

NCP4555, NCP4586

100 mA and 150 mA CMOS LDOs with Shutdown and Error Output

The NCP4555 and NCP4586 are high accuracy (typically $\pm 0.5\%$) CMOS upgrades for older (bipolar) low dropout regulators. Designed specifically for battery-operated systems, the devices' CMOS construction eliminates wasted ground current, significantly extending battery life. Total supply current is typically 50 μA at full load (20 to 60 times lower than in bipolar regulators).

The devices' key features include ultra low noise operation, very low dropout voltage – typically 180 mV (NCP4555) and 270 mV (NCP4586) at full load – and fast response to step changes in load. An error output ($\overline{\text{ERROR}}$) is asserted when the devices are out-of-regulation (due to a low input voltage or excessive output current). $\overline{\text{ERROR}}$ can be used as a low battery warning or as a processor $\overline{\text{RESET}}$ signal (with the addition of an external RC network). Supply current is reduced to 0.5 μA (max) and both V_{OUT} and $\overline{\text{ERROR}}$ are disabled when the shutdown input is low. The devices incorporate both over-temperature and over-current protection.

The NCP4555 and NCP4586 are stable with an output capacitor of only 1.0 μF and have a maximum output current of 100 mA and 150 mA, respectively. For higher output current regulators, please see the NCP4569 ($I_{\text{OUT}} = 300 \text{ mA}$) data sheet.

Features

- Zero Ground Current for Longer Battery Life
- Very Low Dropout Voltage
- Guaranteed 100 mA and 150 mA Output (NCP4555 and NCP4586 Respectively)
- High Output Voltage Accuracy
- Standard or Custom Output Voltages
- Power-Saving Shutdown Mode
- $\overline{\text{ERROR}}$ Output Can Be Used as a Low Battery Detector, or Processor Reset Generator
- Over-Current and Over-Temperature Protection
- Space-Saving 5-Pin SOT-23A Package
- Pin Compatible Upgrades for Bipolar Regulators

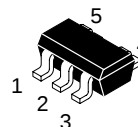
Applications

- Battery-Operated Systems
- Portable Computers
- Medical Instruments
- Instrumentation
- Cellular/GSMS/PHS Phones
- Linear Post-Regulators for SMPS
- Pagers



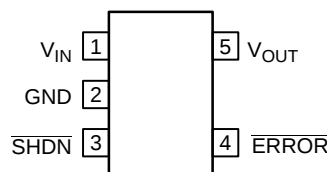
ON Semiconductor™

<http://onsemi.com>



SOT-23
SN SUFFIX
CASE 1212

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 11 of this data sheet.

DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 11 of this data sheet.

NCP4555, NCP4586

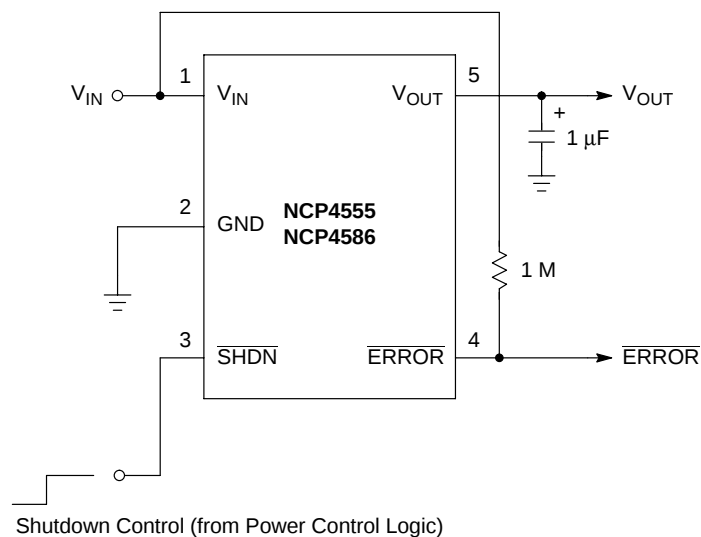


Figure 1. Typical Application

ABSOLUTE MAXIMUM RATINGS*

Rating	Symbol	Value	Unit	
Input Voltage	–	6.5	V	
Output Voltage	–	–0.3 to V _{IN} + 0.3	V	
Power Dissipation	–	Internally Limited	–	
Operating Temperature Range	T _A	–40 < T _J < 125	°C	
Storage Temperature	T _{stg}	–65 to +150	°C	
Maximum Voltage on any Pin	–	V _{IN} + 0.3 to – 0.3	V	
Lead Temperature (Soldering, 10 Sec.)	–	+260	°C	
ESD Withstand Voltage	Human Body Model (Note 1.)	V _{ESD}	> 2000	V
Latch–Up Performance (Note 2.)	I _{LATCH–UP}		mA	
Positive		250		
Negative		> 500		

*Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions above those indicated in the operation sections of the specifications is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

1. Tested to EIA/JESD22–A114–A
2. Tested to EIA/JESD78

NCP4555, NCP4586

ELECTRICAL CHARACTERISTICS ($V_{IN} = V_{OUT} + 1.0\text{ V}$, $I_L = 100\text{ }\mu\text{A}$, $C_L = 3.3\text{ }\mu\text{F}$, $\overline{\text{SHDN}} > V_{IH}$, $T_A = 25^\circ\text{C}$, unless otherwise noted. **Boldface** type specifications apply for junction temperatures of -40°C to $+125^\circ\text{C}$.)

