

# Voltage Regulator - Low Dropout

30 mA

## NCV4294C

The NCV4294C is a monolithic integrated low dropout voltage regulator with an output current capability of 30 mA available in the TSOP-5 package.

The output voltage is accurate within  $\pm 4.0\%$  with a maximum dropout voltage of 250 mV with an input up to 45 V. Low quiescent current is a feature typically drawing only 160  $\mu\text{A}$  with a 1 mA load. This part is ideal for automotive and all battery operated microprocessor equipment.

The regulator is protected against reverse battery, short circuit and thermal overload conditions.

### Features

- Output Voltage Options: 3.3 V, 5.0 V
- Output Voltage Accuracy:  $\pm 4.0\%$
- Output Current: up to 30 mA
- Low Quiescent Current (typ. 160  $\mu\text{A}$  @ 1 mA)
- Low Dropout Voltage (typ. 65 mV @ 20 mA)
- Wide Input Voltage Operating Range: up to 45 V
- Protection Features:
  - ♦ Current Limitation
  - ♦ Thermal Shutdown
  - ♦ Reverse Polarity Protection and Reverse Bias Protection
- AEC-Q100 Grade 1 Qualified and PPAP Capable
- This is a Pb-Free Device

### Typical Applications

- Microprocessor Systems Power Supply

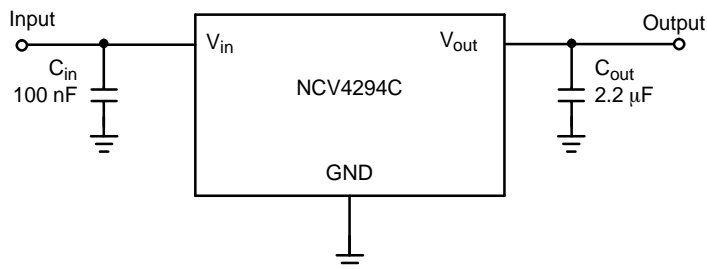
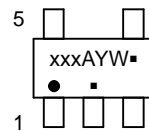


Figure 1. Applications Circuit



TSOP-5  
CASE 483

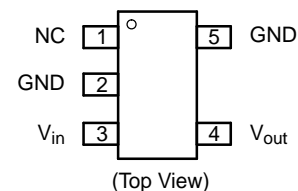
### MARKING DIAGRAM



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

(Note: Microdot may be in either location)

### PIN CONNECTIONS



### ORDERING INFORMATION

See detailed ordering, marking and shipping information on page 10 of this data sheet.

# NCV4294C

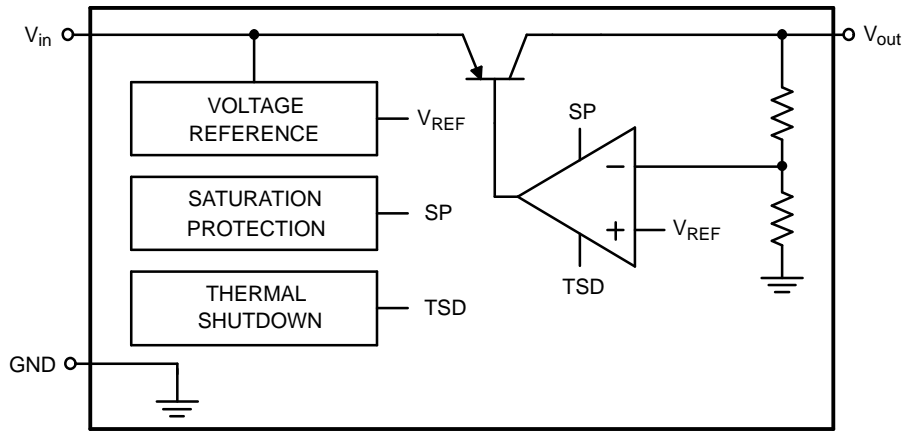


Figure 2. Simplified Block Diagram

## PIN FUNCTION DESCRIPTION

| Pin No.<br>TSOP-5 | Pin Name         | Description   |
|-------------------|------------------|---|
| 1                 | NC               | Not connected. (Not internally bonded)  |
| 2                 | GND              | Power Supply Ground.  |
| 3                 | V <sub>in</sub>  | Unregulated Positive Power Supply Input. Connect 0.1 $\mu$ F capacitor to ground.                 |
| 4                 | V <sub>out</sub> | Regulated Positive Output Voltage. Connect 2.2 $\mu$ F capacitor with ESR < 7 $\Omega$ to ground. |
| 5                 | GND              | Power Supply Ground.  |

