National Semiconductor

December 2006

LP2980-ADJEP
Micropower SOT, 50 mA Ultra Low-Dropout Adjustable Voltage Regulator

General Description

The LP2980-ADJEP is a 50 mA adjustable voltage regulator designed to provide ultra low dropout in battery powered applications.

Using an optimized VIP® (vertically Integrated PNP) process, the LP2980-ADJEP delivers unequalled performance in all specifications critical to battery-powered designs:

Adjustable Output: output voltage can be set from 1.23V to 15V.

Precision Reference: 0.75% tolerance.

Dropout Voltage: typically 120 mV @ 50 mA load, and 7 mV @ 1 mA load.

Ground Pin Current: typically 320 µA @ 50 mA load, and 80 µA @ 1 mA load.

Sleep Mode: less than 1 µA quiescent current when on/off pin is pulled low.

Smallest Possible Size: SOT-23 package uses minimum board space.

ENHANCED PLASTIC

- Extended Temperature Performance of -40°C to +125°C
- Baseline Control - Single Fab & Assembly Site
- Process Change Notification (PCN)
- Qualification & Reliability Data
- Solder (PbSn) Lead Finish is standard
- Enhanced Diminishing Manufacturing Sources (DMS) Support

Features

- Ultra low dropout voltage
- Output adjusts from 1.23V to 15V
- Guaranteed 50 mA output current
- Uses tiny SOT-23 package
- Requires few external components
- <1 µA quiescent current when shutdown
- Low ground pin current at all loads
- High peak current capability (150 mA typical)
- Wide supply voltage range (2.5V–16V)
- Overtemperature/overcurrent protection

Applications

- Selected Military Applications
- Selected Avionics Applications

Order Information

PART NUMBER	VID PART NUMBER	NS PACKAGE NUMBER (Note 3)
LP2980IM5-ADJEP	V62/07601-01XA	MF05A
(Notes 1, 2)	TBD	TBD

Note 1: For the following (Enhanced Plastic) version, check for availability: LP2980IM5XADJEP

Note 2: FOR ADDITIONAL ORDERING AND PRODUCT INFORMATION, PLEASE VISIT THE ENHANCED PLASTIC WEB SITE AT: www.national.com/mil

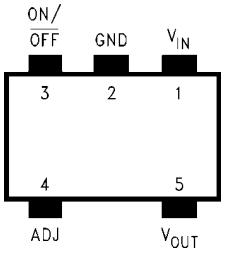
Note 3: Refer to package details under Physical Dimensions

VIP® is a registered trademark of National Semiconductor Corporation.

© 2007 National Semiconductor Corporation

Connection Diagram

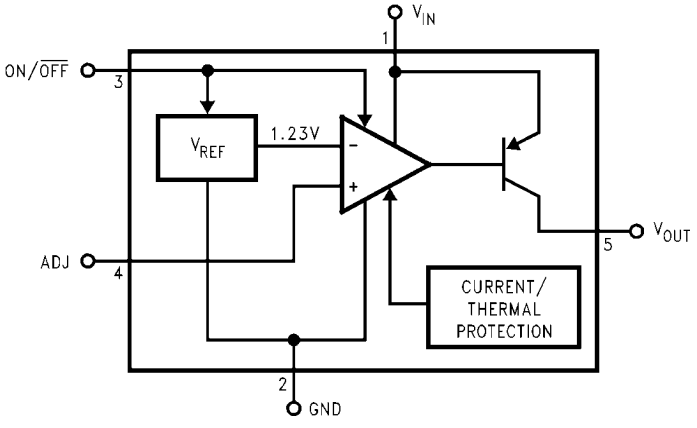
5-Lead Small Outline Package (M5)