Characteristics	Test Conditions	Symbol	Min	Typ	Max	Unit
Input Operating Voltage	—	V_{IN}	—	—	6.0	V
Maximum Output Current NCP4555 NCP4586	—	I_{OUTMAX}	100 150	— —	— —	mA
Output Voltage	Note 3.	V_{OUT}	$V_R - 2.5\%$	$V_R \pm 0.5\%$	$V_R + 2.5\%$	V
V_{OUT} Temperature Coefficient	Note 4.	TCV_{OUT}	— —	20 40	— —	ppm/ $^\circ\text{C}$
Line Regulation	$(V_R + 1.0\text{ V}) \leq V_{IN} \leq 6.0\text{ V}$	$\Delta V_{OUT}/\Delta V_{IN}$	—	0.05	0.35	%
Load Regulation NCP4555 NCP4586	$I_L = 0.1\text{ mA}$ to I_{OUTMAX} $I_L = 0.1\text{ mA}$ to I_{OUTMAX} Note 5.	$\Delta V_{OUT}/V_{OUT}$	— —	0.5 0.5	2.0 3.0	%
Dropout Voltage NCP4555, NCP4586 NCP4586	$I_L = 100\text{ }\mu\text{A}$ $I_L = 20\text{ mA}$ $I_L = 50\text{ mA}$ $I_L = 100\text{ mA}$ $I_L = 150\text{ mA}$ Note 6.	$V_{IN} - V_{OUT}$	— — — — —	2.0 65 85 180 270	— — 120 250 400	mV
Supply Current (Note 10.)	$\overline{\text{SHDN}} = V_{IH}$, $I_L = 0$	I_{IN}	—	50	80	μA
Shutdown Supply Current	$\overline{\text{SHDN}} = 0\text{ V}$	I_{INSD}	—	0.05	0.5	μA
Power Supply Rejection Ratio	$F_{RE} \leq 1.0\text{ kHz}$	PSRR	—	64	—	dB
Output Short Circuit Current	$V_{OUT} = 0\text{ V}$	I_{OUTSC}	—	300	450	mA
Thermal Regulation	Notes 7., 8.	$\Delta V_{OUT}/\Delta P_D$	—	0.04	—	V/W
Thermal Shutdown Die Temperature	—	T_{SD}	—	160	—	$^\circ\text{C}$
Thermal Shutdown Hysteresis	—	ΔT_{SD}	—	10	—	$^\circ\text{C}$
Output Noise	$I_L = I_{OUTMAX}$ 470 pF from Bypass to GND	eN	—	260	—	nV/ $\sqrt{\text{Hz}}$

SHDN Input

SHDN Input High Threshold	$V_{IN} = 2.5\text{ V}$ to 6.5 V	V_{IH}	45	—	—	% V_{IN}
SHDN Input Low Threshold	$V_{IN} = 2.5\text{ V}$ to 6.5 V	V_{IL}	—	—	15	% V_{IN}

ERROR Output

Minimum V_{IN} Operating Voltage	—	V_{INMIN}	1.0	—	—	V
Output Logic Low Voltage	1.0 mA Flows to ERROR	V_{OL}	—	—	400	mV
ERROR Threshold Voltage	See Figure 3	V_{TH}	—	$0.95 \times V_R$	—	V
ERROR Positive Hysteresis	Note 9.	V_{HYS}	—	50	—	mV

3. V_R is the regulator output voltage setting. For example: $V_R = 2.5\text{ V}$, 2.7 V , 2.85 V , 3.0 V , 3.3 V , 3.6 V , 4.0 V , 5.0 V .

4. $T_C V_{OUT} = \frac{(V_{OUTMAX} - V_{OUTMIN}) \times 10^6}{V_{OUT} \times \Delta T}$

5. Regulation is measured at a constant junction temperature using low duty cycle pulse testing. Load regulation is tested over a load range from 0.1 mA to the maximum specified output current. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

6. Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value.

7. Thermal Regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a current pulse equal to I_{LMAX} at $V_{IN} = 6.0\text{ V}$ for $T = 10\text{ msec}$.

8. The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature, and the thermal resistance from junction-to-air (i.e. T_A , T_J , θ_{JA}). Exceeding the maximum allowable power dissipation causes the device to initiate thermal shutdown. Please see *Thermal Considerations* section of this data sheet for more details.

9. Hysteresis voltage is referenced by V_R .

10. Apply for Junction Temperatures of -40°C to $+85^\circ\text{C}$.

PIN DESCRIPTION

Pin Number	Symbol	Description
1	V_{IN}	Unregulated supply input.
2	GND	Ground terminal.
3	$\overline{SHDN}$	Shutdown control input. The regulator is fully enabled when a logic high is applied to this input. The regulator enters shutdown when a logic low is applied to this input. During shutdown, output voltage falls to zero, $\overline{ERROR}$ is open circuited and supply current is reduced to 0.5 μA (max).
4	$\overline{ERROR}$	Out-of-Regulation Flag. (Open drain output). This output goes low when V_{OUT} is out-of-tolerance by approximately -5.0% .
5	V_{OUT}	Regulated voltage output.

DETAILED DESCRIPTION

The NCP4555 and NCP4586 are precision fixed output voltage regulators. Unlike bipolar regulators, the NCP4555 and NCP4586 supply current does not increase with load current. In addition, V_{OUT} remains stable and within regulation at very low load currents (an important consideration in RTC and CMOS RAM battery back-up applications).

Figure 2 shows a typical application circuit. The regulator is enabled any time the shutdown input ($\overline{SHDN}$) is at or above V_{IH} , and shutdown (disabled) when $\overline{SHDN}$ is at or below V_{IL} . $\overline{SHDN}$ may be controlled by a CMOS logic gate, or I/O port of a microcontroller. If the $\overline{SHDN}$ input is not required, it should be connected directly to the input supply. While in shutdown, supply current decreases to 0.05 μA (typical), V_{OUT} falls to zero volts, and $\overline{ERROR}$ is open-circuited.

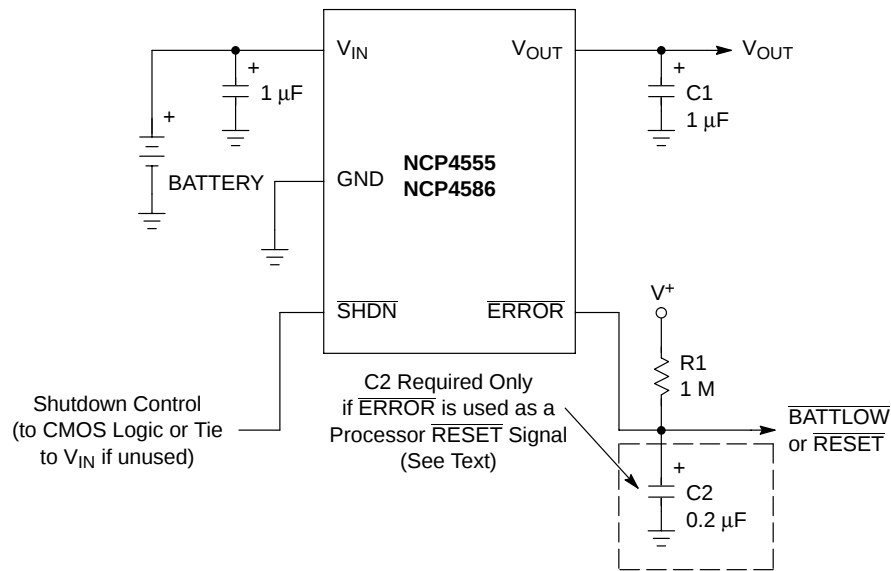


Figure 2. Typical Application Circuit

$\overline{ERROR}$ Open Drain Output

$\overline{ERROR}$ is driven low whenever V_{OUT} falls out of regulation by more than -5.0% (typical). This condition may be caused by low input voltage, output current limiting, or thermal limiting. The $\overline{ERROR}$ threshold is 5.0% below rated V_{OUT} regardless of the programmed output voltage value (e.g. $\overline{ERROR} = V_{OL}$ at 4.75 V (typ.) for a 5.0 V regulator and 2.85 V (typ.) for a 3.0 V regulator). $\overline{ERROR}$ output operation is shown in Figure 3.