## ABSOLUTE MAXIMUM RATINGS

| Rating   | Symbol              | Min | Max | Unit |
|--|---------------------|-----|-----|------|
| Input Voltage DC (Note 1)<br>DC                  | V <sub>in</sub>     | -42 | 45  | V    |
| Input Voltage (Note 2)<br>Load Dump - Suppressed | U <sub>s</sub>      | -   | 60  | V    |
| Output Voltage                                   | V <sub>out</sub>    | -6  | 30  | V    |
| Maximum Junction Temperature                     | T <sub>J(max)</sub> | -40 | 150 | °C   |
| Storage Temperature                              | T <sub>STG</sub>    | -50 | 150 | °C   |

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. Load Dump Test B (with centralized load dump suppression) according to ISO16750-2 standard. Guaranteed by design. Not tested in production. Passed Class A according to ISO16750-1.

## ESD CAPABILITY (Note 3)

| Rating                           | Symbol             | Min | Max | Unit |
|----------------------------------|--------------------|-----|-----|------|
| ESD Capability, Human Body Model | ESD <sub>HBM</sub> | -2  | 2   | kV   |

3. This device series incorporates ESD protection and is tested by the following methods:

ESD Human Body Model tested per AEC-Q100-002 (JS-001-2010)

Field Induced Charge Device Model ESD characterization is not performed on plastic molded packages with body sizes <50mm<sup>2</sup> due to the inability of a small package body to acquire and retain enough charge to meet the minimum CDM discharge current waveform characteristic defined in JEDEC JS-002-2014.

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## LEAD SOLDERING TEMPERATURE AND MSL (Note 4)

| Rating                     | Symbol | Min | Max | Unit |
|----------------------------|--------|-----|-----|------|
| Moisture Sensitivity Level | MSL    | 1   |     | -    |

4. For more information, please refer to our Soldering and Mounting Techniques Reference Manual, SOLDERRM/D

## THERMAL CHARACTERISTICS

| Rating  | Symbol          | Value | Unit |
|---|-----------------|-------|------|
| Thermal Characteristics, TSOP-5<br>Thermal Resistance, Junction-to-Air (Note 5) | $R_{\theta JA}$ | 136.2 | °C/W |

5. Values based on copper area of 645 mm<sup>2</sup> (or 1 in<sup>2</sup>) of 1 oz copper thickness and FR4 PCB substrate.

## RECOMMENDED OPERATING RANGES

| Rating                 | Symbol   | Min                         | Max | Unit |
|------------------------|----------|-----------------------------|-----|------|
| Input Voltage (Note 6) | $V_{in}$ | $V_{out, nom} + 0.5$ or 3.5 | 45  | V    |
| Junction Temperature   | $T_J$    | -40                         | 150 | °C   |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

6. Minimum  $V_{in} = V_{out, nom} + 0.5$  or 3.5, whichever is higher.

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## ELECTRICAL CHARACTERISTICS

$V_{in} = 13.5\text{ V}$ ,  $C_{in} = 0.1\text{ }\mu\text{F}$ ,  $C_{out} = 2.2\text{ }\mu\text{F}$ , for typical values  $T_J = 25^\circ\text{C}$ , for min/max values  $T_J = -40^\circ\text{C}$  to  $150^\circ\text{C}$ ; unless otherwise noted. (Note 7)

| Parameter                | Test Conditions  | Symbol       | Min                          | Typ                          | Max                          | Unit |
|--------------------------|--|--------------|------------------------------|------------------------------|------------------------------|------|
| <b>REGULATOR OUTPUT</b>  |  |              |                              |                              |                              |      |
| Output Voltage           | 5.0 V<br>$V_{in} = 13.5\text{ V}$ , $I_{out} = 1\text{ mA}$ to $30\text{ mA}$<br>$V_{in} = 6\text{ V}$ to $40\text{ V}$ , $I_{out} = 10\text{ mA}$<br>3.3 V<br>$V_{in} = 13.5\text{ V}$ , $I_{out} = 1\text{ mA}$ to $30\text{ mA}$<br>$V_{in} = 4.3\text{ V}$ to $40\text{ V}$ , $I_{out} = 10\text{ mA}$ | $V_{out}$    | 4.80<br>4.80<br>3.17<br>3.17 | 5.00<br>5.00<br>3.30<br>3.30 | 5.20<br>5.20<br>3.43<br>3.43 | V    |
| Line Regulation          | $V_{in} = V_{in, min}$ to $36\text{ V}$ , $I_{out} = 5\text{ mA}$ , $T_J = 25^\circ\text{C}$<br>$V_{in} = V_{in, min}$ to $36\text{ V}$ , $I_{out} = 5\text{ mA}$  | $Reg_{line}$ | –<br>–                       | 5<br>10                      | 20<br>30                     | mV   |
| Load Regulation          | $I_{out} = 1\text{ mA}$ to $25\text{ mA}$ , $T_J = 25^\circ\text{C}$<br>$I_{out} = 1\text{ mA}$ to $25\text{ mA}$  | $Reg_{load}$ | –<br>–                       | 3<br>10                      | 20<br>30                     | mV   |
| Dropout Voltage (Note 8) | $I_{out} = 20\text{ mA}$   | $V_{DO}$     | –                            | 65                           | 250                          | mV   |

