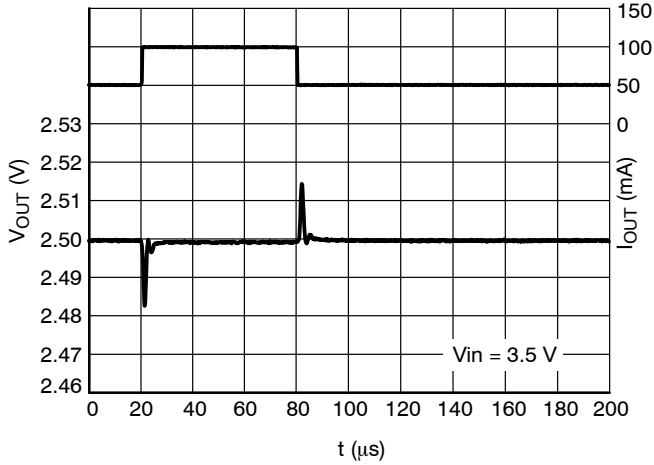


Figure 33. Load Transient Response Load Step 50 mA to 100 mA NCP4688xx25

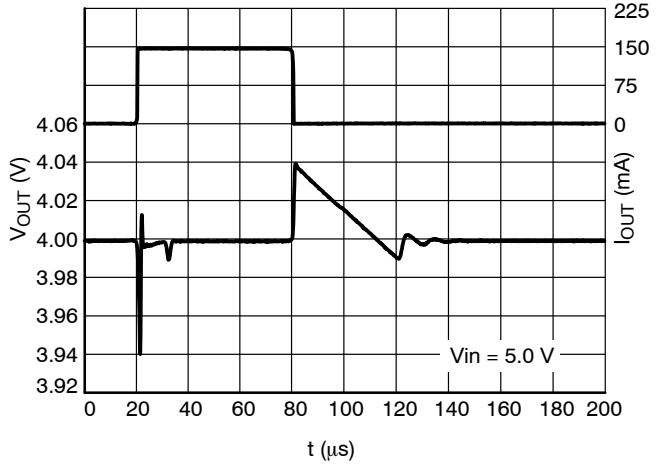


Figure 34. Load Transient Response Load Step 1 mA to 150 mA NCP4688xx40

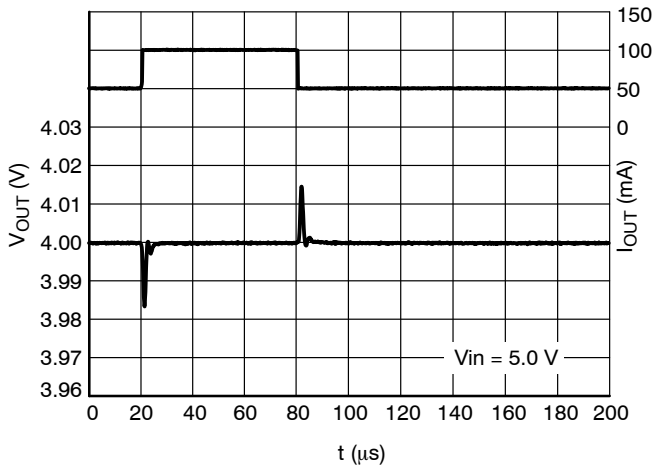


Figure 35. Load Transient Response Load Step 50 mA to 100 mA NCP4688xx40

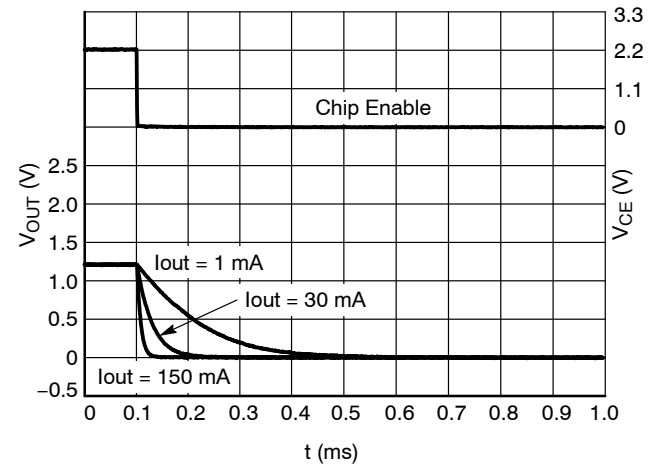


Figure 36. Turn Off with CE Behavior NCP4688Dx12

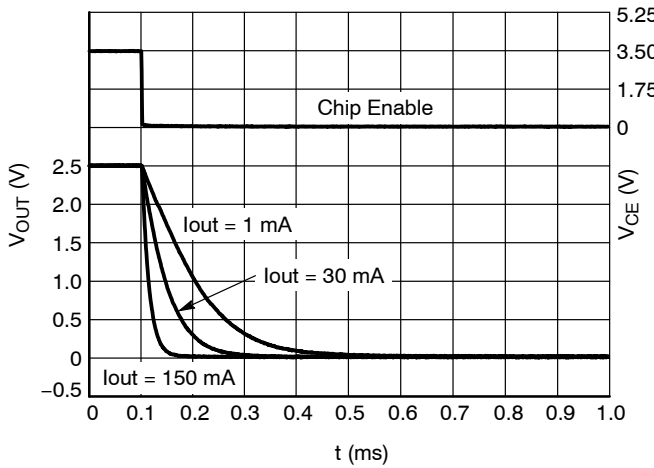


Figure 37. Turn Off with CE Behavior NCP4688Dx25

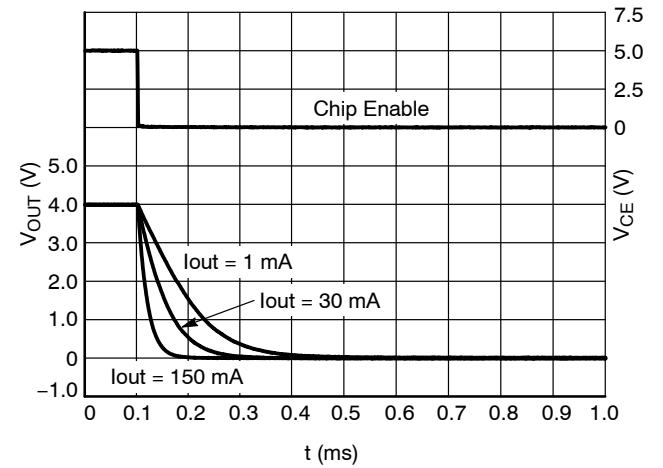


Figure 38. Turn Off with CE Behavior NCP4688Dx40

TYPICAL CHARACTERISTICS

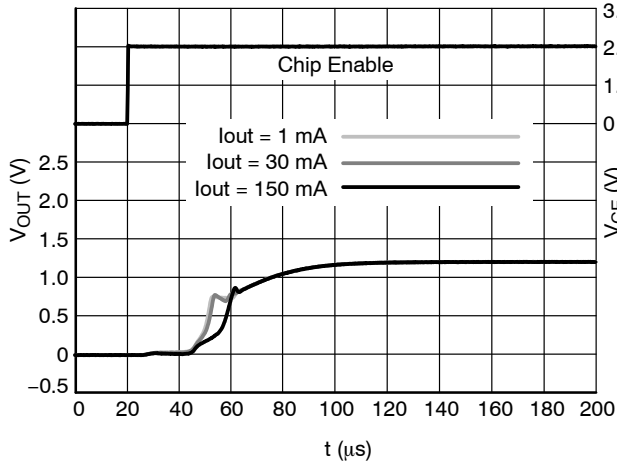


Figure 39. Turn ON with CE Behavior  
NCP4688xx12

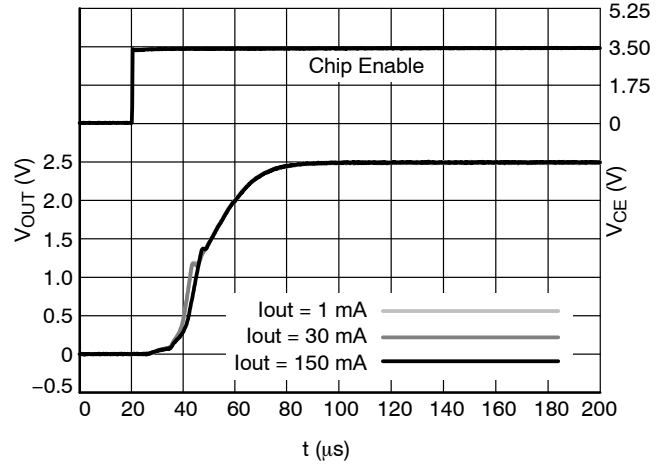


Figure 40. Turn ON with CE Behavior  
NCP4688xx25

## APPLICATION INFORMATION

A typical application circuit for NCP4688 series is shown in the Figure 41.

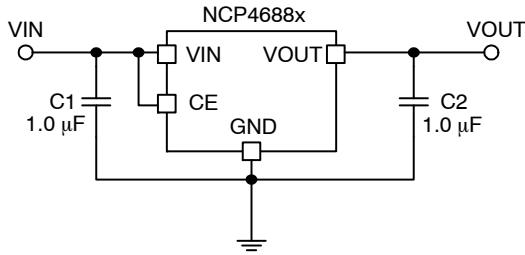


Figure 41. Typical Application Schematic

