

LM4050QML

LM4050QML Precision Micropower Shunt Voltage Reference



Literature Number: SNVS627C

LM4050QML

Precision Micropower Shunt Voltage Reference

General Description

The LM4050QML precision voltage reference is available in a 10 Lead Ceramic SOIC package. The LM4050QML's design eliminates the need for an external stabilizing capacitor while ensuring stability with any capacitive load, thus making the LM4050QML easy to use. The LM4050-2.5QML has a 60 μ A minimum and 15 mA maximum operating current.

The LM4050QML utilizes fuse and zener-zap reverse breakdown voltage trim during wafer sort to ensure that the prime parts have an accuracy of better than $\pm 0.1\%$ at 25°C. Bandgap reference temperature drift curvature correction and low dynamic impedance ensure stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents.

The LM4050QML operates over the temperature range of -55°C to +125°C.

Features

- Low Dose Rate Qualified 100 krad(Si)
- SEFI Immune
- SET Immune with 60 μ F C_{LOAD}
- C_{LOAD} 0 μ F to 100 μ F
- Fixed reverse breakdown voltage of 2.500V

Key Specifications LM4050-2.5QML

- Output voltage tolerance $I_R = 100\mu$ A $\pm 0.1\%$ (max)
- Low temperature coefficient 17 ppm/°C
- Low output noise 50 μ V_{rms}(typ)
- Wide operating current range 60 μ A to 15 mA

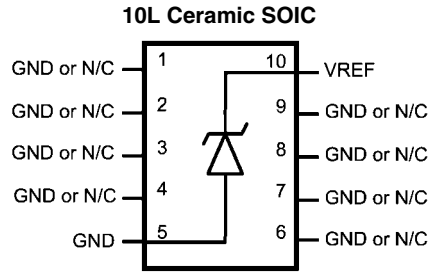
Applications

- Control Systems
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management

Ordering Information

NS Part Number	SMD Part Number	NS Package Number	Package Description
LM4050WG2.5RLQV Low Dose Rate Qualified	5962R0923561VZA 100 krad(Si)	WG10A	10LD Ceramic SOIC
LM4050WG2.5-MPR Pre-Flight Prototype		WG10A	10LD Ceramic SOIC

Connection Diagram



30104101

Top View
See NS Package Number WG10A

Pin Descriptions

Pin Number	Pin Name	Function
1	GND/NC	Ground or No Connect
2	GND/NC	Ground or No Connect
3	GND/NC	Ground or No Connect
4	GND/NC	Ground or No Connect
5	GND	Ground
6	GND/NC	Ground or No Connect
7	GND/NC	Ground or No Connect
8	GND/NC	Ground or No Connect
9	GND/NC	Ground or No Connect
10	VREF	Reference Voltage

Absolute Maximum Ratings (Note 1)

Reverse Current	20 mA
Forward Current	10 mA
Power Dissipation ($T_A = 25^\circ\text{C}$) (Note 2)	
10LD Ceramic SOIC Package	467 mW
Lead Temperature (Soldering, 10 seconds)	
Ceramic SOIC	260°C
Storage Temperature	-65°C to +150°C
Package Weight (typical)	
Ceramic SOIC	241mg
ESD Tolerance (Note 3)	Class 2 (2000V)

Operating Ratings (Note 2)

Temperature Range	$-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$
Reverse Current	
LM4050-2.5QML	60 μA to 15 mA

Package Thermal Resistance

Package	θ_{JA} (Still Air)	θ_{JA} (500LF/Min Air flow)	θ_{JC}
10L Ceramic SOIC Package on 2 layer, 1oz PCB	214°C/ W	147°C/ W	20.87°C/ W

Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

Subgroup	Description	Temp (C)
1	Static tests at	+25
2	Static tests at	+125
3	Static tests at	-55
4	Dynamic tests at	+25
5	Dynamic tests at	+125
6	Dynamic tests at	-55
7	Functional tests at	+25
8A	Functional tests at	+125
8B	Functional tests at	-55
9	Switching tests at	+25
10	Switching tests at	+125
11	Switching tests at	-55
12	Setting time at	+25
13	Setting time at	+125
14	Setting time at	-55

LM4050-2.5QML Electrical Characteristics

The initial Reverse Breakdown Voltage tolerance is $\pm 0.1\%$ @ $100\mu\text{A}$.