## QUIESCENT CURRENT

|   |   |       |             |                   |                 |                                      |
|---|---|-------|-------------|-------------------|-----------------|--------------------------------------|
| Quiescent Current, $I_q = I_{in} - I_{out}$ | $I_{out} < 0.1\text{ mA}$ , $T_J < 85^\circ\text{C}$<br>$I_{out} < 1\text{ mA}$<br>$I_{out} < 30\text{ mA}$ | $I_q$ | –<br>–<br>– | 150<br>160<br>0.8 | 170<br>200<br>4 | $\mu\text{A}$<br>$\mu\text{A}$<br>mA |
|---|---|-------|-------------|-------------------|-----------------|--------------------------------------|

## CURRENT LIMIT PROTECTION

|               |  |           |    |   |   |    |
|---------------|--|-----------|----|---|---|----|
| Current Limit | $V_{out} = V_{out, nom} - 100\text{ mV}$ | $I_{LIM}$ | 30 | – | – | mA |
|---------------|--|-----------|----|---|---|----|

## PSRR

|                               |   |      |   |    |   |    |
|-------------------------------|---|------|---|----|---|----|
| Power Supply Ripple Rejection | $f = 100\text{ Hz}$ , $0.5\text{ V}_{pp}$ | PSRR | – | 60 | – | dB |
|-------------------------------|---|------|---|----|---|----|

## THERMAL SHUTDOWN

|                                       |  |          |     |     |     |                  |
|---------------------------------------|--|----------|-----|-----|-----|------------------|
| Thermal Shutdown Temperature (Note 9) |  | $T_{SD}$ | 151 | 175 | 195 | $^\circ\text{C}$ |
|---------------------------------------|--|----------|-----|-----|-----|------------------|

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 tested at  $T_A \approx T_J$ . Low duty cycle pulse techniques are used during testing to maintain the junction temperature as close to ambient as possible.
- Measured when output voltage falls 100 mV below the regulated voltage at  $V_{in} = 13.5\text{ V}$ . If  $V_{out} < 5\text{ V}$ , then  $V_{DO} = V_{in} - V_{out}$ . Maximum dropout voltage value is limited by minimum input voltage  $V_{in} = V_{out, nom} + 0.5\text{ V}$  recommended for guaranteed operation at maximum output current.
- Values based on design and/or characterization.