Note that $\overline{ERROR}$ is active when V_{OUT} falls to V_{TH} , and inactive when V_{OUT} rises above V_{TH} by V_{HYS} .

As shown in Figure 2, $\overline{ERROR}$ can be used as a battery low flag, or as a processor $\overline{RESET}$ signal (with the addition of timing capacitor C2). $R1 \times C2$ should be chosen to maintain $\overline{ERROR}$ below V_{IH} of the processor $\overline{RESET}$ input for at least 200 msec to allow time for the system to stabilize. Pull-up resistor R1 can be tied to V_{OUT} , V_{IN} or any other voltage less than $(V_{IN} + 0.3 V)$.

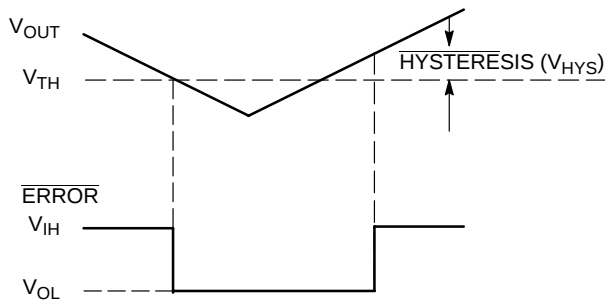


Figure 3. $\overline{\text{ERROR}}$ Output Operation

Output Capacitor

A 1.0 μF (min) capacitor from V_{OUT} to ground is recommended. The output capacitor should have an effective series resistance of 5.0 Ω or less, and a resonant frequency above 1.0 MHz. A 1.0 μF capacitor should be connected from V_{IN} to GND if there is more than 10 inches of wire between the regulator and the AC filter capacitor, or if a battery is used as the power source. Aluminum electrolytic or tantalum capacitor types can be used. (Since many aluminum electrolytic capacitors freeze at approximately -30°C , solid tantalums are recommended for applications operating below -25°C .) When operating from sources other than batteries, supply-noise rejection and transient response can be improved by increasing the value of the input and output capacitors and employing passive filtering techniques.

Thermal Considerations

Thermal Shutdown

Integrated thermal protection circuitry shuts the regulator off when die temperature exceeds 160°C . The regulator remains off until the die temperature drops to approximately 150°C .

Power Dissipation

The amount of power the regulator dissipates is primarily a function of input and output voltage, and output current. The following equation is used to calculate worst case *actual* power dissipation:

$$P_D \approx (V_{\text{INMAX}} - V_{\text{OUTMIN}})I_{\text{LOADMAX}}$$

Where : P_D = worst case actual power dissipation

V_{INMAX} = maximum voltage on V_{IN}

V_{OUTMIN} = minimum regulator output voltage

I_{LOADMAX} = maximum output (load) current

(eq. 1)

The maximum *allowable* power dissipation (Equation 2) is a function of the maximum ambient temperature (T_{AMAX}), the maximum allowable die temperature (125°C), and the thermal resistance from junction-to-air (θ_{JA}). The 5-Pin SOT-23 package has a θ_{JA} of approximately **200 $^\circ\text{C}/\text{Watt}$** when mounted on a single layer FR4 dielectric copper clad PC board.

$$P_{\text{DMAX}} = \frac{(T_{\text{JMAX}} - T_{\text{AMAX}})}{\theta_{\text{JA}}}$$

Where all terms are previously defined. (eq. 2)

Equation 1 can be used in conjunction with Equation 2 to ensure regulator thermal operation is within limits. For example:

$$\begin{aligned} \text{GIVEN : } V_{\text{INMAX}} &= 3.0 \text{ V} \pm 5.0\% \\ V_{\text{OUTMIN}} &= 2.7 \text{ V} - 2.5\% \\ I_{\text{LOAD}} &= 40 \text{ mA} \\ T_{\text{AMAX}} &= 55^\circ\text{C} \end{aligned}$$

- FIND : 1. Actual power dissipation.
2. Maximum allowable dissipation.

Actual power dissipation :

$$\begin{aligned} P_D &\approx (V_{\text{INMAX}} - V_{\text{OUTMIN}})I_{\text{LOADMAX}} \\ &= [(3.0 \times 1.05) - (2.7 \times .975)] 40 \times 10^{-3} \\ &= \underline{20.7 \text{ mW}} \end{aligned}$$

Maximum allowable power dissipation :

$$\begin{aligned} P_{\text{DMAX}} &= \frac{(T_{\text{JMAX}} - T_{\text{AMAX}})}{\theta_{\text{JA}}} \\ &= \frac{(125 - 55)}{220} \\ &= \underline{318 \text{ mW}} \end{aligned}$$

In this example, the NCP4555 dissipates a maximum of only 20.7 mW; far below the allowable limit of 318 mW. In a similar manner, Equation 1 and Equation 2 can be used to calculate maximum current and/or input voltage limits.

Layout Considerations

The primary path of heat conduction out of the package is via the package leads. Therefore, layouts having a ground plane, wide traces at the pads, and wide power supply bus lines combine to lower θ_{JA} and, therefore, increase the maximum allowable power dissipation limit.