Symbol	Parameter	Conditions	Notes	Typical (Note 4)	Min	Max	Units	Sub-groups
V_R	Reverse Breakdown Voltage	$I_R = 100\mu\text{A}$		2.500			V	
	Reverse Breakdown Voltage Tolerance	$I_R = 60\mu\text{A}$				± 2.5	mV	1
		$I_R = 100\mu\text{A}$				± 2.5		
		$I_R = 1\text{mA}$				± 3.75		
		$I_R = 10\text{mA}$				± 10		
		$I_R = 15\text{mA}$				± 13		
		$I_R = 60\mu\text{A}$				± 5	mV	2
		$I_R = 100\mu\text{A}$				± 5		
		$I_R = 1\text{mA}$				± 6.25		
		$I_R = 10\text{mA}$				± 12.5		
		$I_R = 15\text{mA}$				± 14		
		$I_R = 60\mu\text{A}$				± 4.5	mV	3
		$I_R = 100\mu\text{A}$				± 4.5		
		$I_R = 1\text{mA}$				± 5.75		
		$I_R = 10\text{mA}$				± 13		
		$I_R = 15\text{mA}$				± 17.5		
I_{RMIN}	Minimum Operating Current			40.5		60	μA	1
						65	μA	2, 3
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient @ $25^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$	$I_R = 60\mu\text{A}$	(Note 8)	± 3		± 17	ppm/ $^\circ\text{C}$	2
		$I_R = 100\mu\text{A}$		± 3		± 17		
		$I_R = 1\text{mA}$		± 3		± 20		
		$I_R = 10\text{mA}$		± 4		± 25		
		$I_R = 15\text{mA}$		± 6				
	Average Reverse Breakdown Voltage Temperature Coefficient @ $-55^\circ\text{C} \leq T_A \leq 25^\circ\text{C}$	$I_R = 60\mu\text{A}$	(Note 8)	± 3		± 19		3
		$I_R = 100\mu\text{A}$		± 3		± 19		
		$I_R = 1\text{mA}$		± 3.5		± 22		
		$I_R = 10\text{mA}$		± 35		± 55		
		$I_R = 15\text{mA}$		± 60				
Z_R	Reverse Dynamic Impedance	$I_R = 1\text{mA}$, $f = 120\text{Hz}$, $I_{AC} = 0.1 I_R$		0.3			Ω	
V_N	Output Noise Voltage	$0.1\text{Hz} \leq f \leq 10\text{Hz}$		9			μVpp	
		$10\text{Hz} \leq f \leq 10\text{KHz}$		50			μVrms	
C_{LOAD}	Load Capacitor	Stable Over Temperature	(Note 6)	60	0	100	μF	
V_{HYST}	Thermal Hysteresis	$\Delta T = -55^\circ\text{C}$ to 125°C	(Note 5)	1			ppm	

Post Radiation @ 25°C (Note 7)

The initial Reverse Breakdown Voltage tolerance is $\pm 0.1\%$ @ 100 μ A.

Symbol	Parameter	Conditions		30 krad	50 krad	100 krad	Sub-groups
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 60\mu A$	Max	+0.42%	+0.67%	+1.5%	1
		$I_R = 100\mu A$					
		$I_R = 1mA$					
		$I_R = 10mA$					
		$I_R = 15mA$					

Post Radiation Tempco (Note 8)

Symbol	Parameter	Conditions	TYPICALS			
			30 krad	50 krad	100 krad	Units
$\Delta V_R/\Delta T$	Average Reverse Breakdown Voltage Temperature Coefficient Drift @ $25^\circ C \leq T_A \leq 125^\circ C$	$60\mu A \leq I_R \leq 15mA$	+41	+83	+144	ppm/ $^\circ C$
	Average Reverse Breakdown Voltage Temperature Coefficient Drift @ $-55^\circ C \leq T_A \leq 25^\circ C$	$60\mu A \leq I_R \leq 15mA$	+46	+87	+166	ppm/ $^\circ C$

Operational Life Test Delta Parameters

This table represents the drift seen from initial measurements post 1000hr Operational Life Burn-In. All units will remain within the electrical characteristics limits post 1000hr Operational Life Burn-In. Deltas required for QMLV product at Group B, Sub-Group 5.