TYPICAL CHARACTERISTICS – 5.0 V VERSION

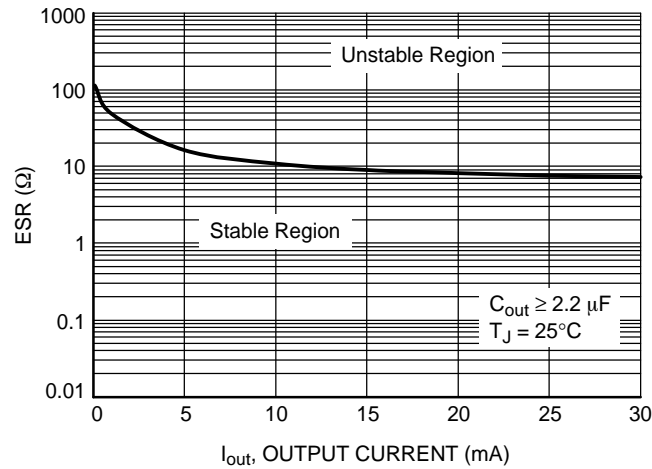


Figure 3. Output Stability with Output Capacitor ESR

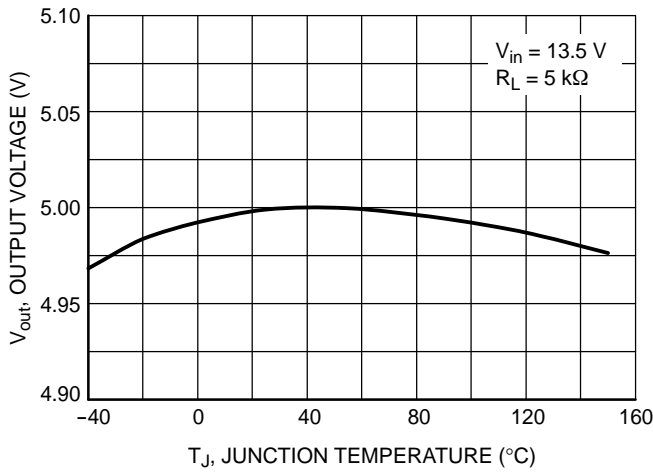


Figure 4. Output Voltage vs. Junction Temperature

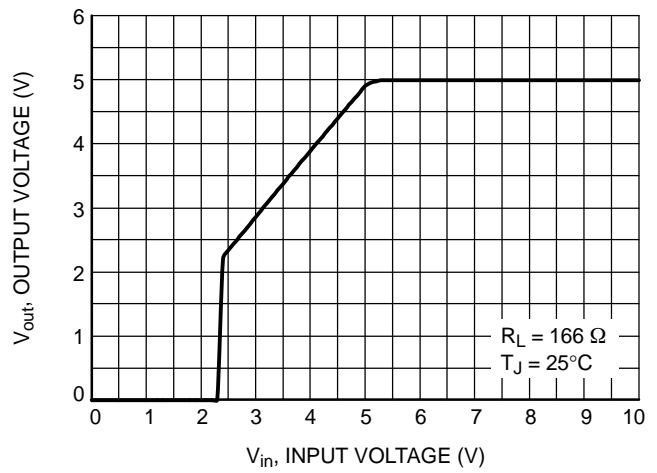


Figure 5. Output Voltage vs. Input Voltage

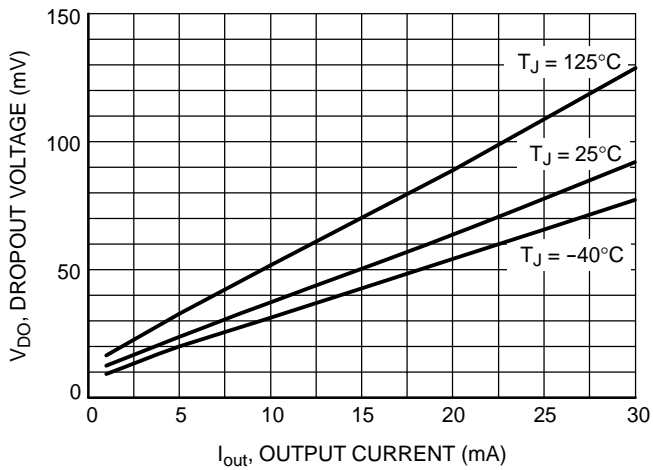


Figure 6. Dropout Voltage vs. Output Current

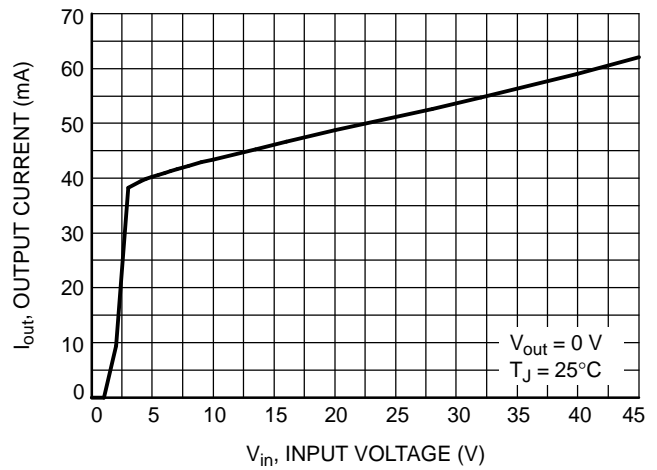
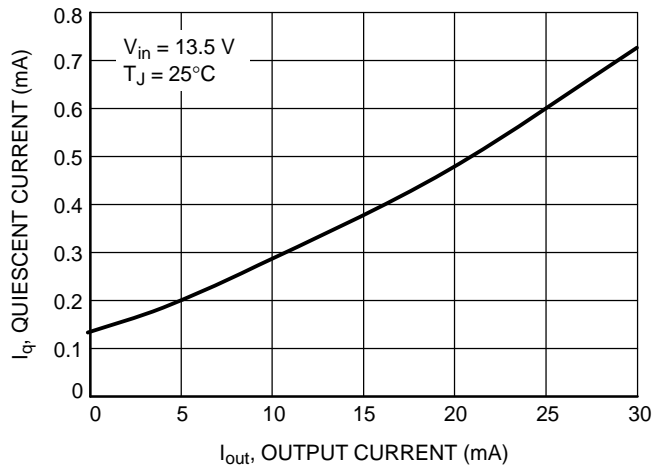