TYPICAL CHARACTERISTICS

(Unless otherwise specified, all parts are measured at Temperature = 25°C)

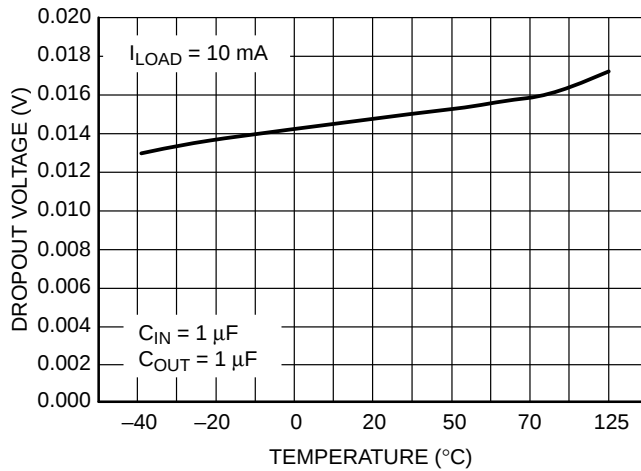


Figure 4. Dropout Voltage vs. Temperature ($V_{OUT} = 3.3\text{ V}$)

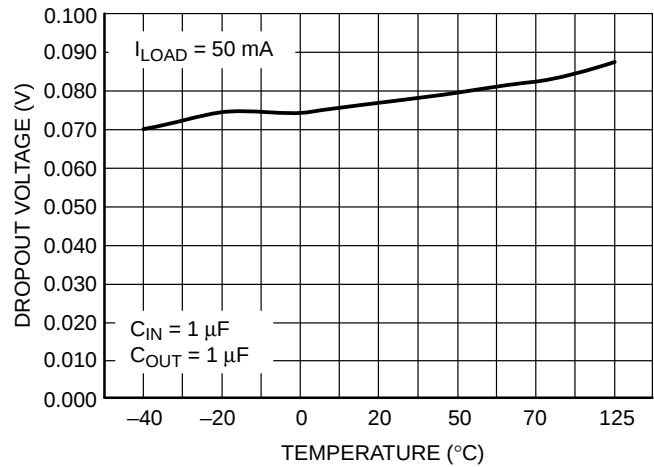


Figure 5. Dropout Voltage vs. Temperature ($V_{OUT} = 3.3\text{ V}$)

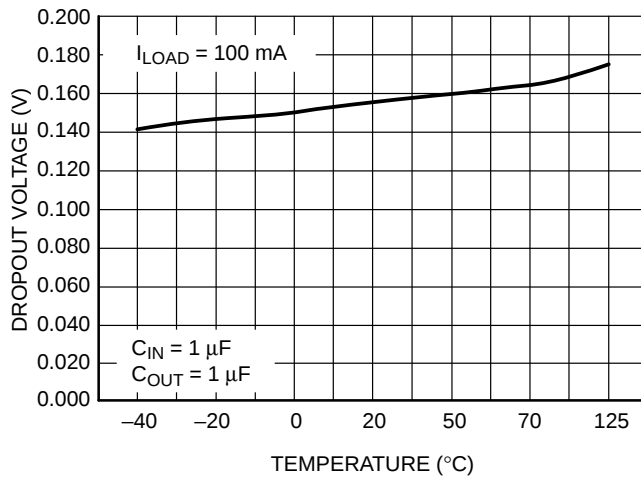


Figure 6. Dropout Voltage vs. Temperature ($V_{OUT} = 3.3\text{ V}$)

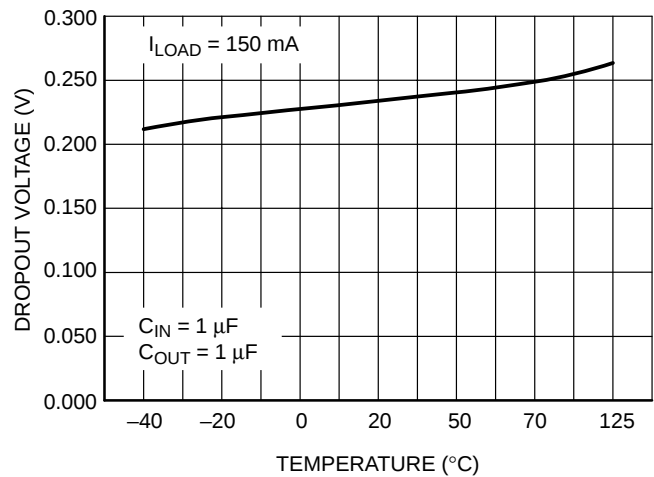


Figure 7. Dropout Voltage vs. Temperature ($V_{OUT} = 3.3\text{ V}$)

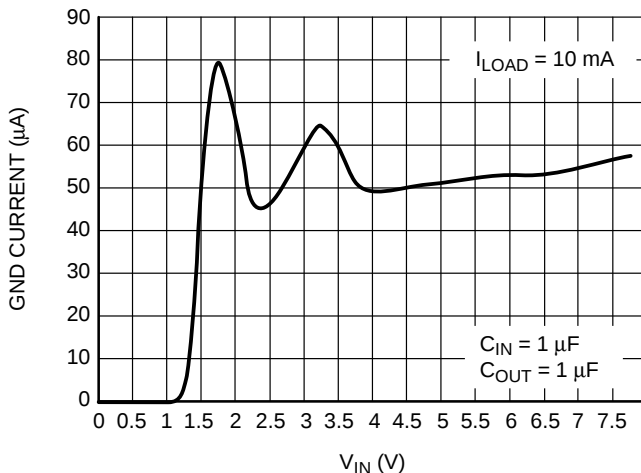


Figure 8. Ground Current vs. V_{IN} ($V_{OUT} = 3.3\text{ V}$)

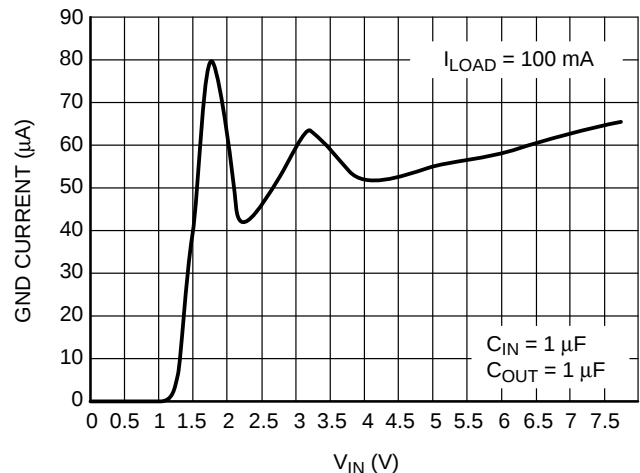


Figure 9. Ground Current vs. V_{IN} ($V_{OUT} = 3.3\text{ V}$)