Symbol	Parameter	Conditions	Note	Min	Max	Units	Temp
V_R	Reverse Breakdown Voltage Tolerance	$I_R = 60\mu A$		-0.873	0.873	mV	1
		$I_R = 100\mu A$		-0.873	0.873		
		$I_R = 1mA$		-0.998	0.998		
		$I_R = 10mA$		-3.93	3.93		
		$I_R = 15mA$		-5	5		
I_{RMIN}	Minimum Operating Current			-0.623	0.623	μA	1

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $PD_{max} = (T_{Jmax} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4050QML, $T_{Jmax} = 125^\circ C$, and the typical thermal resistance (θ_{JA}), when board mounted, is $214^\circ C/W$ for the 10 Lead Ceramic SOIC package.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 k Ω resistor into each pin.

Note 4: Typicals are at $T_A = 25^\circ C$ and represent most likely parametric norm.

Note 5: Thermal hysteresis is defined as the change in voltage measured at $+25^\circ C$ after cycling to temperature $-55^\circ C$ and the $25^\circ C$ measurement after cycling to temperature $+125^\circ C$.

$$V_{HYST} = \frac{|V_{R1} - V_{R2}|}{V_R} \times 10^6 \text{ ppm}$$

Where: V_{HYST} = Thermal hysteresis expressed in ppm

V_R = Nominal preset output voltage

V_{R1} = V_R before temperature fluctuation

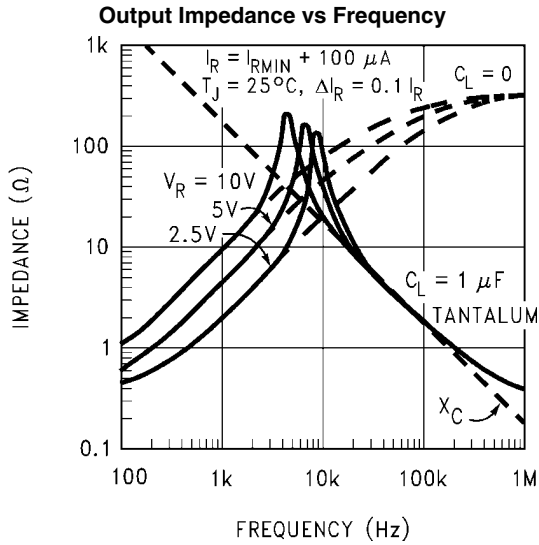
V_{R2} = V_R after temperature fluctuation.

Note 6: Capacitive load not required but improves SET stability. This parameter is guaranteed by design and/or characterization and is not tested in production.

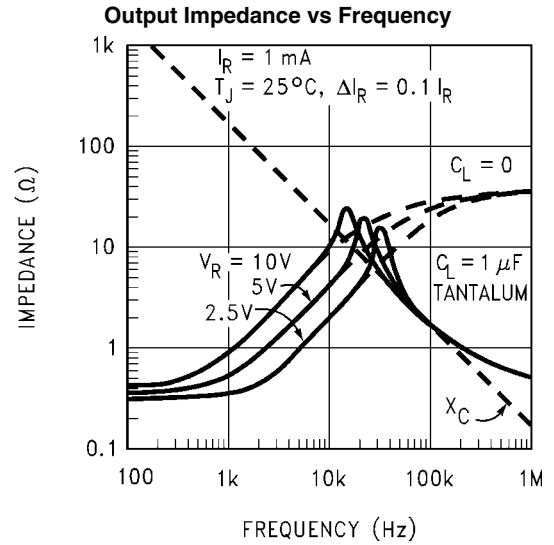
Note 7: Pre and post irradiation limits are identical to those listed under electrical characteristics except as listed in the post radiation table.

Note 8: Not tested post irradiation. Typical post irradiation values listed in the post radiation Tempco table.