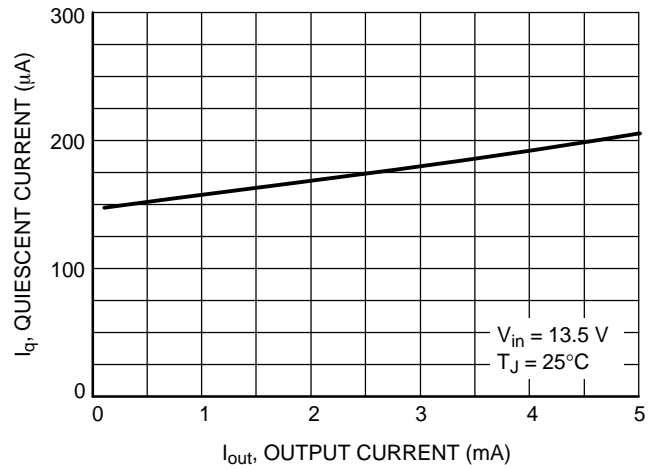
Figure 7. Maximum Output Current vs. Input Voltage

# NCV4294C

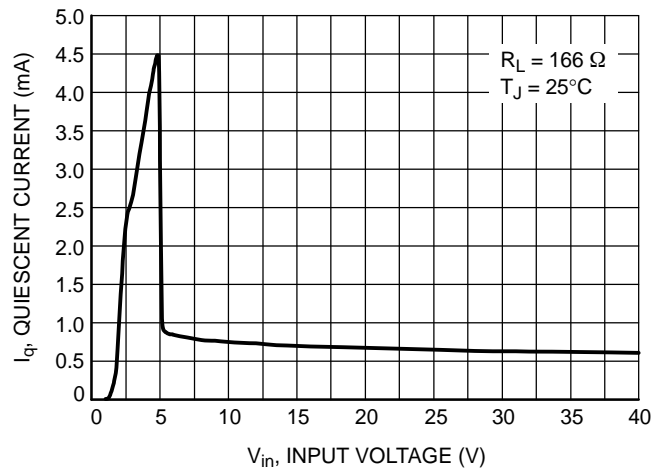
## TYPICAL CHARACTERISTICS – 5.0 V VERSION