NCP4555, NCP4586

TYPICAL CHARACTERISTICS

(Unless otherwise specified, all parts are measured at Temperature = 25°C)

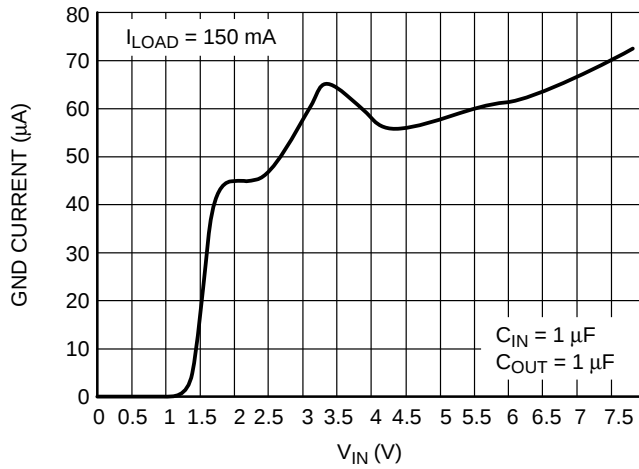


Figure 10. Ground Current vs. V_{IN} ($V_{OUT} = 3.3$ V)

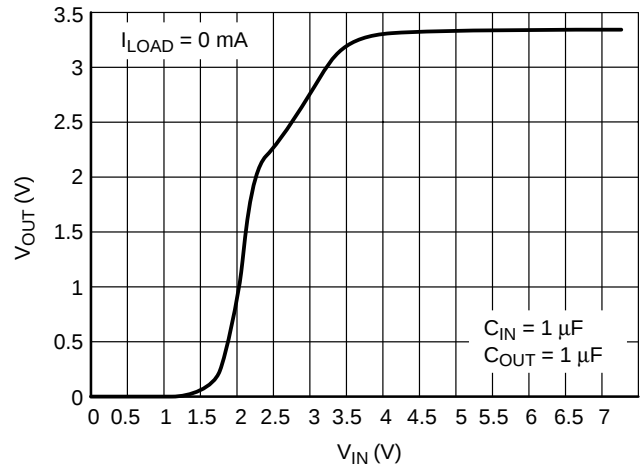


Figure 11. V_{OUT} vs. V_{IN} ($V_{OUT} = 3.3$ V)

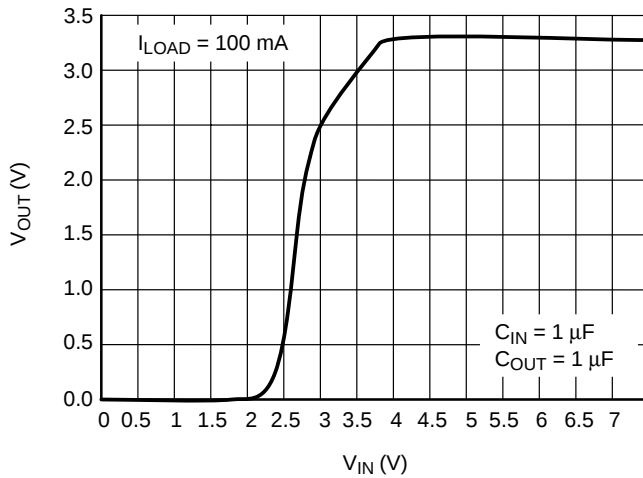


Figure 12. V_{OUT} vs. V_{IN} ($V_{OUT} = 3.3$ V)

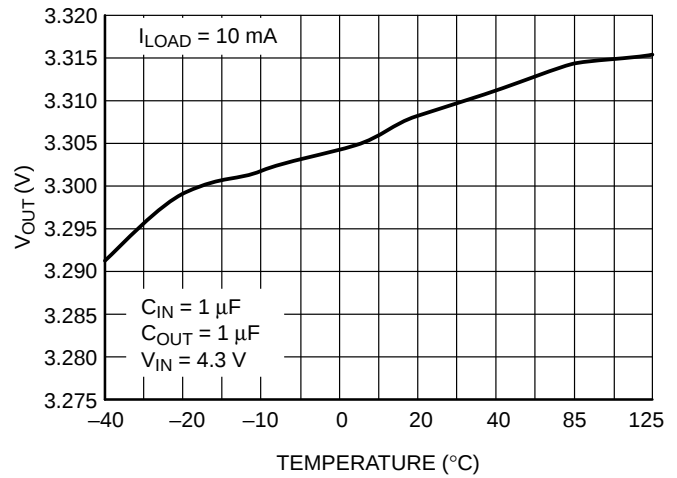


Figure 13. Output Voltage vs. Temperature ($V_{OUT} = 3.3$ V)

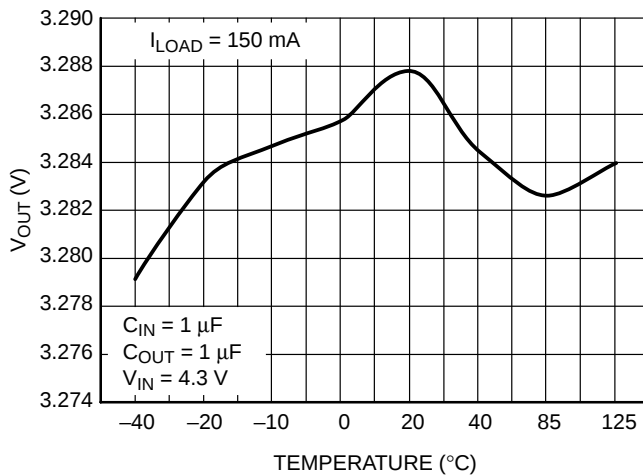


Figure 14. Output Voltage vs. Temperature ($V_{OUT} = 3.3$ V)

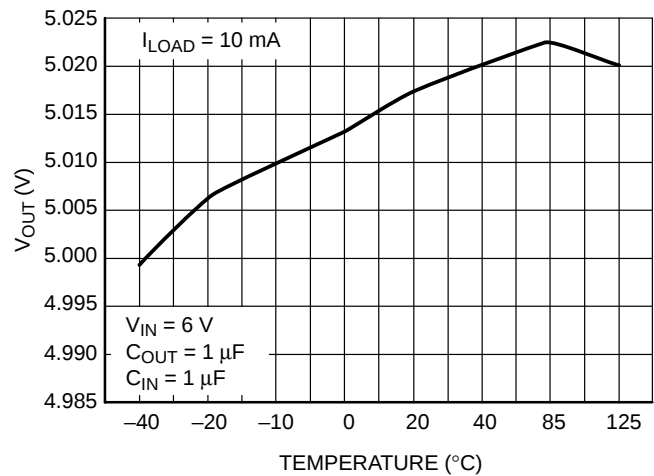


Figure 15. Output Voltage vs. Temperature ($V_{OUT} = 5$ V)

