# NCV8603

# 300 mA High Performance CMOS LDO Regulator with Enable and Enhanced ESD Protection

The NCV8603 provides 300 mA of output current at fixed voltage options. It is designed for portable battery powered applications and offers high performance features such as low power operation, fast enable response time, and low dropout.

The device is designed to be used with low cost ceramic capacitors and is packaged in the TSOP−5/SOT23−5.

### Features

- Fast Enable Turn−on Time of 15 μs
- Wide Supply Voltage Range Operating Range
- Excellent Line and Load Regulation
- Typical Noise Voltage of 50 $\mu V_{rms}$ without a Bypass Capacitor
- Enhanced ESD Protection (HBM 3.5 kV, MM 400 V)
- NCV Prefix for Automotive and Other Applications Requiring Site and Change Controls
- These are Pb−Free Devices

### Typical Applications

- SMPS Post−Regulation
- Hand−held Instrumentation & Audio Players
- Noise Sensitive Circuits – VCO, RF Stages, etc.
- Camcorders and Cameras
- Portable Computing

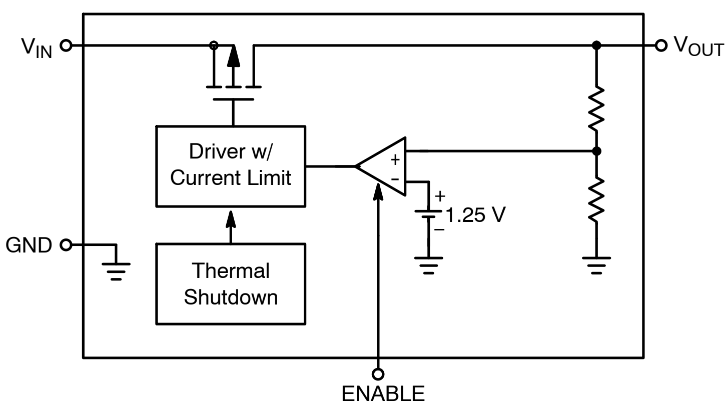


**Figure 1. Simplified Block Diagram**

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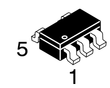
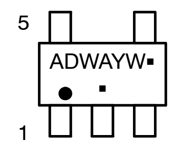
**http://onsemi.com**




**TSOP−5**
**SN SUFFIX**
**CASE 483**

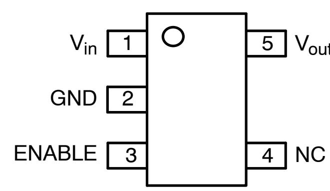
### MARKING DIAGRAM




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

(Note: Microdot may be in either location)

### PIN CONNECTIONS




(Top View)

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 9 of this data sheet.

## PIN FUNCTION DESCRIPTION

| Pin No. | Pin Name | Description |
|---|---|---|
| 1 | $V_{in}$ | Positive Power Supply Input |
| 2 | GND | Power Supply Ground; Device Substrate |
| 3 | ENABLE | The Enable Input places the device into low−power standby when pulled to logic low (< 0.4 V). Connect to $V_{in}$ if the function is not used. |
| 4 | NC | No Connection (Note 1) |
| 5 | $V_{out}$ | Regulated Output Voltage |

1. True no connect. Printed circuit board traces are allowable.

## ABSOLUTE MAXIMUM RATINGS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Input Voltage (Note 2) | $V_{in}$ | −0.3 to 6.5 | V |
| Output, Enable | $V_{out}$, ENABLE | −0.3 to 6.5 (or $V_{in}$ + 0.3) Whichever is Lower | V |
| Maximum Junction Temperature | $T_{J(max)}$ | 150 | °C |
| Storage Temperature | $T_{STG}$ | −65 to 150 | °C |
| ESD Capability, Human Body Model (Note 3) | $ESD_{HBM}$ | 3500 | V |
| ESD Capability, Machine Model (Note 3) | $ESD_{MM}$ | 400 | V |
| Moisture Sensitivity Level | MSL | MSL1/260 | − |

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.
2. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
3. 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: ≤150 mA per JEDEC standard: JESD78.