**Figure 8. Quiescent Current vs. Output Current (High Load)**



**Figure 9. Quiescent Current vs. Output Current (Low Load)**



**Figure 10. Quiescent Current vs. Input Voltage**

TYPICAL CHARACTERISTICS – 3.3 V VERSION

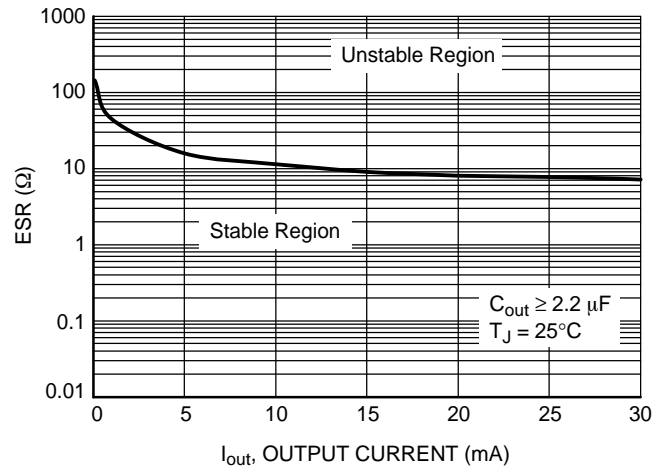


Figure 11. Output Stability with Output Capacitor ESR

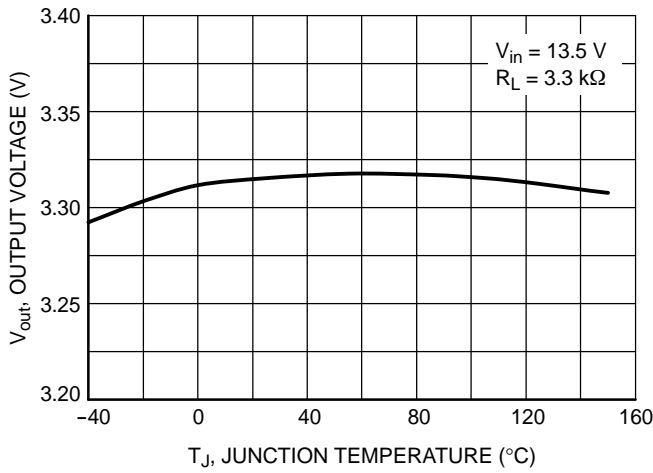


Figure 12. Output Voltage vs. Junction Temperature

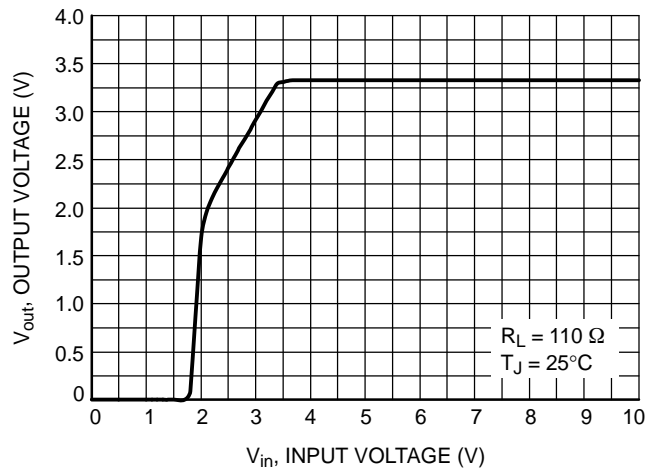


Figure 13. Output Voltage vs. Input Voltage

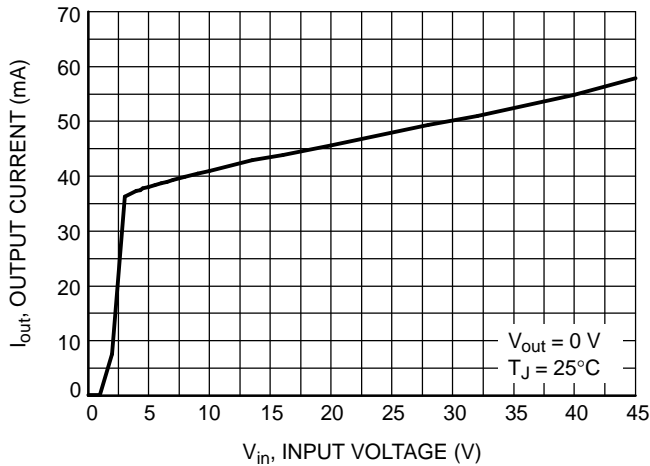


Figure 14. Maximum Output Current vs. Input Voltage

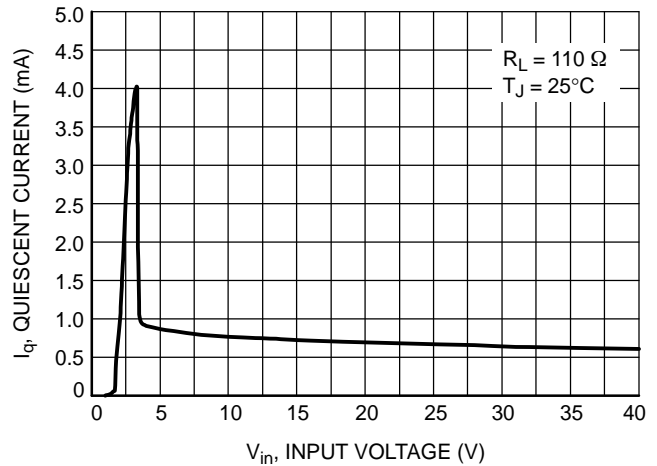
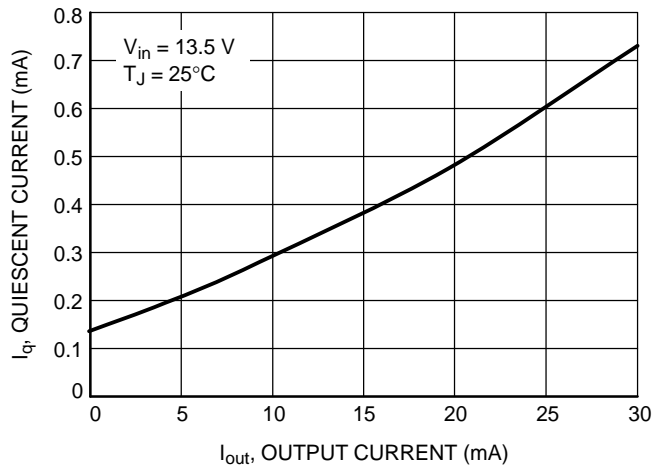


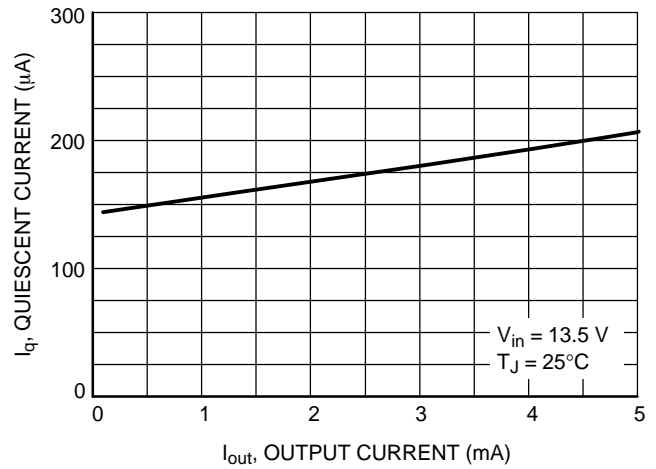
Figure 15. Quiescent Current vs. Input Voltage