TYPICAL CHARACTERISTICS

(Unless otherwise specified, all parts are measured at Temperature = 25°C)

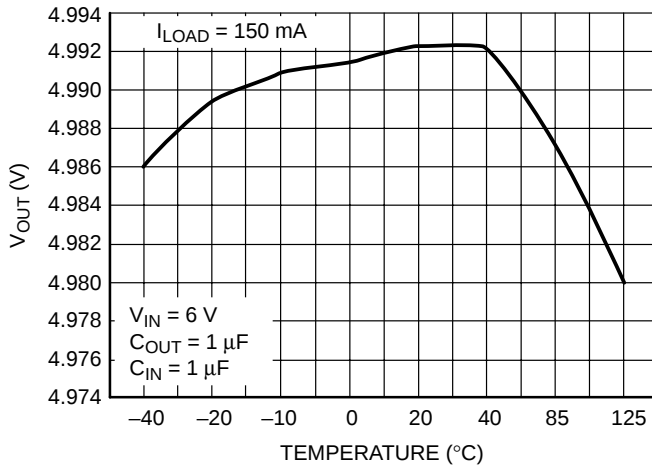


Figure 16. Output Voltage vs. Temperature
($V_{OUT} = 5\text{ V}$)

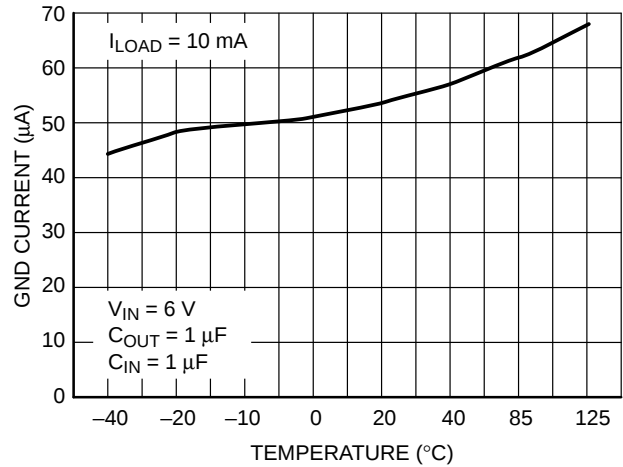


Figure 17. Temperature vs. Quiescent Current
($V_{OUT} = 5\text{ V}$)

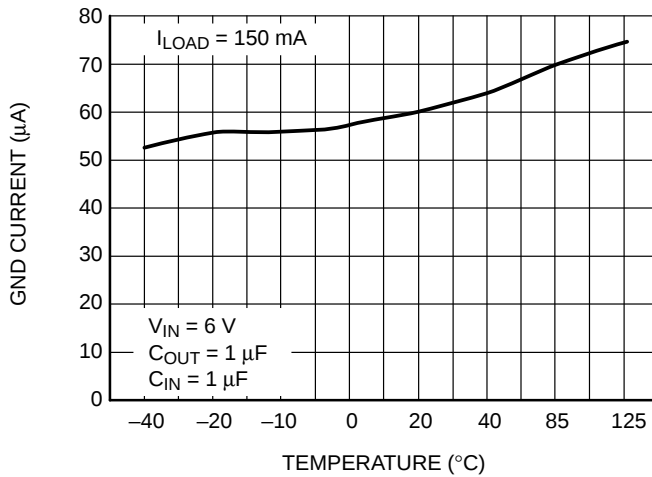


Figure 18. Temperature vs. Quiescent Current
($V_{OUT} = 5\text{ V}$)