20207002

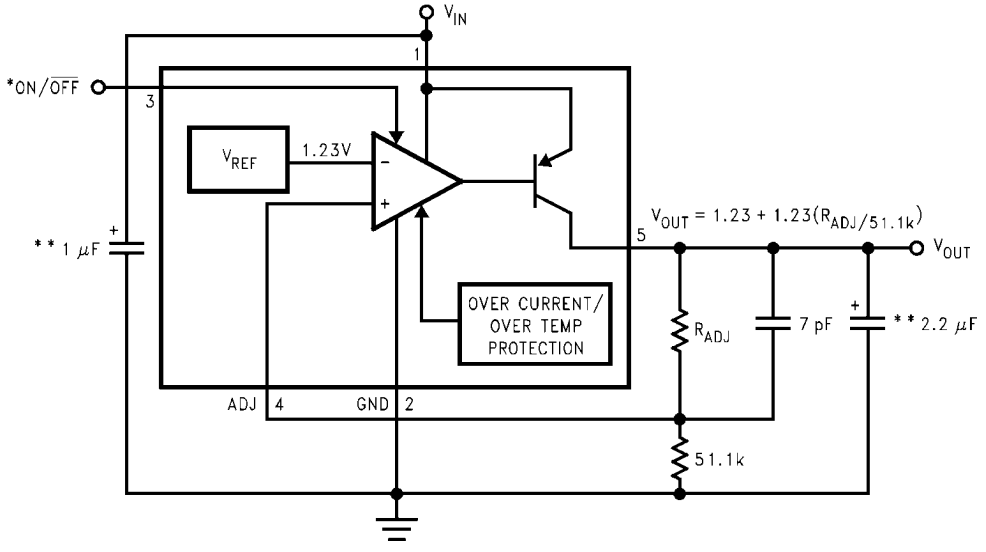
Top View
See NS Package Number MF05A

Block Diagram



20207001

Basic Application Circuit



20207003

*ON/$\overline{\text{OFF}}$ INPUT MUST BE ACTIVELY TERMINATED. TIE TO V_{IN} IF THIS FUNCTION IS NOT TO BE USED.
**MINIMUM CAPACITANCE IS SHOWN TO ENSURE STABILITY OVER FULL LOAD CURRENT RANGE (SEE APPLICATION HINTS).

Absolute Maximum Ratings (Note 4)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Storage Temperature Range	−65 to +150°C
Operating Junction Temperature Range	−40 to +125°C
Lead Temp. (Soldering, 5 seconds)	260°C
ESD Rating (Note 5)	2 kV
Power Dissipation (Note 6)	Internally Limited
Input Supply Voltage (Survival)	−0.3V to +16V
Input Supply Voltage (Operating)	2.5V to +16V
Shutdown Input Voltage (Survival)	−0.3V to +16V
Output Voltage (Survival) (Note 7)	−0.3V to 16V
I_{OUT} (Survival)	Short Circuit Protected
Input-Output Voltage (Survival) (Note 8)	−0.3V to 16V

Electrical Characteristics (Note 13)

Limits in standard typeface are for T_J = 25°C, and limits in **boldface type** apply over the full operating temperature range. Unless otherwise specified: V_{IN} = 4.3V, V_{OUT} = 3.3V, I_L = 1 mA, C_{IN} = 1 µF, C_{OUT} = 2.2 µF, $V_{ON/OFF}$ = 2V.

Symbol	Parameter	Conditions	Typ	**LP2980I-ADJEP** (Note 9)		Units
				Min	**Max**	
V_{REF}	Reference Voltage		1.225	1.213	1.237	V
		1 mA < I_L < 50 mA V_{OUT} + 1 ≤ V_{IN} ≤ 16V	1.225	1.206 **1.182**	1.243 **1.268**	
$\frac{\Delta V_{REF}}{\Delta V_{IN}}$	Reference Voltage Line Regulation	2.5V ≤ V_{IN} ≤ 16V	3		6.0 **15.0**	mV
V_{IN}–V_O	Dropout Voltage (Note 10)	I_L = 0	1		3 **5**	mV
		I_L = 1 mA	7		10 **15**	
		I_L = 10 mA	40		60 **90**	
		I_L = 50 mA	120		150 **225**	
I_{GND}	Ground Pin Current	I_L = 0	60		95 **125**	µA
		I_L = 1 mA	80		110 **170**	
		I_L = 10 mA	120		220 **460**	
		I_L = 50 mA	320		600 **1200**	
		$V_{ON/OFF}$ < 0.18V	0.01		**1**	
I_{ADJ}	ADJ Pin Bias Current	1 mA ≤ I_L ≤ 50 mA	150		350	nA
$V_{ON/OFF}$	ON/OFF Input Voltage (Note 11)	High = O/P ON	1.4	**1.6**		V
		Low = O/P OFF	0.55		**0.18**	
$I_{ON/OFF}$	ON/OFF Input Current	$V_{ON/OFF}$ = 0	0.01		**−1**	µA
		$V_{ON/OFF}$ = 5V	5		**15**	
I_O(PK)	Peak Output Current	V_{OUT} ≥ V_O(NOM) − 5%	150	100		mA
e_n	Output Noise Voltage (RMS)	BW = 300 Hz to 50 kHz, C_{OUT} = 10 µF	160			µV
$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	Ripple Rejection	f = 1 kHz C_{OUT} = 10 µF	68			dB
I_O(MAX)	Short Circuit Current	R_L = 0 (Steady State) (Note 12)	150			mA