#### Input Decoupling Capacitor (C1)

A 1.0  $\mu\text{F}$  ceramic input decoupling capacitor should be connected as close as possible to the input and ground pin of the NCP4688 device. Higher values and lower ESR improves line transient response.

#### Output Decoupling Capacitor (C2)

A 1.0  $\mu\text{F}$  ceramic output decoupling capacitor is sufficient to achieve stable operation of the device. If tantalum capacitor is used, and its ESR is high, the loop oscillation may result. For information about ESR see Figures 42, 43 and 44. The capacitor should be connected as close as possible to the output and ground pin. Larger values and lower ESR improves dynamic parameters.

#### Enable Operation

The enable pin CE may be used for turning the regulator on and off. The IC is switched on when a high level voltage is applied to the CE pin. The enable pin has an internal pull down current source which assure off state of LDO in case the CE pin will stay floating. If the enable function is not needed connect CE pin to  $V_{\text{IN}}$ .

The D version of the NCP4688 device includes a transistor between  $V_{\text{OUT}}$  and GND that is used for faster discharging of the output capacitor. This function is activated when the IC goes into disable mode.

#### Thermal Consideration

As a power across the IC increase, it might become necessary to provide some thermal relief. 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 also the ambient temperature affect the rate of temperature increase for the part. When the device has good thermal conductivity through the PCB the junction temperature will be relatively low in high power dissipation applications.

#### ESR vs. Output Current

When using the NCP4688 devices, consider the following points:

The relation between Output Current  $I_{\text{out}}$  and ESR of the output capacitor are shown below in Figures 42, 43 and 44. The conditions when the device performs stable operation are marked as the hatched area in the charts.