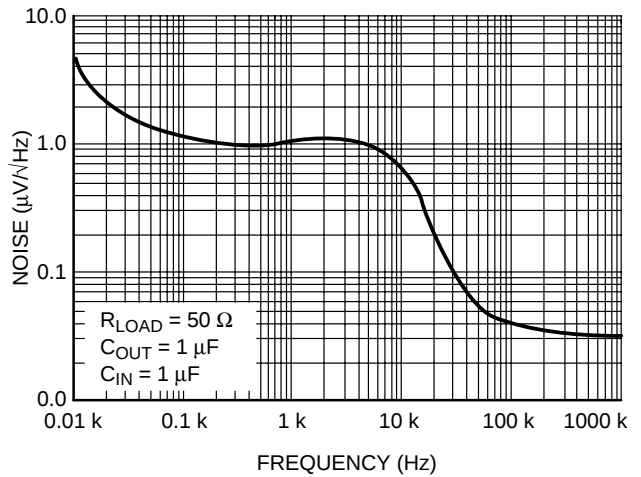


Figure 19. Output Noise vs. Frequency

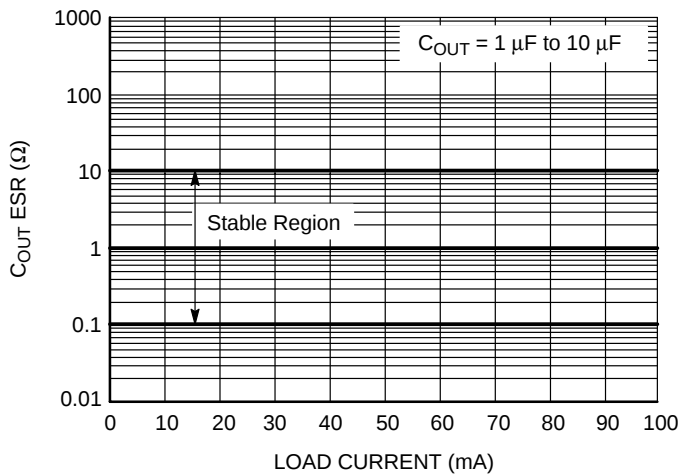


Figure 20. Stability Region vs. Load Current

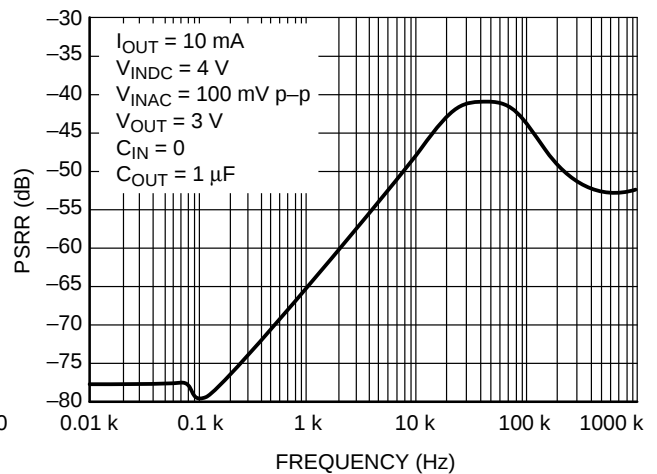


Figure 21. Power Supply Rejection Ratio

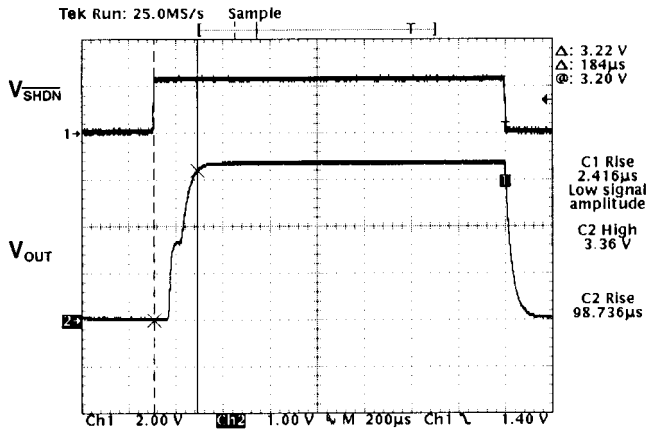


Figure 22. Measure Rise Time of 3.3 V LDO

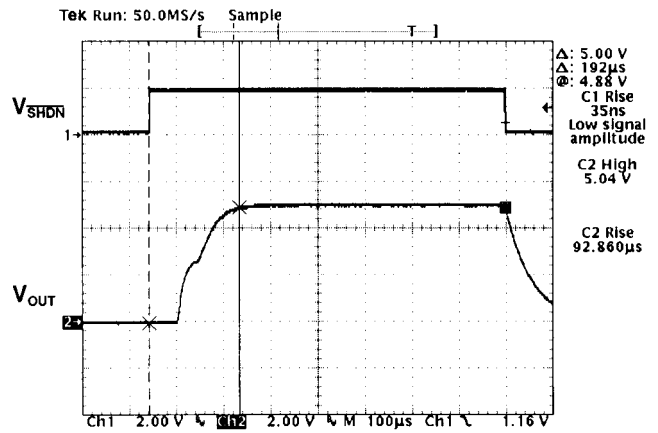


Figure 23. Measure Rise Time of 5.0 V LDO

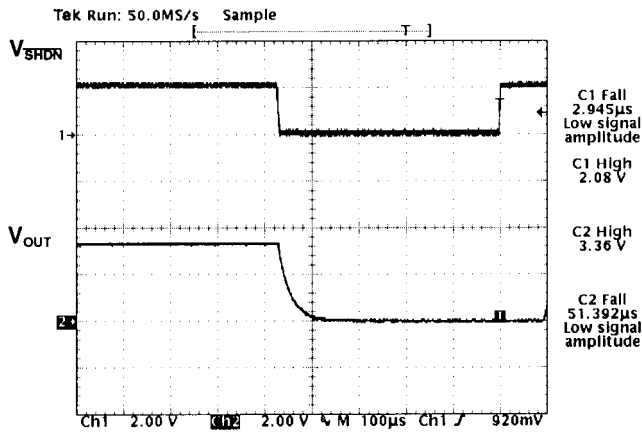


Figure 24. Measure Fall Time of 3.3 V LDO

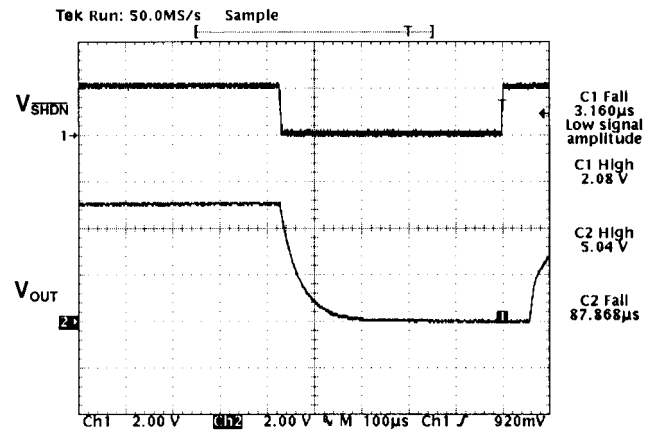
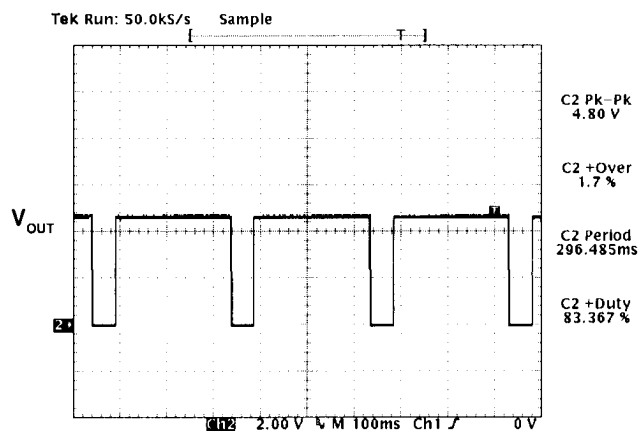