Note 4: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.

Note 5: The ESD rating of pins 3 and 4 is 1 kV.

Note 6: The maximum allowable power dissipation is a function of the maximum junction temperature, $T_J(MAX)$, the junction-to-ambient thermal resistance, θ_{J-A}, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using:

$$P(MAX) = \frac{T_J(MAX) - T_A}{\theta_{J-A}}$$

The value of θ_{J-A} for the SOT-23 package is 300°C/W. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown.

Note 7: If used in a dual-supply system where the regulator load is returned to a negative supply, the LP2980-ADJEP output must be diode-clamped to ground.

Note 8: The output PNP structure contains a diode between the V_{IN} and V_{OUT} terminals that is normally reverse-biased. Reversing the polarity from V_{IN} to V_{OUT} will turn on this diode (see Application Hints).

Note 9: Limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's Average Outgoing Quality Level (AOQL).

Note 10: Dropout voltage is defined as the input to output differential at which the output voltage drops 100 mV below the value measured with a 1V differential.

Note 11: The ON/OFF input must be properly driven to prevent possible misoperation. For details, refer to Application Hints.

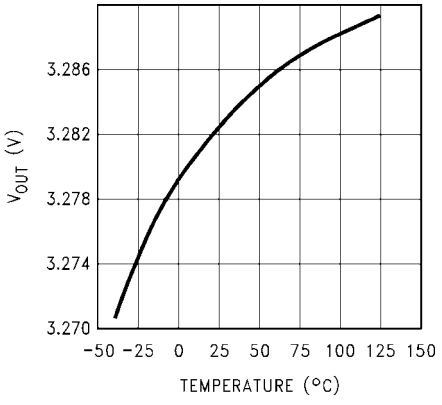
Note 12: See Typical Performance Characteristics curves.

Note 13: Testing and other quality control techniques are used to the extent deemed necessary to ensure product performance over the specified temperature range. Product may not necessarily be tested across the full temperature range and all parameters may not necessarily be tested. In the absence of specific PARAMETRIC testing, product performance is assured by characterization and/or design.

Typical Performance Characteristics

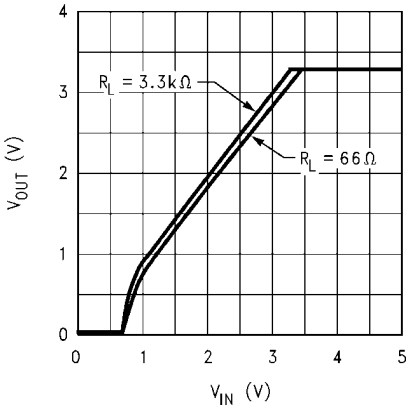
Unless otherwise specified: T_A = 25°C, $V_{IN} = V_O(NOM) + 1V$, I_L = 1 mA, ON/OFF pin tied to V_{IN}, R_{ADJ} = 86.6k, and test circuit is as shown in Basic Application Circuit.