## THERMAL CHARACTERISTICS

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Thermal Characteristics, TSOP−5 (Note 4)<br>Thermal Resistance, Junction−to−Air (Note 5) | $R_{\theta JA}$ | 215 | °C/W |

4. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
5. Value based on copper area of 645 $mm^2$ (or 1 $in^2$) of 1 oz copper thickness.

## OPERATING RANGES (Note 6)

| Rating | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Input Voltage (Note 7) | $V_{in}$ | 1.75 | 6 | V |
| Output Current | $I_{out}$ | 0 | 300 | mA |
| Ambient Temperature | $T_A$ | −40 | 125 | °C |

6. Refer to ELECTRICAL CHARACTERISTICS and APPLICATION INFORMATION for Safe Operating Area.
7. Minimum $V_{in}$ = 1.75 V or ($V_{out}$ + $V_{DO}$), whichever is higher.

**ELECTRICAL CHARACTERISTICS** ($V_{in}$ = $V_{out}$ + 0.5 V (fixed version), $C_{in}$ = $C_{out}$ =1.0 μF, for typical values $T_A$ = 25°C, for min/max values $T_A$ = −40°C to 125°C, unless otherwise specified.) (Note 8)

| Characteristic | Symbol | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Regulator Output** | | | | | | |
| Output Voltage | $V_{out}$ | $I_{out}$ = 1.0 mA to 300 mA<br>$V_{in}$ = ($V_{out}$ + 0.5 V) to 6.0 V | (−3%)<br>3.201 | 3.3 | (+3%)<br>3.399 | V |
| Power Supply Ripple Rejection (Note 9) | PSRR | $I_{out}$ = 1.0 mA to 150 mA<br>$V_{in}$ = $V_{out}$ + 1 V + 0.5 $V_{p-p}$<br>f = 120 Hz<br>f = 1.0 kHz<br>f = 10 kHz | –<br>–<br>– | 62<br>55<br>38 | –<br>–<br>– | dB |
| Line Regulation | $Reg_{line}$ | $V_{in}$ = 1.750 V to 6.0 V,<br>$I_{out}$ = 1.0 mA | – | 1.0 | 10 | mV |
| Load Regulation | $Reg_{load}$ | $I_{out}$ = 1.0 mA to 300 mA | – | 2.0 | 45 | mV |
| Output Noise Voltage (Note 9) | $V_n$ | f = 10 Hz to 100 kHz | – | 50 | – | $\mu V_{rms}$ |
| Output Short Circuit Current | $I_{sc}$ | | 350 | 650 | 900 | mA |
| Dropout Voltage | $V_{DO}$ | Measured at: $V_{out}$ – 2.0%<br>$I_{out}$ = 300 mA | – | 157 | 230 | mV |
| Output Current Limit (Note 9) | $I_{out(max)}$ | | 300 | 650 | – | mA |
| **General** | | | | | | |
| Disable Current | $I_{DIS}$ | ENABLE = 0 V, Vin = 6 V<br>−40°C ≤ $T_A$ ≤ 85°C | – | 0.01 | 1.0 | μA |
| Ground Current | $I_{GND}$ | ENABLE = 0.9 V,<br>$I_{out}$ = 1.0 mA to 300 mA | – | 145 | 180 | μA |
| Thermal Shutdown Temperature (Note 9) | $T_{SD}$ | | – | 175 | – | °C |
| Thermal Shutdown Hysteresis (Note 9) | $T_{SH}$ | | – | 10 | – | °C |
| **Chip Enable** | | | | | | |
| ENABLE Input Threshold Voltage<br>Voltage Increasing, Logic High<br>Voltage Decreasing, Logic Low | $V_{th(EN)}$ | | <br>0.9<br>– | <br>–<br>– | <br>–<br>0.4 | V |
| Enable Input Bias Current (Note 9) | $I_{EN}$ | | – | 3.0 | 100 | nA |
| **Timing** | | | | | | |
| Output Turn On Time (Note 9) | $t_{EN}$ | ENABLE = 0 V to $V_{in}$ | – | 15 | 25 | μs |

8. 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.
9. Values based on design and/or characterization.