Figure 25. Measure Fall Time of 5.0 V LDO

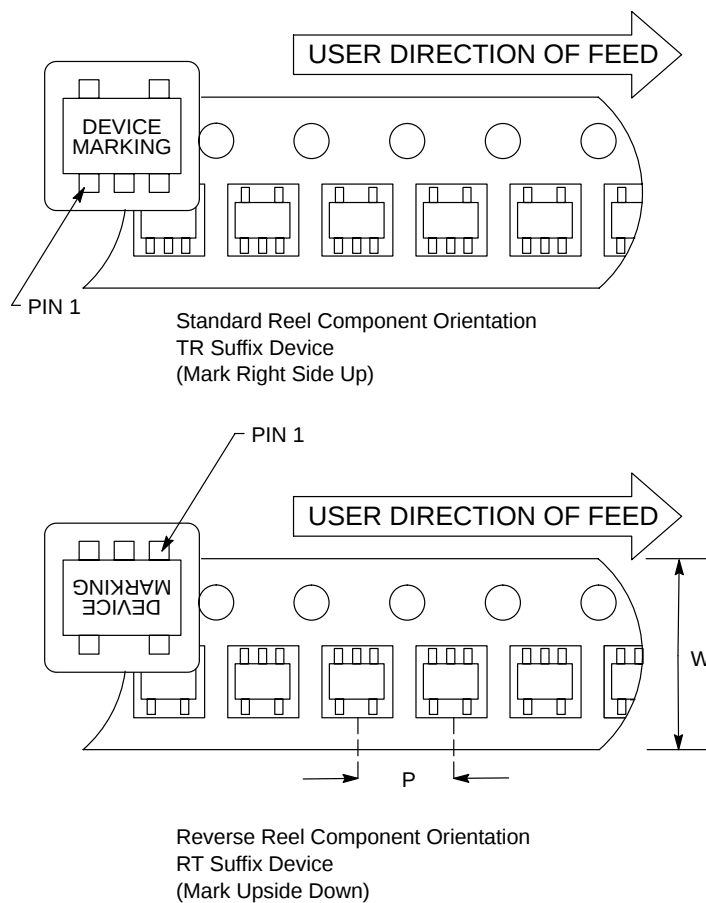
NCP4555, NCP4586



I_{LOAD} was increased until temperature of die reached about 160°C , at which time integrated thermal protection circuitry shuts the regulator off when die temperature exceeds approximately 160°C . The regulator remains off until die temperature drops to approximately 150°C .

Figure 26. Thermal Shutdown Response of 5.0 V LDO

Component Taping Orientation for 5-Pin SOT-23 Devices

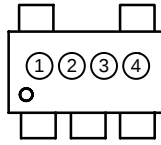


Carrier Tape, Number of Components Per Reel and Reel Size

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
SOT-23	8 mm	4 mm	3000	7 inches

NCP4555, NCP4586

MARKING DIAGRAM



- ① and ② = Two Letter Part Number Codes
+ Temperature Range and Voltage
- ③ = Year and Quarter Code
- ④ = Lot ID Number

ORDERING INFORMATION

Device	Voltage Option*	Marking ① and ②	Package	Junction Temperature Range	Shipping
NCP4555SNxxT1	1.8 2.8 2.85 3.0 3.3	DY DZ D8 D3 D5	SOT-23	-40°C to + 125°C	3000 Tape & Reel
NCP4586SNxxT1	2.5 2.7 2.8 2.85 3.0 3.3 3.6 4.0 5.0	P1 P2 PZ P8 P3 P5 P9 P0 P7			

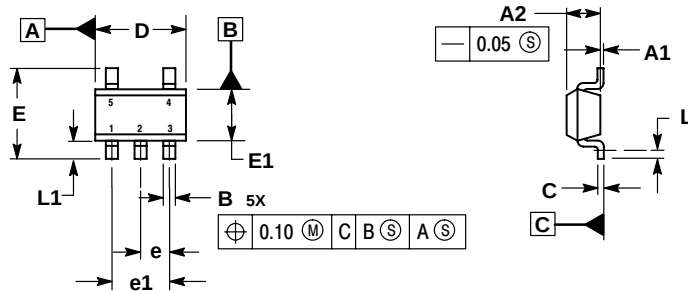
xx Indicates Output Voltages

*Other output voltages are available. Please contact ON Semiconductor for details.

NCP4555, NCP4586

PACKAGE DIMENSIONS

SOT-23
SN SUFFIX
CASE 1212-01
ISSUE O



NOTES:

1. DIMENSIONS ARE IN MILLIMETERS.
2. INTERPRET DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DATUM C IS A SEATING PLANE.

MILLIMETERS		
DIM	MIN	MAX
A1	0.00	0.10
A2	1.00	1.30
B	0.30	0.50
C	0.10	0.25
D	2.80	3.00
E	2.50	3.10
E1	1.50	1.80
e	0.95 BSC	
e1	1.90 BSC	
L	0.20	---
L1	0.45	0.75

ON Semiconductor and  are trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer.

PUBLICATION ORDERING INFORMATION

NORTH AMERICA Literature Fulfillment:

Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303-675-2175 or 800-344-3860 Toll Free USA/Canada
Fax: 303-675-2176 or 800-344-3867 Toll Free USA/Canada
Email: ONlit@hibbertco.com
Fax Response Line: 303-675-2167 or 800-344-3810 Toll Free USA/Canada

N. American Technical Support: 800-282-9855 Toll Free USA/Canada

EUROPE: LDC for ON Semiconductor – European Support

German Phone: (+1) 303-308-7140 (Mon-Fri 2:30pm to 7:00pm CET)
Email: ONlit-german@hibbertco.com

French Phone: (+1) 303-308-7141 (Mon-Fri 2:00pm to 7:00pm CET)
Email: ONlit-french@hibbertco.com

English Phone: (+1) 303-308-7142 (Mon-Fri 12:00pm to 5:00pm GMT)
Email: ONlit@hibbertco.com

EUROPEAN TOLL-FREE ACCESS*: 00-800-4422-3781

*Available from Germany, France, Italy, UK, Ireland

CENTRAL/SOUTH AMERICA:

Spanish Phone: 303-308-7143 (Mon-Fri 8:00am to 5:00pm MST)

Email: ONlit-spanish@hibbertco.com

Toll-Free from Mexico: Dial 01-800-288-2872 for Access –
then Dial 866-297-9322

ASIA/PACIFIC: LDC for ON Semiconductor – Asia Support

Phone: 303-675-2121 (Tue-Fri 9:00am to 1:00pm, Hong Kong Time)

Toll Free from Hong Kong & Singapore:

001-800-4422-3781

Email: ONlit-asia@hibbertco.com

JAPAN: ON Semiconductor, Japan Customer Focus Center

4-32-1 Nishi-Gotanda, Shinagawa-ku, Tokyo, Japan 141-0031

Phone: 81-3-5740-2700

Email: r14525@onsemi.com

ON Semiconductor Website: <http://onsemi.com>

For additional information, please contact your local
Sales Representative.