# NCV4294C

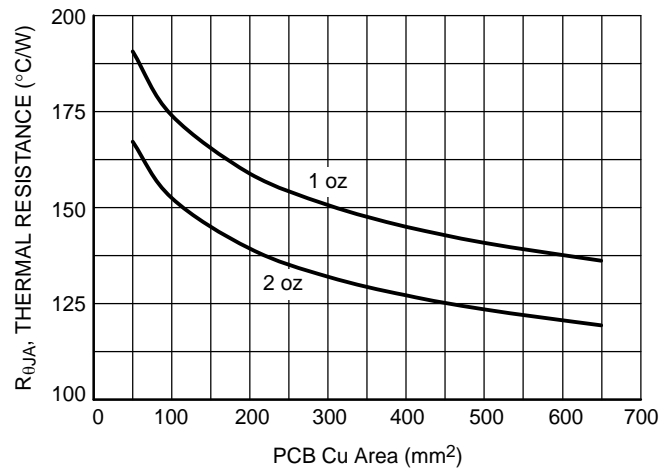
## TYPICAL CHARACTERISTICS – 3.3 V VERSION



**Figure 16. Quiescent Current vs. Output Current (High Load)**



**Figure 17. Quiescent Current vs. Output Current (Low Load)**



**Figure 18.  $R_{\theta JA}$  vs. PCB Cu Area**



**DEFINITIONS****General**

All measurements are performed using short pulse low duty cycle techniques to maintain junction temperature as close as possible to ambient temperature.

**Output Voltage**

The output voltage parameter is defined for specific temperature, input voltage and output current values or specified over Line, Load and Temperature ranges.

**Line Regulation**

The change in output voltage for a change in input voltage measured for specific output current over operating ambient temperature range.

**Load Regulation**

The change in output voltage for a change in output current measured for specific input voltage over operating ambient temperature range.

**Dropout Voltage**

The input to output differential at which the regulator output no longer maintains regulation against further reductions in input voltage. It is measured when the output drops 100 mV below its nominal value. The junction temperature, load current, and minimum input supply requirements affect the dropout level.

**Quiescent Current**

Quiescent Current ( $I_Q$ ) is the difference between the input current (measured through the LDO input pin) and the output load current.

**Current Limit**

Current Limit is value of output current by which output voltage drops 100 mV below its nominal value. It means that the device is capable to supply minimum 30 mA.

**PSRR**

Power Supply Rejection Ratio is defined as ratio of output voltage and input voltage ripple. It is measured in decibels (dB).

**Thermal Protection**

Internal thermal shutdown circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When activated at typically 175°C, the regulator turns off. This feature is provided to prevent failures from accidental overheating.

**Maximum Package Power Dissipation**

The power dissipation level is maximum allowed power dissipation for particular package or power dissipation at which the junction temperature reaches its maximum operating value, whichever is lower.

## APPLICATIONS INFORMATION

The NCV4294C low dropout regulator is self-protected with internal thermal shutdown and internal current limit. Typical characteristics are shown in Figure 3 to Figure 18.

### Input Decoupling (C<sub>in</sub>)

A ceramic or tantalum 0.1 µF capacitor is recommended and should be connected close to the NCV4294C package. Higher capacitance and lower ESR will improve the overall line and load transient response.

### Output Decoupling (C<sub>out</sub>)

The NCV4294C is a stable component and does not require a minimum Equivalent Series Resistance (ESR) for the output capacitor. Stability region of ESR vs. Output Current is shown in Figures 3 and 11. The minimum output decoupling value is 2.2 µF and can be augmented to fulfill stringent load transient requirements. The regulator works with ceramic chip capacitors as well as tantalum devices. Larger values improve noise rejection and load transient response.