Output Voltage vs. Temperature



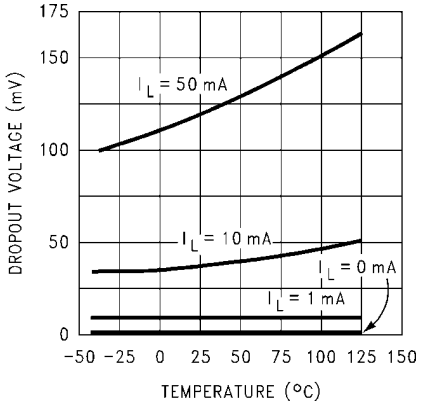
20207005

Dropout Characteristics



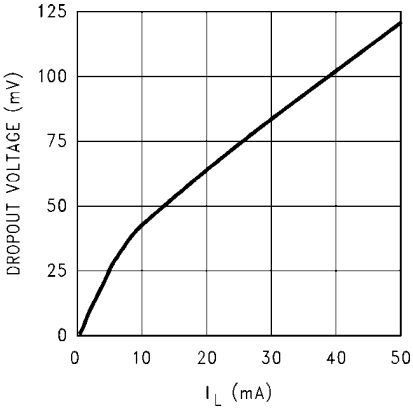
20207006

Dropout Voltage vs. Temperature



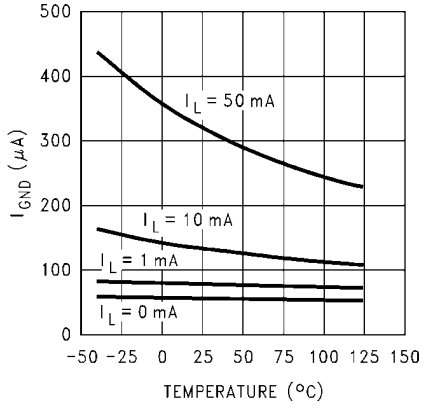
20207007

Dropout Voltage vs. Load Current



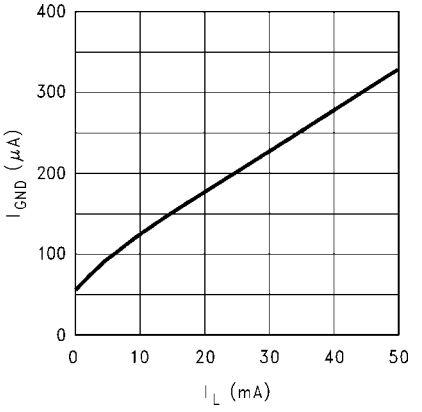
20207008

Ground Pin Current vs. Temperature



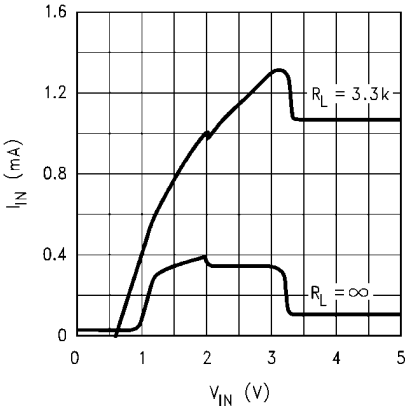
20207009

Ground Pin Current vs. Load Current



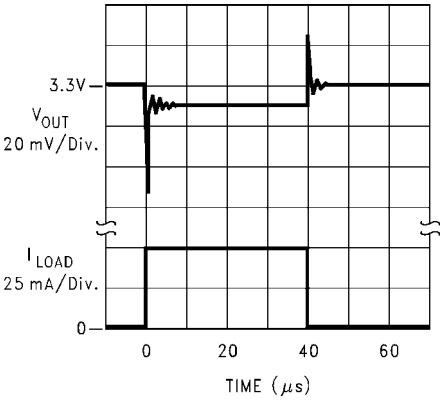
20207010

Input Current vs. V_{IN}



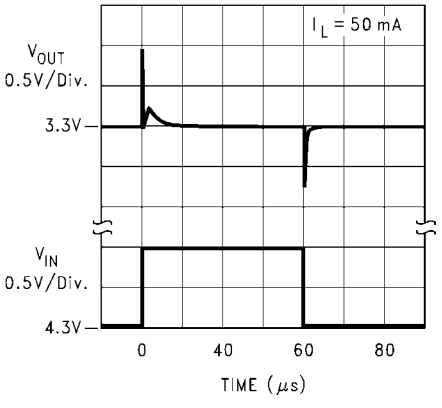
20207011

Load Transient Response



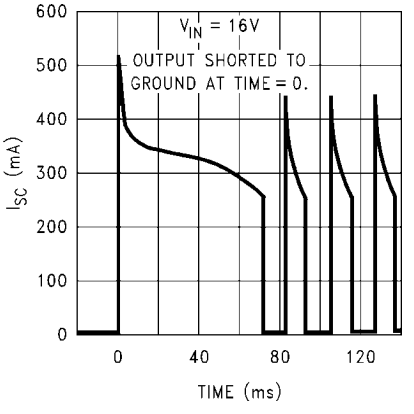
20207012

Line Transient Response



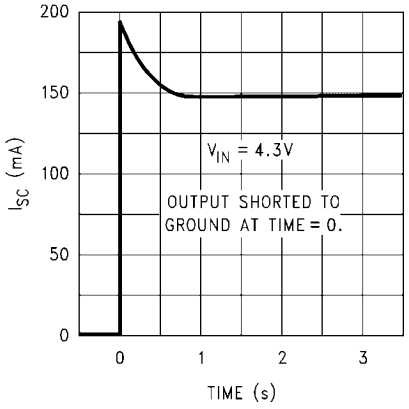
20207013

Short Circuit Current



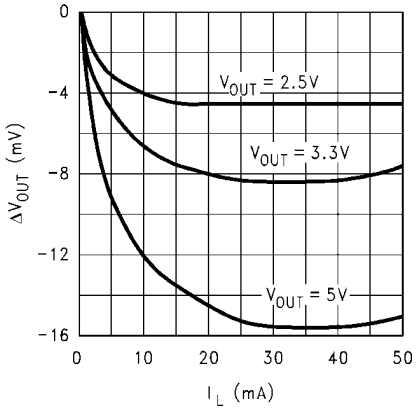
20207014

Short Circuit Current



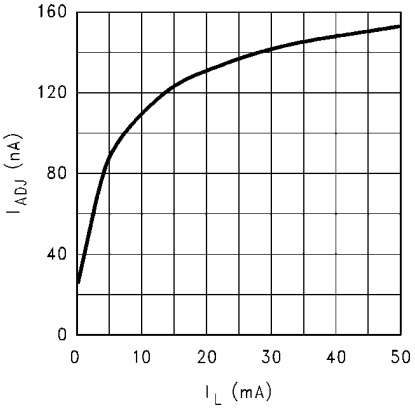
20207015

Load Regulation



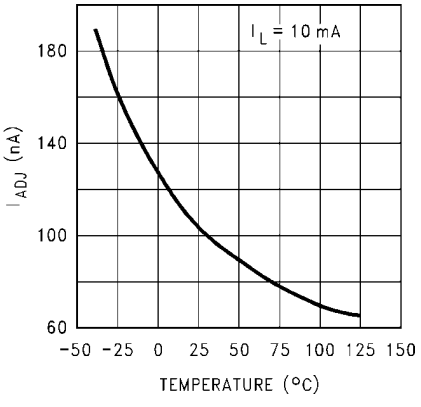
20207016

ADJ Pin Bias Current vs. Load Current



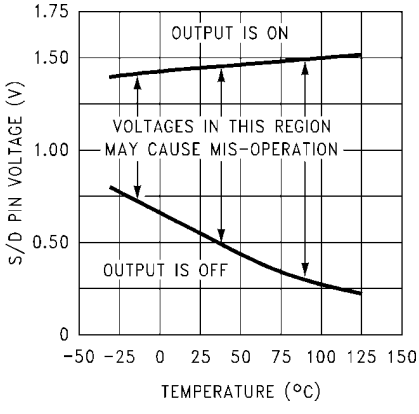
20207017

ADJ Pin Bias Current vs. Temperature



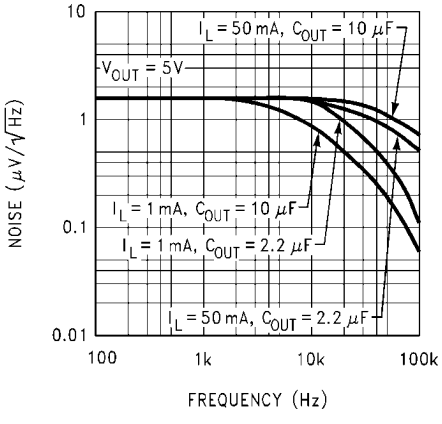
20207018

ON/OFF Threshold vs.Temperature



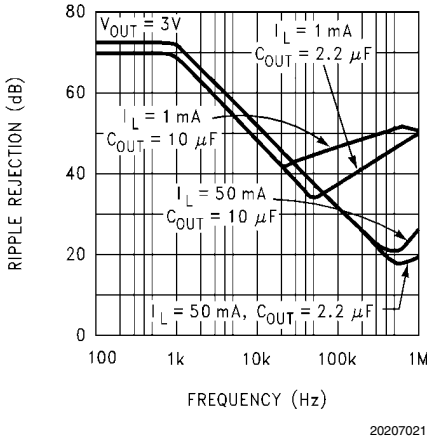
20207019

Output Noise Density



20207020

Ripple Rejection



20207021

Application Hints

EXTERNAL CAPACITORS

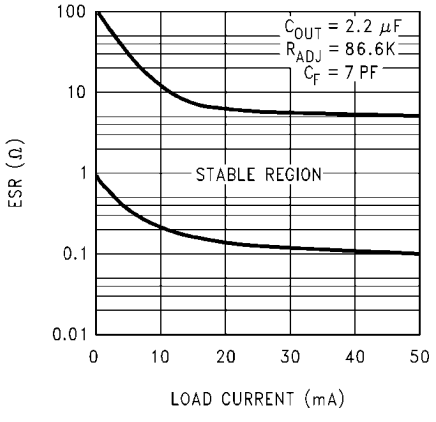