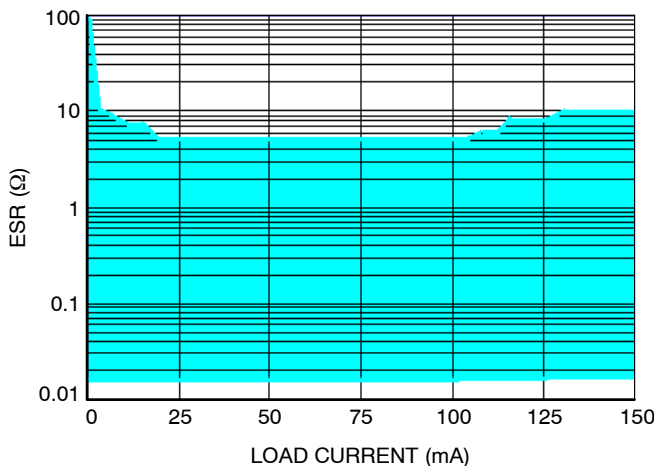


Figure 42. ESR vs. Load Current NCP4688xx12

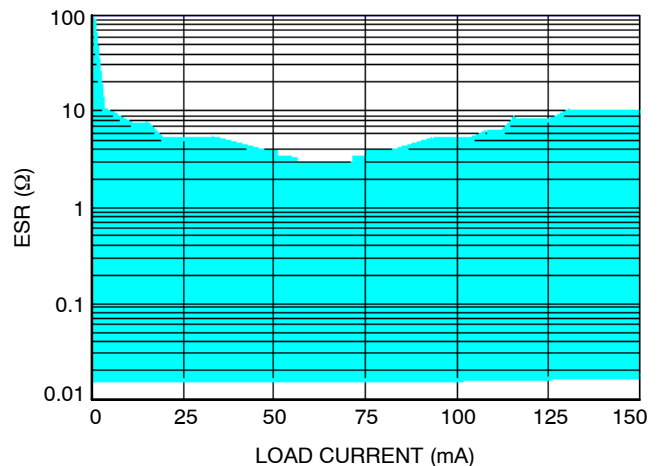


Figure 43. ESR vs. Load Current NCP4688xx25

## NCP4688

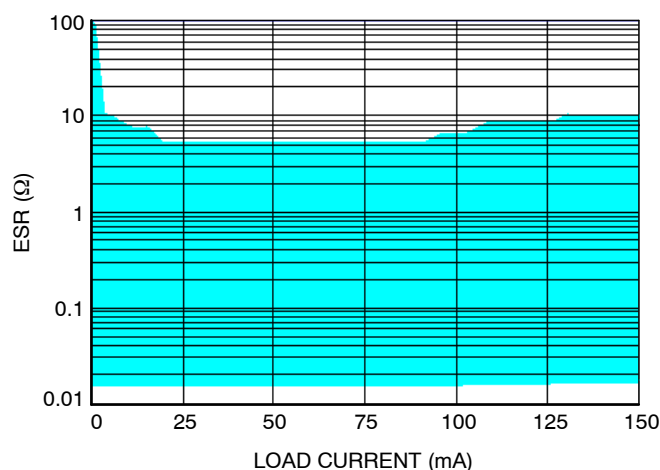


Figure 44. ESR vs. Load Current NCP4688xx40

### ORDERING INFORMATION

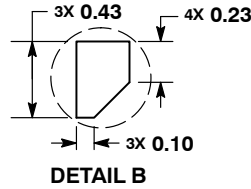
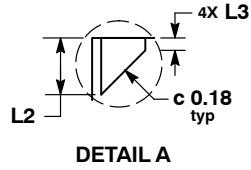
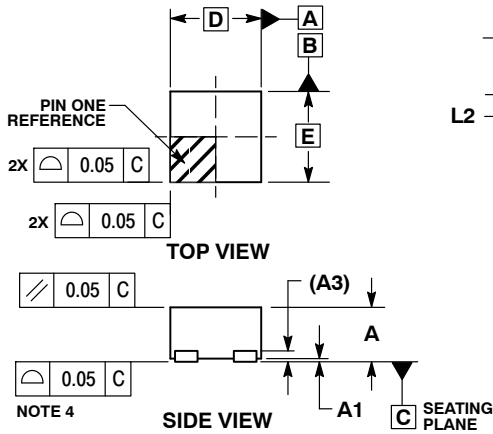
| Device          | Marking | Nominal Output Voltage | Feature        | Package           | Shipping <sup>†</sup> |
|-----------------|---------|------------------------|----------------|-------------------|-----------------------|
| NCP4688DMU12TCG | 3A      | 1.2 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DMU15TCG | 3E      | 1.5 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DMU18TCG | 3H      | 1.8 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DMU25TCG | 3R      | 2.5 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DMU28TCG | 3U      | 2.8 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DMU30TCG | 3X      | 3.0 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DMU33TCG | 4A      | 3.3 V                  | Auto discharge | DFN1010 (Pb-Free) | 10000 / Tape & Reel   |
| NCP4688DSN12T1G | L12     | 1.2 V                  | Auto discharge | SOT-23 (Pb-Free)  | 3000 / Tape & Reel    |
| NCP4688DSN15T1G | L15     | 1.5 V                  | Auto discharge | SOT-23 (Pb-Free)  | 3000 / Tape & Reel    |
| NCP4688DSN18T1G | L18     | 1.8 V                  | Auto discharge | SOT-23 (Pb-Free)  | 3000 / Tape & Reel    |
| NCP4688DSN25T1G | L25     | 2.5 V                  | Auto discharge | SOT-23 (Pb-Free)  | 3000 / Tape & Reel    |
| NCP4688DSN28T1G | L28     | 2.8 V                  | Auto discharge | SOT-23 (Pb-Free)  | 3000 / Tape & Reel    |
| NCP4688DSN33T1G | L33     | 3.3 V                  | Auto discharge | SOT-23 (Pb-Free)  | 3000 / Tape & Reel    |

<sup>†</sup>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.