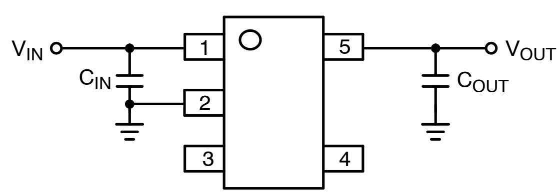



**Figure 2. Typical Application Circuit**

## TYPICAL CHARACTERISTICS

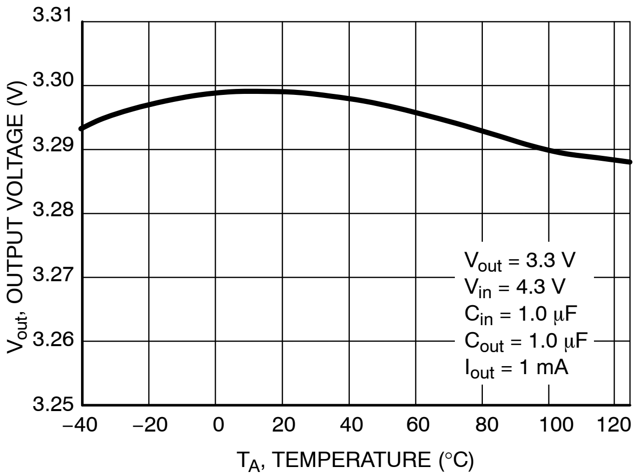



**Figure 3. $V_{out}$ vs. Temperature**

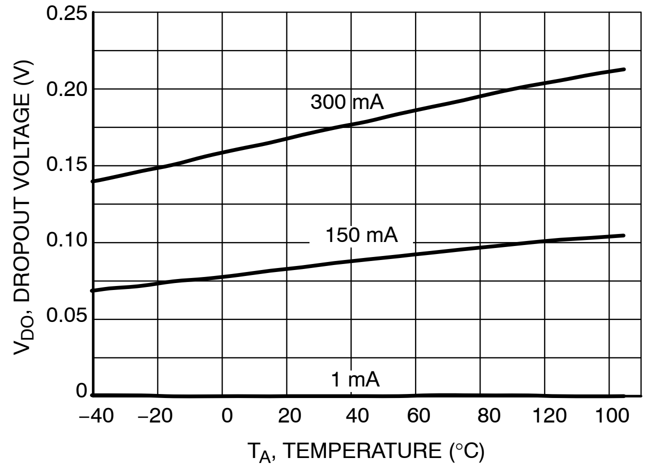



**Figure 4. Dropout Voltage vs. Temperature (Over Current Range)**

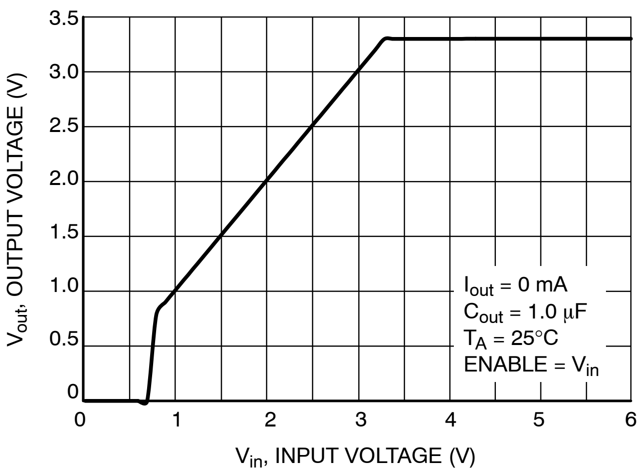



**Figure 5. Output Voltage vs. Input Voltage**

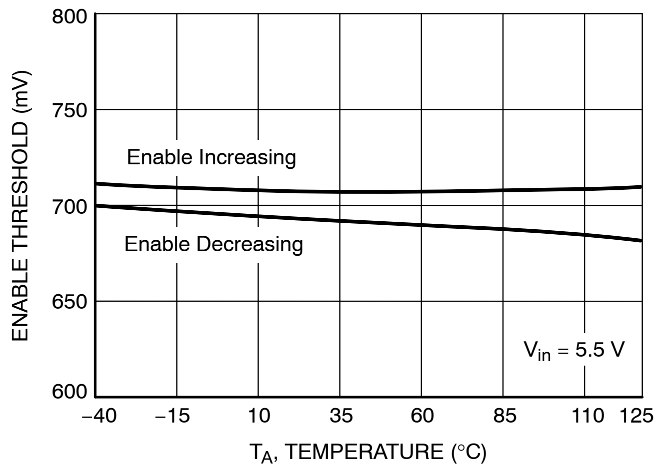



**Figure 6. Enable Threshold vs. Temperature**

## TYPICAL CHARACTERISTICS

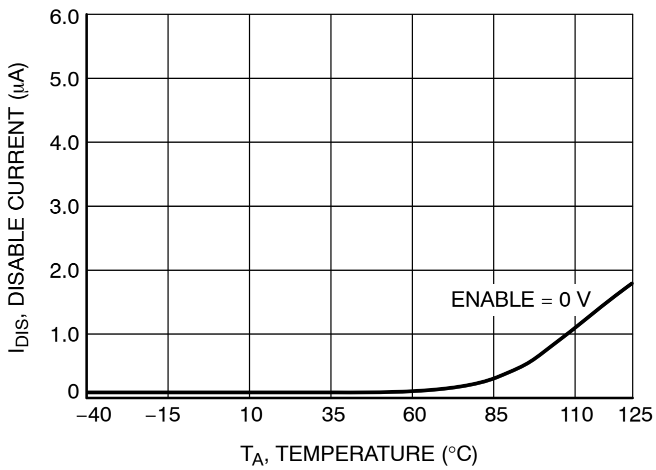



**Figure 7. Ground Current (Sleep Mode) vs. Temperature**

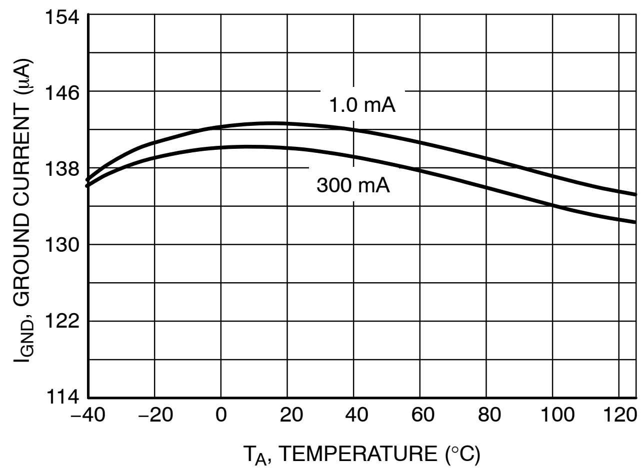



**Figure 8. Ground Current vs. Temperature**

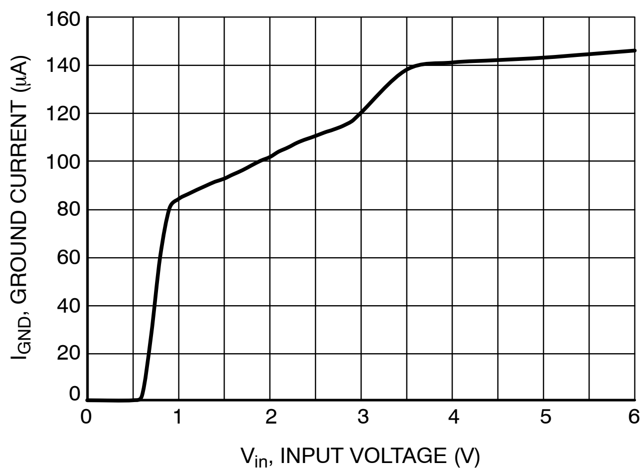



**Figure 9. Ground Current vs. Input Voltage**

## TYPICAL CHARACTERISTICS

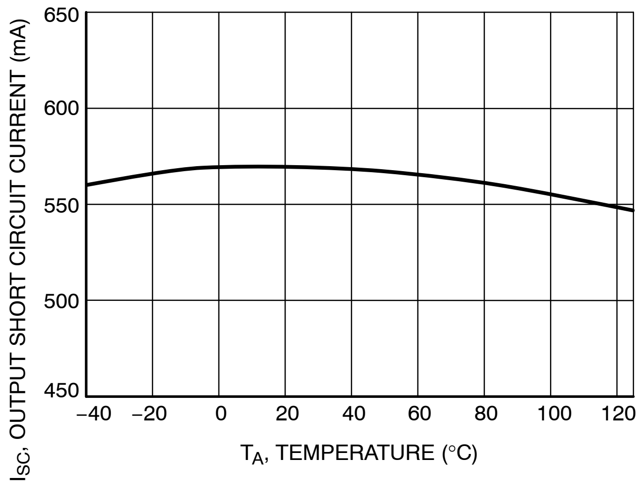



**Figure 10. Output Short Circuit Current vs. Temperature**

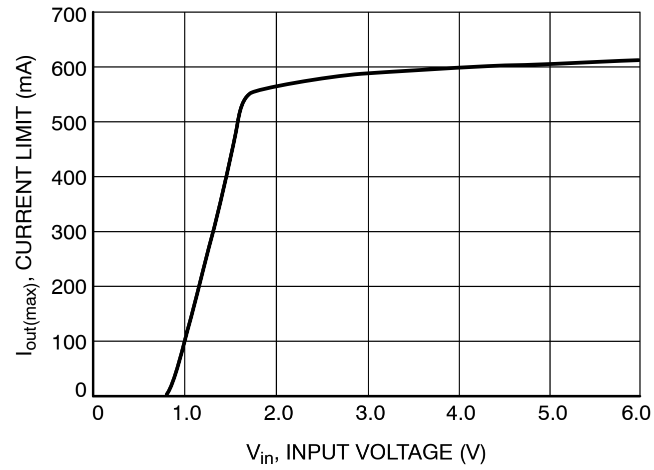



**Figure 11. Current Limit vs. Input Voltage**

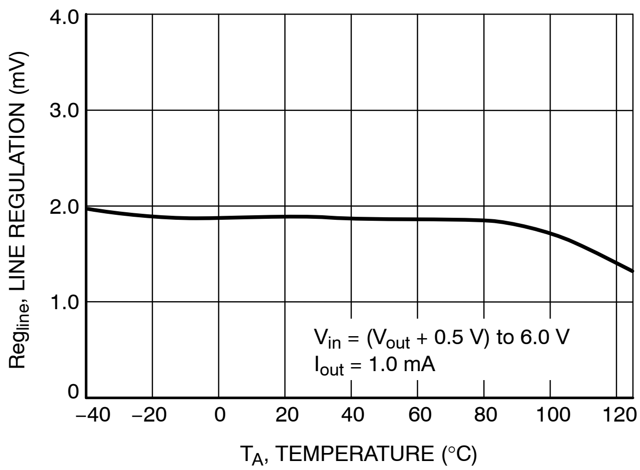