Like any low-dropout regulator, the external capacitors must be selected carefully to assure regulator loop stability.

INPUT CAPACITOR: An input capacitor whose value is ≥1 µF is *required* (the amount of capacitance may be increased without limit).

Any good quality Tantalum or Ceramic capacitor may be used here. The capacitor must be located not more than 0.5″ from the input pin and returned to a clean analog ground.

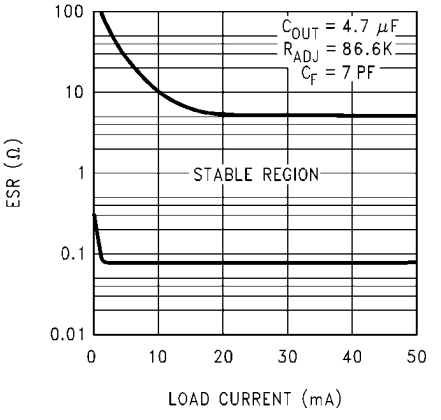
OUTPUT CAPACITOR: The output capacitor must meet both the requirement for minimum amount of capacitance and E.S.R. (Equivalent Series Resistance) for stable operation.

Curves are provided below which show the allowable ESR of the output capacitor as a function of load current for both 2.2 µF and 4.7 µF. A solid Tantalum capacitor is the best choice for the output.



20207022

2.2 µF ESR Curves



20207023

4.7 µF ESR Curves

IMPORTANT: The output capacitor must maintain its ESR in the stable region *over the full operating temperature range* to assure stability. Also, capacitor tolerance and variation with temperature must be considered to assure the minimum amount of capacitance is provided at all times.

Note that this capacitor must be located not more than 0.5" from the output pin and returned to a clean analog ground.

FEED-FORWARD CAPACITOR: A 7 pF feed-forward capacitor is required (see Basic Application Circuit). The function of this capacitor is to provide the lead compensation necessary for loop stability.