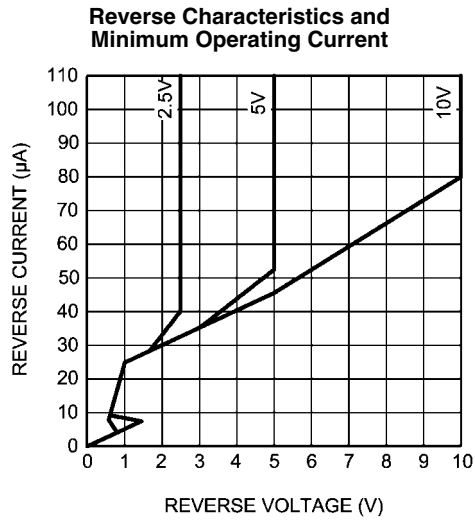
Typical Performance Characteristics



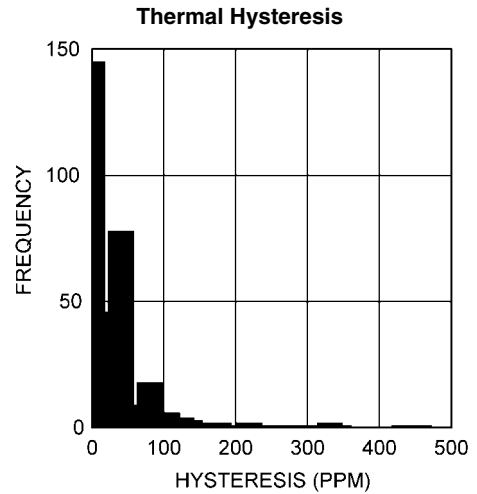
30104110



30104111

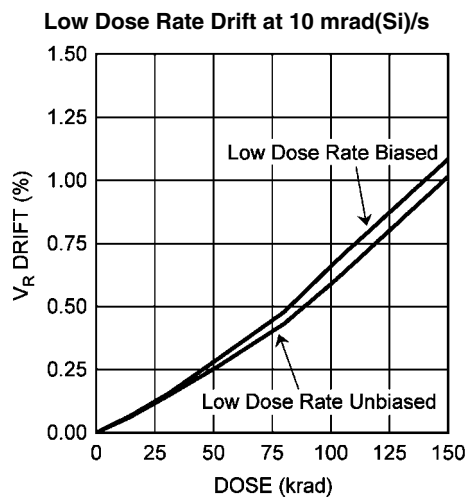


30104112



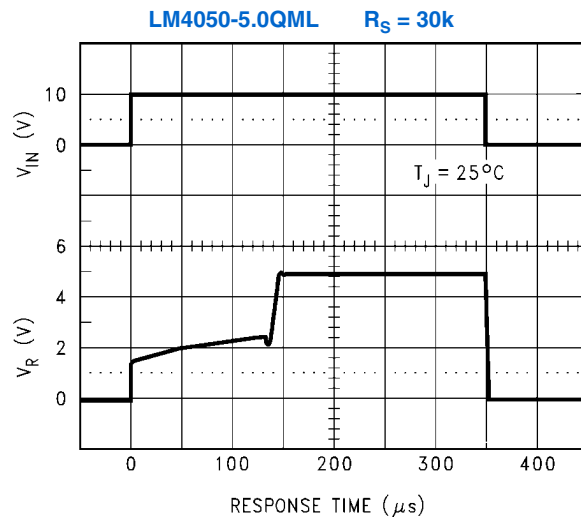
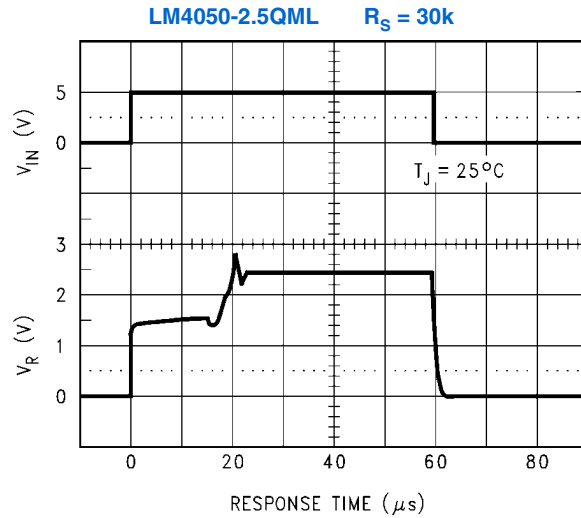
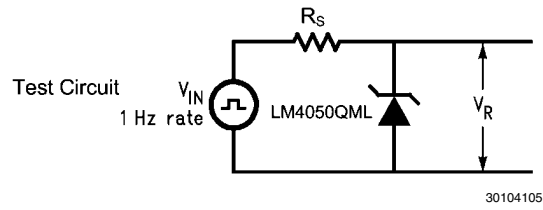
30104129