**Figure 12. Line Regulation vs. Temperature**

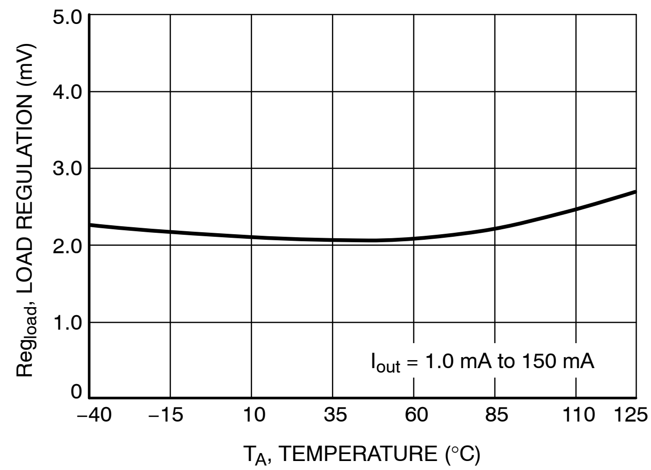



**Figure 13. Load Regulation vs. Temperature**

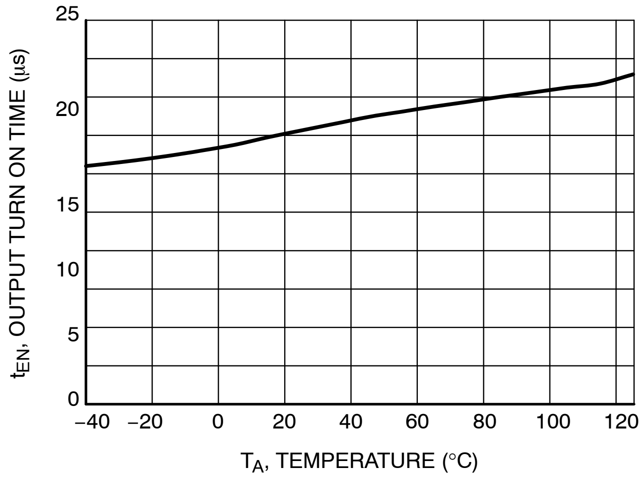



**Figure 14. Output Turn On Time vs. Temperature**

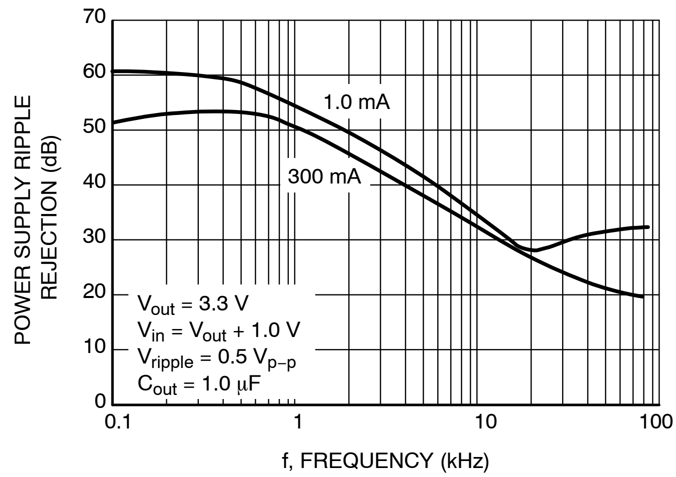



**Figure 15. Power Supply Ripple Rejection vs. Frequency**

## TYPICAL CHARACTERISTICS

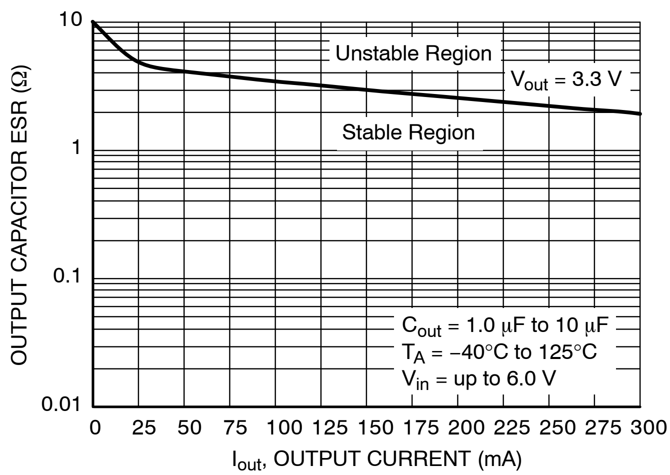



**Figure 16. Output Stability with Output Capacitor ESR over Output Current**

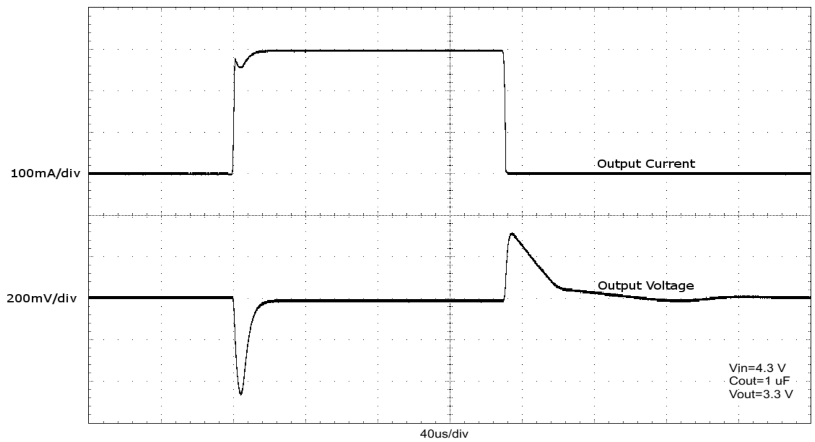



**Figure 17. Load Transient Response (1.0 μF)**

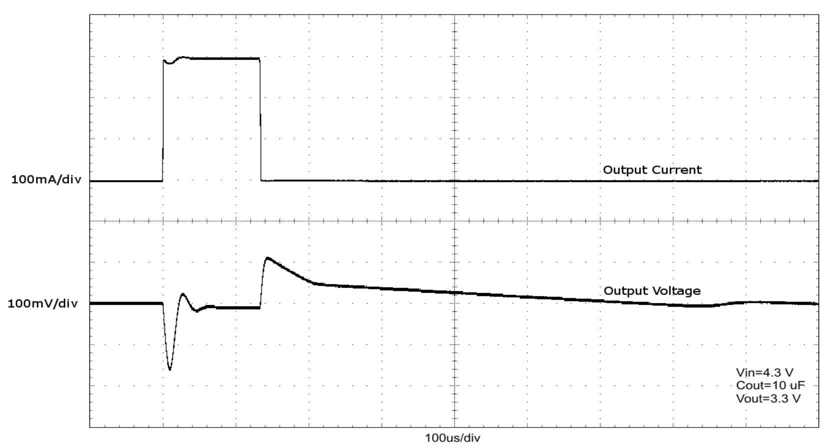



**Figure 18. Load Transient Response (10 μF)**

## DEFINITIONS

### Load Regulation

The change in output voltage for a change in output load current at a constant temperature.

### Dropout Voltage

The input/output differential at which the regulator output no longer maintains regulation against further reductions in input voltage. Measured when the output drops 2% below its nominal. The junction temperature, load current, and minimum input supply requirements affect the dropout level.