A temperature-stable ceramic capacitor (type NPO or COG) should be used here.

CAPACITOR CHARACTERISTICS

TANTALUM: The best capacitor choice for the LP2980-ADJEP output is solid Tantalum. The ESR of a good quality Tantalum is almost perfectly centered in the middle of the "stable" range of the ESR curve (about 0.5Ω–1Ω).

The temperature stability of Tantalums is typically very good, with a total variation of only about 2:1 over the temperature range of –40°C to +125°C (ESR increases at colder temperatures).

Off-brand capacitors should be avoided, as some poor quality Tantalums are seen with ESR's > 10Ω, and this usually causes oscillation problems.

One caution about Tantalums if they are used on the input: the ESR of a Tantalum is low enough that it can be destroyed by surge current if powered up from a low impedance source

(like a battery) that has no limit on inrush current. In these cases, use a ceramic input capacitor which does not have this problem.

CERAMIC: Ceramics are generally larger and more costly than Tantalums for a given amount of capacitance. Also, they have a very low ESR which is quite stable with temperature.

Be warned that the ESR of a ceramic capacitor is typically low enough to make an LDO oscillate: a 2.2 µF ceramic demonstrated an ESR of about 15 mΩ when tested. If used as an output capacitor, this will cause instability (see ESR Curves).