# NCP4688

## PACKAGE DIMENSIONS

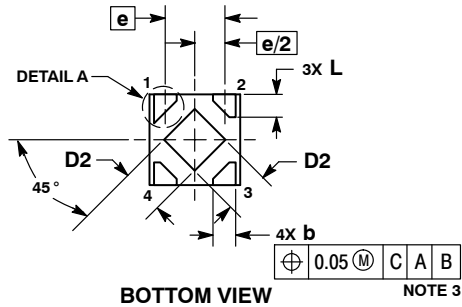
UDFN4 1.0x1.0, 0.65P  
CASE 517BR-01  
ISSUE O



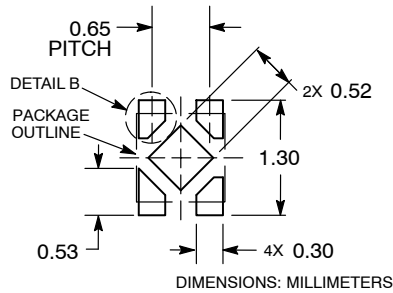
### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.20 mm FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

| MILLIMETERS |      |      |
|-------------|------|------|
| DIM         | MIN  | MAX  |
| A           | ---  | 0.60 |
| A1          | 0.00 | 0.05 |
| A3          | 0.10 | REF  |
| b           | 0.20 | 0.30 |
| D           | 1.00 | BSC  |
| D2          | 0.43 | 0.53 |
| E           | 1.00 | BSC  |
| e           | 0.65 | BSC  |
| L           | 0.20 | 0.30 |
| L2          | 0.27 | 0.37 |
| L3          | 0.02 | 0.12 |



### RECOMMENDED MOUNTING FOOTPRINT\*

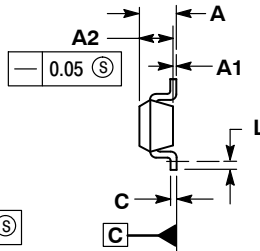
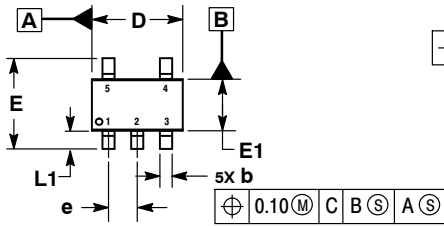


\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# NCP4688

## PACKAGE DIMENSIONS

### SOT-23 5-LEAD CASE 1212-01 ISSUE A

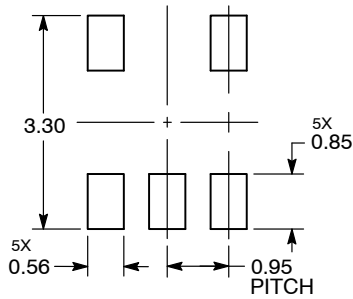


#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSIONS: MILLIMETERS.
3. DATUM C IS THE SEATING PLANE.

| MILLIMETERS |          |      |
|-------------|----------|------|
| DIM         | MIN      | MAX  |
| A           | ---      | 1.45 |
| A1          | 0.00     | 0.10 |
| A2          | 1.00     | 1.30 |
| b           | 0.30     | 0.50 |
| c           | 0.10     | 0.25 |
| D           | 2.70     | 3.10 |
| E           | 2.50     | 3.10 |
| E1          | 1.50     | 1.80 |
| e           | 0.95 BSC |      |
| L           | 0.20     | ---  |
| L1          | 0.45     | 0.75 |

### RECOMMENDED SOLDERING FOOTPRINT\*



DIMENSIONS: MILLIMETERS

\*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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