### Output Noise Voltage

This is the integrated value of the output noise over a specified frequency range. Input voltage and output load current are kept constant during the measurement. Results are expressed in $\mu V_{rms}$ or nV √ Hz.

### Ground Current

Ground Current is the current that flows through the ground pin when the regulator operates without a load on its output ($I_{GND}$). This consists of internal IC operation, bias, etc. It is actually the difference between the input current (measured through the LDO input pin) and the output load current. If the regulator has an input pin that reduces its internal bias and shuts off the output (enable/disable function), this term is called the standby current ($I_{STBY}$.)

### Line Regulation

The change in output voltage for a change in input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average junction temperature is not significantly affected.

### Line Transient Response

Typical output voltage overshoot and undershoot response when the input voltage is excited with a given slope.

### Load Transient Response

Typical output voltage overshoot and undershoot response when the output current is excited with a given slope between no−load and full−load conditions.

### 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 at which the junction temperature reaches its maximum operating value.

## APPLICATIONS INFORMATION

The NCV8603 series regulator is self−protected with internal thermal shutdown and internal current limit. Typical application circuits are shown in Figures NO TAG and NO TAG.

### Input Decoupling ($C_{in}$)

A ceramic or tantalum 1.0 μF capacitor is recommended and should be connected close to the NCV8603 package. Higher capacitance and lower ESR will improve the overall line transient response.

### Output Decoupling ($C_{out}$)

The NCV8603 is a stable component and does not require a minimum Equivalent Series Resistance (ESR) for the output capacitor. The minimum output decoupling value is 1.0 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 regulation transient response. Figure 16 shows the stability region for a range of operating conditions and ESR values.

### No−Load Regulation Considerations

The NCV8603 adjustable regulator will operate properly under conditions where the only load current is through the resistor divider that sets the output voltage. However, in the case where the NCV8603 is configured to provide a 1.250 V output, there is no resistor divider. If the part is enabled under no−load conditions, leakage current through the pass transistor at junction temperatures above 85°C can approach several microamperes, especially as junction temperature approaches 150°C. If this leakage current is not directed into a load, the output voltage will rise up to a level approximately 20 mV above nominal.

The NCV8603 contains an overshoot clamp circuit to improve transient response during a load current step release. When output voltage exceeds the nominal by approximately 20 mV, this circuit becomes active and clamps the output from further voltage increase. Tying the ENABLE pin to $V_{in}$ will ensure that the part is active whenever the supply voltage is present, thus guaranteeing that the clamp circuit is active whenever leakage current is present.