If a ceramic is used on the output of an LDO, a small resistance (about 1Ω) should be placed in series with the capacitor. If it is used as an input capacitor, no resistor is needed as there is no requirement for ESR on capacitors used on the input.

EXTERNAL RESISTORS

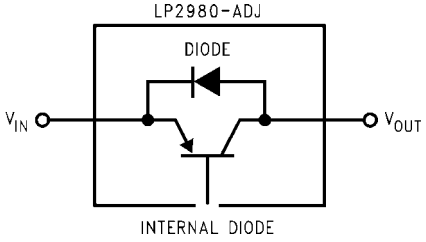
The output voltage is set using two external resistors (see Basic Application Circuit). It is recommended that the resistor from the ADJ pin to ground be 51.1k.

The other resistor (R_{ADJ}) which connects between V_{OUT} and the ADJ pin is selected to set V_{OUT} as given by the formula:

$$V_{OUT} = 1.23 + 1.23\ (R_{ADJ}/51.1k)$$

REVERSE CURRENT PATH

The power transistor used in the LP2980-ADJEP has an inherent diode connected between the input and output pin (see below).

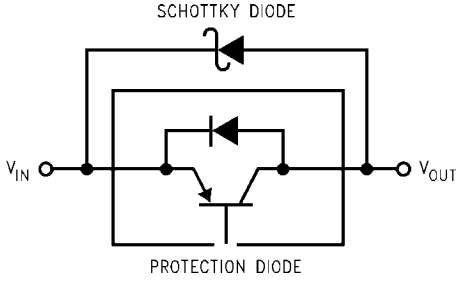


20207024

If the output is forced above the input by more than a V_{BE}, this diode will become forward biased and current will flow into the output pin and out the input pin. This current must be limited to < 100 mA to prevent damage to the part.

The internal diode can also be turned on if the input voltage is abruptly stepped down to a voltage which is a V_{BE} below the output voltage. To prevent mis-operation, an external Schottky diode (see below) must be used in applications where the internal diode may be turned on.

Since the external Schottky diode turns on at a lower voltage than the internal diode, the Schottky conducts all of the current and prevents the internal diode from becoming forward biased.



20207025

ON/OFF INPUT OPERATION

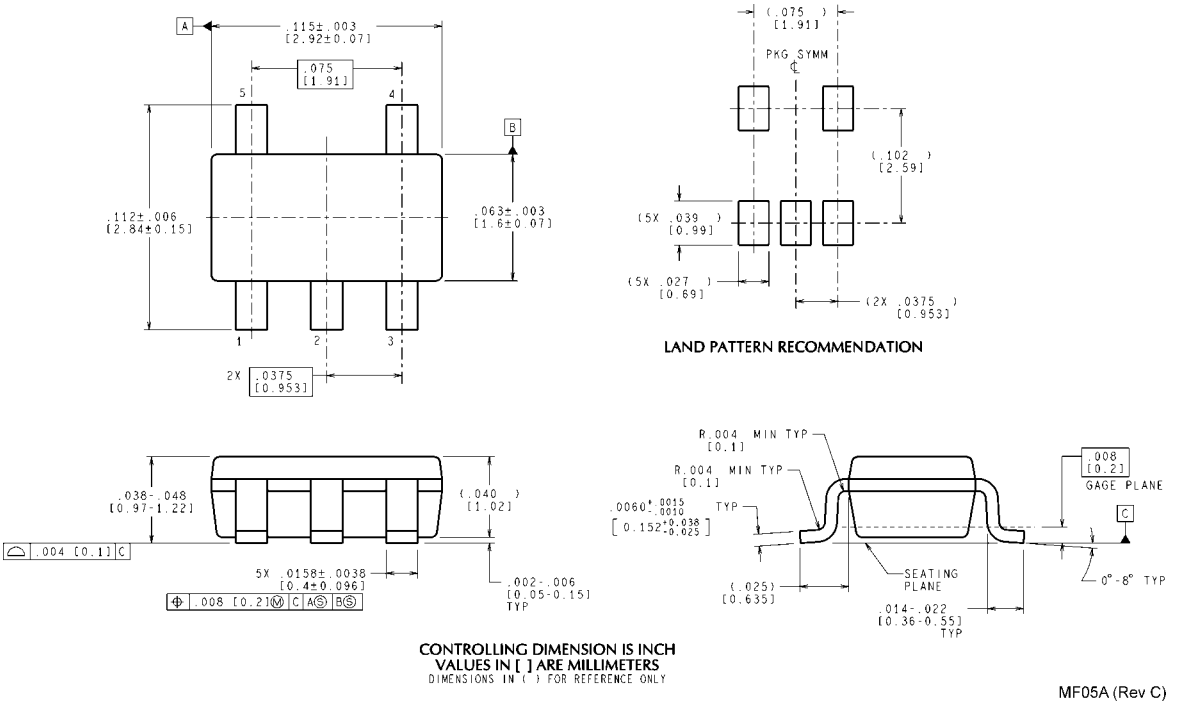
The LP2980-ADJEP is shut off by driving the ON/OFF input low, and turned on by pulling the ON/OFF input high. If this feature is not to be used, the ON/OFF input must be tied to V_{IN} to keep the regulator output on at all times (the ON/OFF input must not be left floating).