Typical Radiation Characteristics

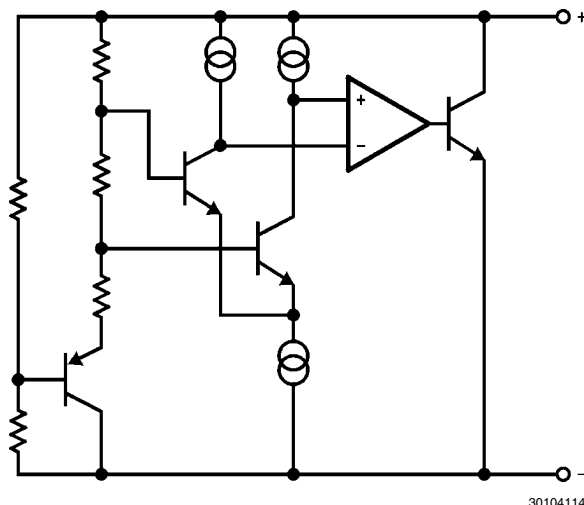


30104123

Start-Up Characteristics



Functional Block Diagram



Applications Information

The LM4050QML is a precision micro-power curvature-corrected bandgap shunt voltage reference. The LM4050QML is available in the 10 Lead Ceramic SOIC package. The LM4050QML has been designed for stable operation without the need of an external capacitor connected between the “+” pin and the “-” pin. If, however, a bypass capacitor is used, the LM4050QML remains stable. The LM4050-2.5QML has a 60 μA minimum and 15 mA maximum operating current.

The typical thermal hysteresis specification is defined as the change in $+25^\circ\text{C}$ voltage measured after thermal cycling. The device is thermal cycled to temperature -55°C and then measured at 25°C . Next the device is thermal cycled to temperature $+125^\circ\text{C}$ and again measured at 25°C . The resulting V_{OUT} delta shift between the 25°C measurements is thermal hysteresis. Thermal hysteresis is common in precision references and is induced by thermal-mechanical package stress. Changes in environmental storage temperature, operating temperature and board mounting temperature are all factors that can contribute to thermal hysteresis.

In a conventional shunt regulator application (*Figure 1*), an external series resistor (R_S) is connected between the supply voltage and the LM4050QML. R_S determines the current that flows through the load (I_L) and the LM4050QML (I_Q). Since load current and supply voltage may vary, R_S should be small enough to supply at least the maximum guaranteed I_{RMIN} (spec. table) to the LM4050QML even when the supply voltage is at its minimum and the load current is at its maximum value. When the supply voltage is at its maximum and I_L is at its minimum, R_S should be large enough so that the current flowing through the LM4050QML is less than 15 mA.

R_S is determined by the supply voltage, (V_S), the load and operating current, (I_L and I_Q), and the LM4050QML's reverse breakdown voltage, V_R .

$$R_S = \frac{V_S - V_R}{I_L + I_Q}$$

Radiation Environments

Careful consideration should be given to environmental conditions when using a product in a radiation environment.

TOTAL IONIZING DOSE

Radiation hardness assured (RHA) products are those part numbers with a total ionizing dose (TID) level specified in the Ordering Information table on the front page. Testing and qualification of these products is done on a wafer level according to MIL-STD-883, Test Method 1019. Wafer level TID data is available with lot shipments.

Testing and qualification is performed at the 30, 50 and 100 krad TID levels at a dose rate of 10 mrad/s, using a 1.5X overtest at each TID level. For the 30 krad level units are tested to 50 krad, for 50 krad units are tested to 80 krad and for 100 krad units are tested to 150 krad, with all parameters remaining inside the post irradiation test limits.

SINGLE EVENT EFFECTS (SEE)

One time single event effects characterization was performed according to EIA/JEDEC Standard, EIA/JEDEC57.

A test report is available upon request.

SINGLE EVENT TRANSIENTS (SET)

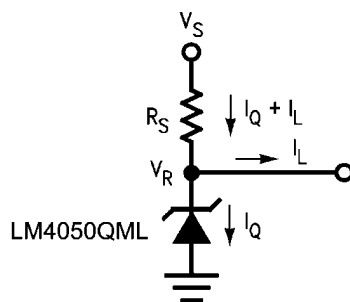
With a 60 μF capacitor on the output, no single event transients were seen at the highest linear energy transfer (LET) tested: 59 $\text{MeV}\cdot\text{cm}^2/\text{mg}$.

SET characterization with other capacitor values is in the SEE report, available upon request.