When the NCV8603 adjustable regulator is disabled, the overshoot clamp circuit becomes inactive and the pass transistor leakage will charge any capacitance on $V_{out}$. If no load is present, the output can charge up to within a few millivolts of $V_{in}$. In most applications, the load will present some impedance to $V_{out}$ such that the output voltage will be inherently clamped at a safe level. A minimum load of 10 μA is recommended.

### Noise Decoupling

The NCV8603 is a low noise regulator and needs no external noise reduction capacitor. Unlike other low noise regulators which require an external capacitor and have slow startup times, the NCV8603 operates without a noise reduction capacitor, has a typical 15 μs start up delay and achieves a 50 $\mu V_{rms}$ overall noise level between 10 Hz and 100 kHz.

### Enable Operation

The enable pin will turn the regulator on or off. The threshold limits are covered in the electrical characteristics table in this data sheet. The turn−on/turn−off transient voltage being supplied to the enable pin should exceed a slew rate of 10 mV/μs to ensure correct operation. If the enable function is not to be used then the pin should be connected to $V_{in}$.

### Thermal

As power in the NCV8603 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 NCV8603 has good thermal conductivity through the PCB, the junction temperature will be relatively low with high power applications. The maximum dissipation the NCV8603 can handle is given by:

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

Since $T_J$ is not recommended to exceed 125°C ($T_{J(MAX)}$), then the NCV8603 can dissipate up to 465 mW when the ambient temperature ($T_A$) is 25°C and the device is assembled on 1 oz PCB with 645 $mm^2$ area.

The power dissipated by the NCV8603 can be calculated from the following equations:

$$P_D \approx V_{IN}(I_{GND@IOUT}) + I_{OUT}(V_{IN} - V_{OUT}) \qquad \text{(eq. 2)}$$

or

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

### 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 NCV8603, and make traces as short as possible.

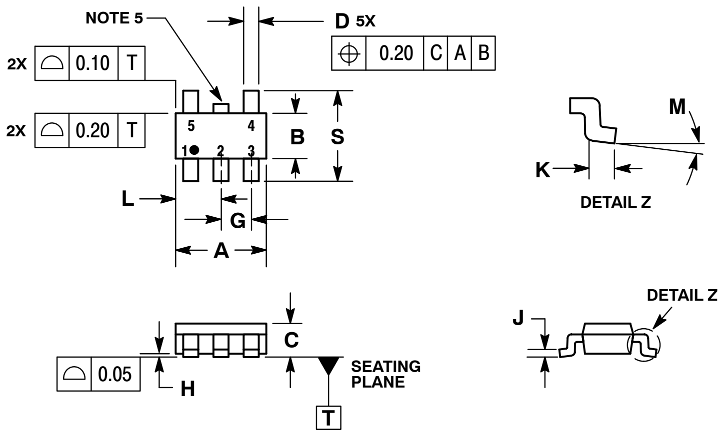
### DEVICE ORDERING INFORMATION

| Device | Marking Code | Version | Package | Shipping* |
|---|---|---|---|---|
| NCV8603SN33T1G | ADW | 3.3 V | TSOP−5 (Pb−Free) | 3000/Tape & Reel |

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

# PACKAGE DIMENSIONS

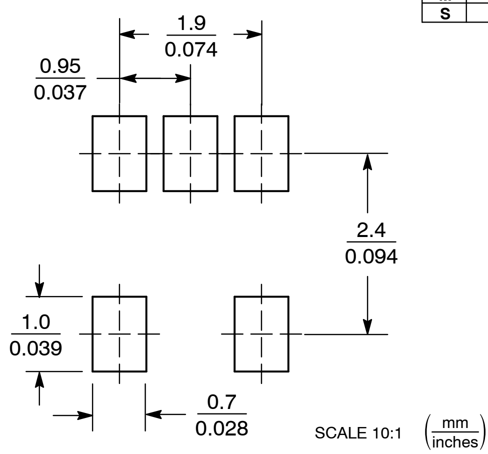
**TSOP−5**
CASE 483−02
ISSUE H




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.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

| | MILLIMETERS | |
|---|---|---|
| DIM | MIN | MAX |
| A | 3.00 BSC | |
| B | 1.50 BSC | |
| 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 |
| L | 1.25 | 1.55 |
| M | 0 ° | 10 ° |
| S | 2.50 | 3.00 |

## SOLDERING 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.



## PUBLICATION ORDERING INFORMATION

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