To ensure proper operation, the signal source used to drive the ON/OFF input must be able to swing above and below the specified turn-on/turn-off voltage thresholds which guarantee an ON or OFF state (see Electrical Characteristics).

It is also important that the turn-on (and turn-off) voltage signals applied to the ON/OFF input have a slew rate which is greater than 40 mV/µs.

IMPORTANT: The shutdown function will not operate correctly if a slow-moving signal is used to drive the S/D input.

Physical Dimensions inches (millimeters) unless otherwise noted



5-Lead Small Outline Package (M5)
NS Package Number MF05A

Notes

THE CONTENTS OF THIS DOCUMENT ARE PROVIDED IN CONNECTION WITH NATIONAL SEMICONDUCTOR CORPORATION ("NATIONAL") PRODUCTS. NATIONAL MAKES NO REPRESENTATIONS OR WARRANTIES WITH RESPECT TO THE ACCURACY OR COMPLETENESS OF THE CONTENTS OF THIS PUBLICATION AND RESERVES THE RIGHT TO MAKE CHANGES TO SPECIFICATIONS AND PRODUCT DESCRIPTIONS AT ANY TIME WITHOUT NOTICE. NO LICENSE, WHETHER EXPRESS, IMPLIED, ARISING BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS IS GRANTED BY THIS DOCUMENT.

TESTING AND OTHER QUALITY CONTROLS ARE USED TO THE EXTENT NATIONAL DEEMS NECESSARY TO SUPPORT NATIONAL'S PRODUCT WARRANTY. EXCEPT WHERE MANDATED BY GOVERNMENT REQUIREMENTS, TESTING OF ALL PARAMETERS OF EACH PRODUCT IS NOT NECESSARILY PERFORMED. NATIONAL ASSUMES NO LIABILITY FOR APPLICATIONS ASSISTANCE OR BUYER PRODUCT DESIGN. BUYERS ARE RESPONSIBLE FOR THEIR PRODUCTS AND APPLICATIONS USING NATIONAL COMPONENTS. PRIOR TO USING OR DISTRIBUTING ANY PRODUCTS THAT INCLUDE NATIONAL COMPONENTS, BUYERS SHOULD PROVIDE ADEQUATE DESIGN, TESTING AND OPERATING SAFEGUARDS.

EXCEPT AS PROVIDED IN NATIONAL'S TERMS AND CONDITIONS OF SALE FOR SUCH PRODUCTS, NATIONAL ASSUMES NO LIABILITY WHATSOEVER, AND NATIONAL DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY RELATING TO THE SALE AND/OR USE OF NATIONAL PRODUCTS INCLUDING LIABILITY OR WARRANTIES RELATING TO FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

National Semiconductor and the National Semiconductor logo are registered trademarks of National Semiconductor Corporation. All other brand or product names may be trademarks or registered trademarks of their respective holders.

Copyright© 2007 National Semiconductor Corporation

For the most current product information visit us at www.national.com

National Semiconductor Americas Customer Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

National Semiconductor Europe Customer Support Center
Fax: +49 (0) 180-530-85-86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +49 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Support Center
Email: ap.support@nsc.com

National Semiconductor Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560