SINGLE EVENT FUNCTIONAL INTERRUPT (SEFI)

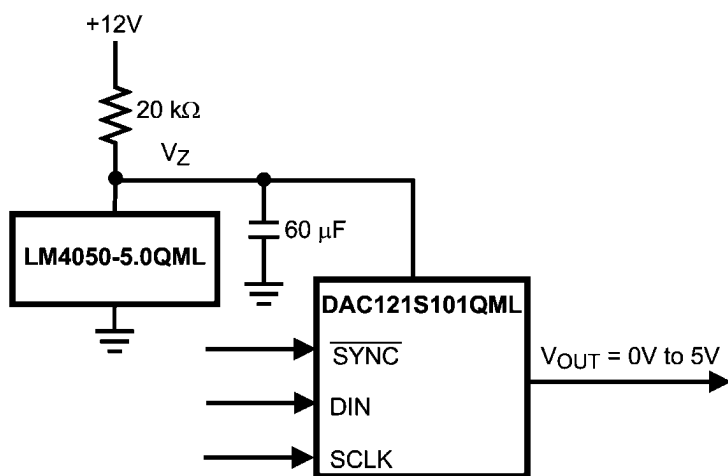
No single event functional interrupts were detected to the highest linear energy transfer (LET) tested: 100 $\text{MeV}\cdot\text{cm}^2/\text{mg}$.