### Thermal Considerations

As power in the NCV4294C increases, 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 the ambient temperature affect the rate of junction temperature rise for the part. When the NCV4294C has good thermal

conductivity through the PCB, the junction temperature will be relatively low with high power applications. The maximum dissipation the NCV4294C can handle is given by:

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

Since T<sub>J</sub> is not recommended to exceed 150°C, then the NCV4294C soldered on 645 mm<sup>2</sup>, 1 oz copper area, FR4 can dissipate up to 0.92 W when the ambient temperature (T<sub>A</sub>) is 25°C. See Figure 18 for R<sub>thJA</sub> versus PCB area. The power dissipated by the NCV4294C can be calculated from the following equations:

$$P_D \approx V_{in}(I_q @ I_{out}) + I_{out}(V_{in} - V_{out}) \quad (\text{eq. 2})$$

or

$$V_{in(MAX)} \approx \frac{P_{D(MAX)} + (V_{out} \times I_{out})}{I_{out} + I_q} \quad (\text{eq. 3})$$

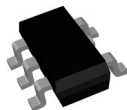
### Hints

V<sub>in</sub> 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 NCV4294C and make traces as short as possible.

## ORDERING INFORMATION

| Device          | Marking | Package             | Shipping <sup>†</sup> |
|-----------------|---------|---------------------|-----------------------|
| NCV4294CSN50T1G | 45V     | TSOP-5<br>(Pb-Free) | 3000 / Tape & Reel    |
| NCV4294CSN33T1G | 43V     |                     |                       |

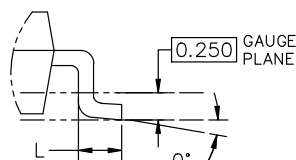
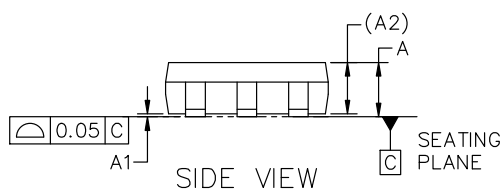
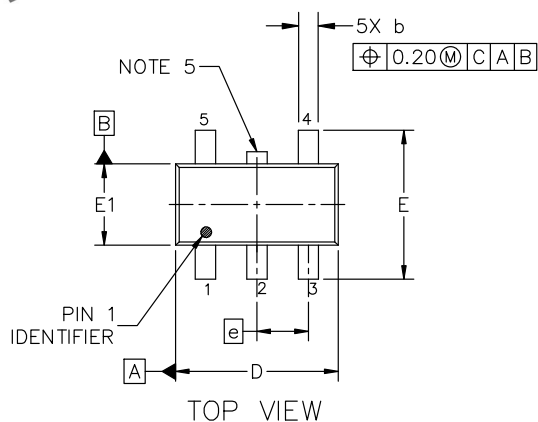
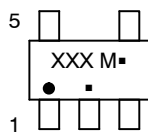
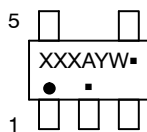
<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.


**TSOP-5 3.00x1.50x0.95, 0.95P**

CASE 483

ISSUE P

DATE 01 APR 2024


**GENERIC MARKING DIAGRAM\***


XXX = Specific Device Code

A = Assembly Location

Y = Year

W = Work Week

▪ = Pb-Free Package

(Note: Microdot may be in either location)

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

XXX = Specific Device Code

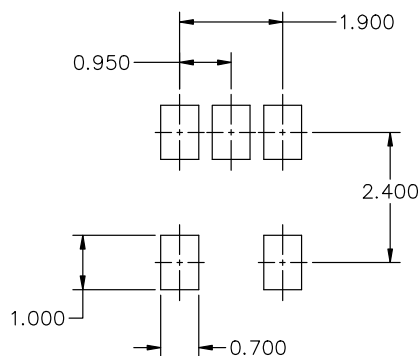
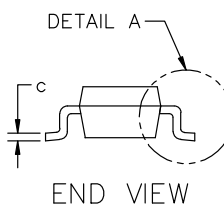
M = Date Code

▪ = Pb-Free Package

## NOTES:

1. DIMENSIONING AND TOLERANCING CONFORM TO ASME Y14.5-2018.
2. ALL DIMENSION ARE IN MILLIMETERS (ANGLES IN DEGREES).
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OF GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION D.
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.        | NOM.  | MAX.  |
| A   | 0.900       | 1.000 | 1.100 |
| A1  | 0.010       | 0.055 | 0.100 |
| A2  | 0.950 REF.  |       |       |
| b   | 0.250       | 0.375 | 0.500 |
| c   | 0.100       | 0.180 | 0.260 |
| D   | 2.850       | 3.000 | 3.150 |
| E   | 2.500       | 2.750 | 3.000 |
| E1  | 1.350       | 1.500 | 1.650 |
| e   | 0.950 BSC   |       |       |
| L   | 0.200       | 0.400 | 0.600 |
| θ   | 0°          | 5°    | 10°   |



\* FOR ADDITIONAL INFORMATION ON OUR Pb-FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ON SEMICONDUCTOR SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERM/D.

DOCUMENT NUMBER: 98ARB18753C

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DESCRIPTION: TSOP-5 3.00x1.50x0.95, 0.95P

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