Typical Applications



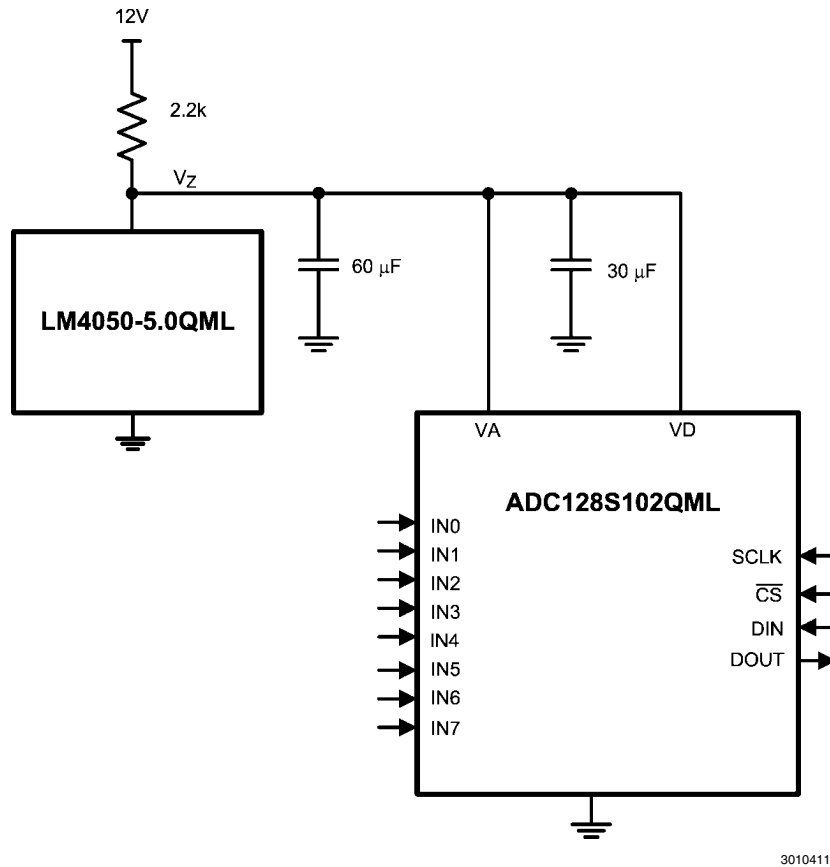
30104115

FIGURE 1. Shunt Regulator



30104120

FIGURE 2. The LM4050QML as a power supply and reference



30104119

FIGURE 3. The LM4050QML as a power supply and reference

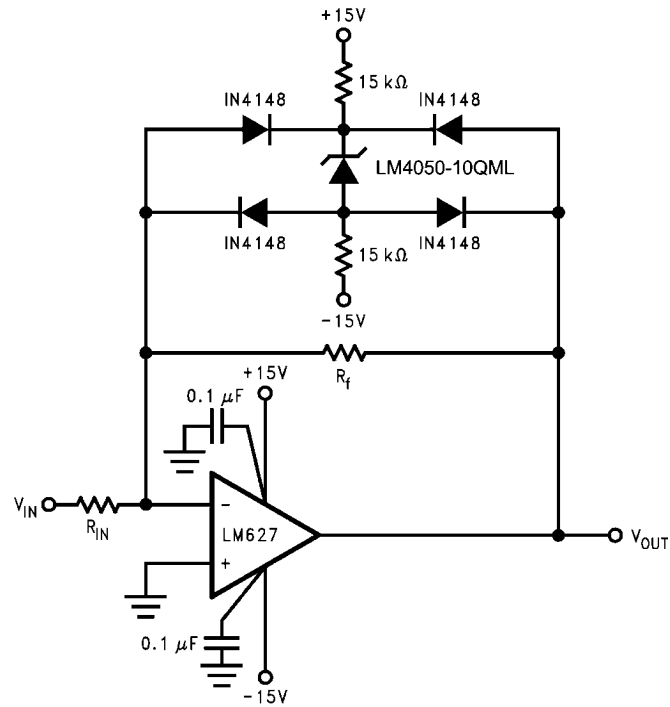
The LM4050QML is a good choice as a power regulator for the DAC121S101QML or ADC128S102QML. The minimum resistor value in the circuit of [Figure 2](#) or [Figure 3](#) should be chosen such that the maximum current through the LM4050QML does not exceed its 15 mA rating. The conditions for maximum current include the input voltage at its maximum, the LM4050QML voltage at its minimum, the resistor value at its minimum due to tolerance, and the DAC121S101QML or ADC128S102QML draws zero current. The maximum resistor value must allow the LM4050QML to draw more than its minimum current for regulation plus the maximum DAC121S101QML or ADC128S102QML current in full operation. The conditions for minimum current include the input voltage at its minimum, the LM4050QML voltage at its maximum, the resistor value at its maximum due to tolerance, and the DAC121S101QML or ADC128S102QML draws its maximum current. These conditions can be summarized as

$$R(\min) = (V_{IN}(\max) - V_Z(\min)) / (I_A(\min) + I_Z(\max))$$

and

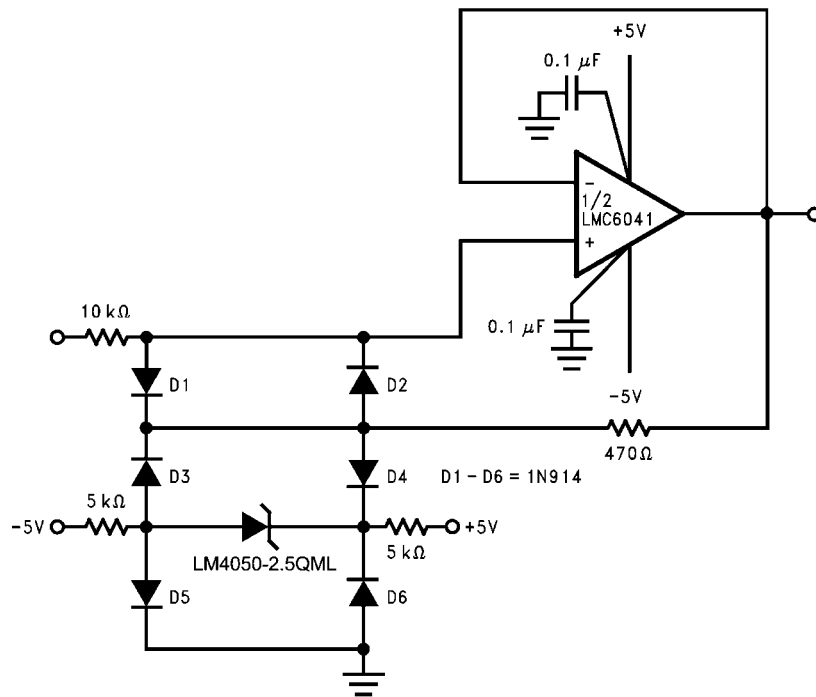
$$R(\max) = (V_{IN}(\min) - V_Z(\max)) / (I_A(\max) + I_Z(\min))$$

where $V_Z(\min)$ and $V_Z(\max)$ are the nominal LM4050QML output voltages \pm the LM4050QML output tolerance over temperature, $I_Z(\max)$ is the maximum allowable current through the LM4050QML, $I_Z(\min)$ is the minimum current required by the LM4050QML for proper regulation, $I_A(\max)$ is the maximum DAC121S101QML or ADC128S102QML supply current, and $I_A(\min)$ is the minimum DAC121S101QML or ADC128S102QML supply current.



30104117

FIGURE 4. Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage. Nominal clamping voltage is $\pm 11.5V$ (LM4050QML's reverse breakdown voltage $+2$ diode V_F).



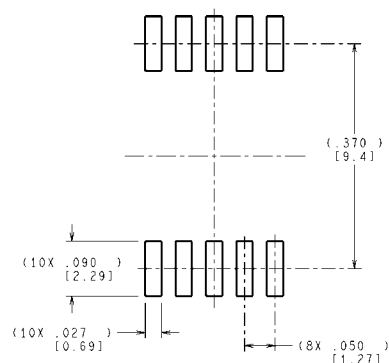
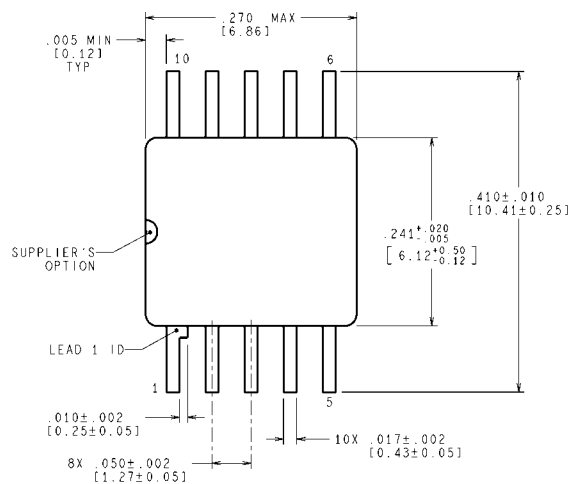
30104118

FIGURE 5. Protecting Op Amp input. The bounding voltage is $\pm 4V$ with the LM4050-2.5QML (LM4050QML's reverse breakdown voltage $+3$ diode V_F).

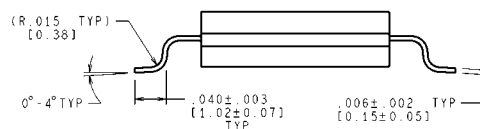
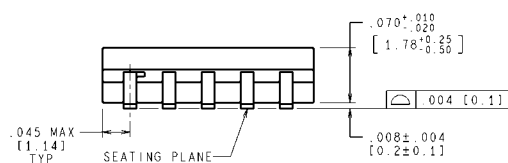
FIGURE 6. Precision 1 μ A to 1 mA Current Sources

Revision History

Date Released	Revision	Section	Changes
08/20/2010	A	Initial Release	New Product Low Dose Qualified LM4050WG2.5RLQV Initial Release

Physical Dimensions inches (millimeters) unless otherwise noted

RECOMMENDED LAND PATTERN



MIL-PRF-38535
CONFIGURATION CONTROL

CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS
DIMENSIONS IN { } FOR REFERENCE ONLY

WG10A (Rev F)

10 Lead Ceramic SOIC
NS Package Number WG10A

Notes

For more National Semiconductor product information and proven design tools, visit the following Web sites at:
www.national.com

Products		Design Support	
Amplifiers	www.national.com/amplifiers	WEBENCH® Tools	www.national.com/webench
Audio	www.national.com/audio	App Notes	www.national.com/appnotes
Clock and Timing	www.national.com/timing	Reference Designs	www.national.com/refdesigns
Data Converters	www.national.com/adac	Samples	www.national.com/samples
Interface	www.national.com/interface	Eval Boards	www.national.com/evalboards
LVDS	www.national.com/lvds	Packaging	www.national.com/packaging
Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
PowerWise® Solutions	www.national.com/powerwise	Applications & Markets	www.national.com/solutions
Serial Digital Interface (SDI)	www.national.com/sdi	Mil/Aero	www.national.com/milaero
Temperature Sensors	www.national.com/tempsensors	SolarMagic™	www.national.com/solarmagic
PLL/VCO	www.national.com/wireless	PowerWise® Design University	www.national.com/training

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© 2010 National Semiconductor Corporation

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



**National Semiconductor
Americas Technical
Support Center**
Email: support@nsc.com
Tel: 1-800-272-9959

**National Semiconductor Europe
Technical Support Center**
Email: europe.support@nsc.com

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

**National Semiconductor Japan
Technical Support Center**
Email: jpn.feedback@nsc.com

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Transportation and Automotive	www.ti.com/automotive
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated