

LF444QML

LF444QML Quad Low Power JFET Input Operational Amplifier



Literature Number: SNOSAO9

LF444QML

Quad Low Power JFET Input Operational Amplifier

General Description

The LF444 quad low power operational amplifier provides many of the same AC characteristics as the industry standard LM148 while greatly improving the DC characteristics of the LM148. The amplifier has the same bandwidth, slew rate, and gain (10 k Ω load) as the LM148 and only draws one fourth the supply current of the LM148. In addition the well matched high voltage JFET input devices of the LF444 reduce the input bias and offset currents by a factor of 10,000 over the LM148. The LF444 also has a very low equivalent input noise voltage for a low power amplifier.

The LF444 is pin compatible with the LM148 allowing an immediate 4 times reduction in power drain in many applications. The LF444 should be used wherever low power dissipation and good electrical characteristics are the major considerations.

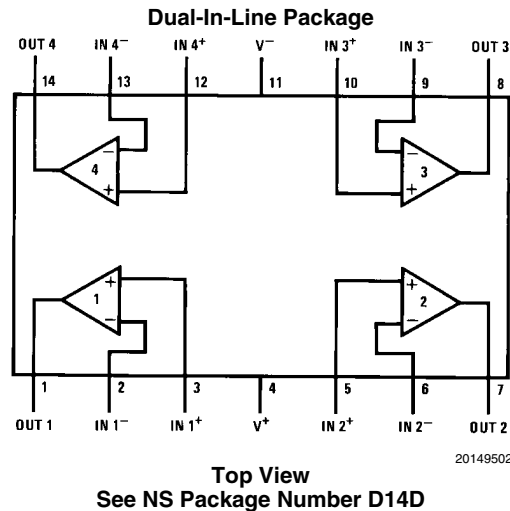
Features

- $\frac{1}{4}$ supply current of a LM148: 250 μ A/Amplifier (max)
- Low input bias current: 100 pA (max)
- High gain bandwidth: 1 MHz
- High slew rate: 1 V/ μ s
- Low noise voltage for low power 35 nV/ $\sqrt{\text{Hz}}$
- Low input noise current 0.01 pA/ $\sqrt{\text{Hz}}$
- High input impedance: $10^{12}\Omega$
- High gain, $V_O = \pm 10\text{V}$, $R_L = 10\text{K}\Omega$: 25K (min)

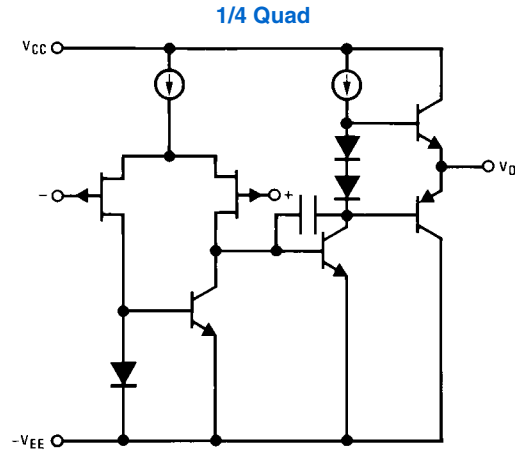
Ordering Information

NS Part Number	SMD Part Number	NS Package Number	Package Description
LF444MD/883		D14D	14LD Sidebrazed Ceramic Dip

Connection Diagram

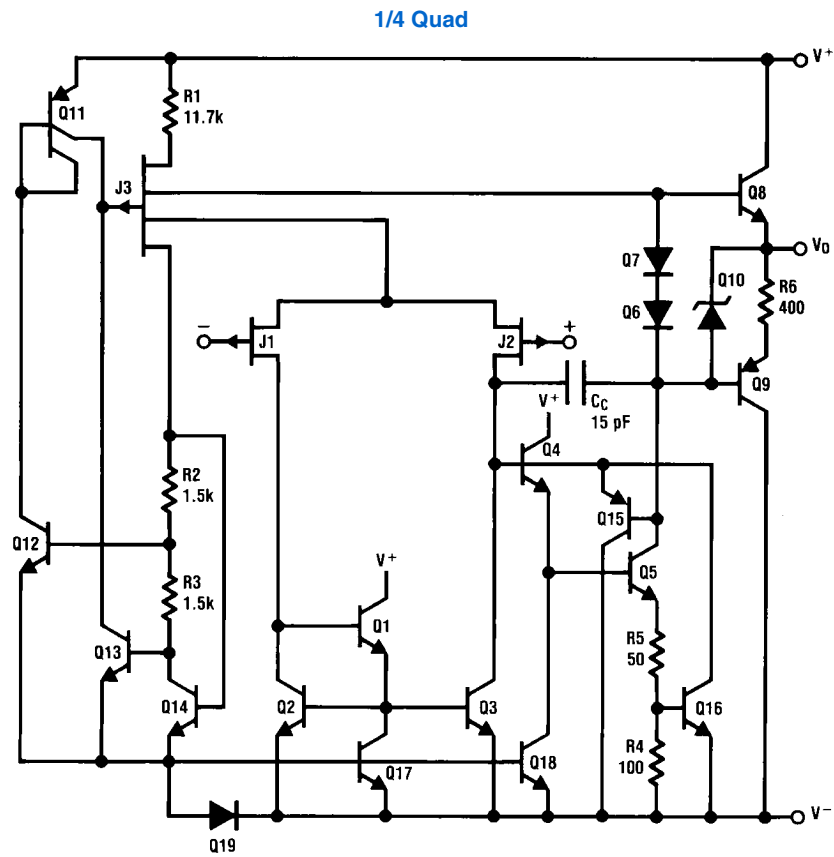


Simplified Schematic



20149501

Detailed Schematic



20149511

Absolute Maximum Ratings *(Note 1)*

Supply Voltage	±18V
Differential Input Voltage	±30V
Input Voltage Range <i>(Note 4)</i>	±15V
Output Short Circuit Duration <i>(Note 5)</i>	Continuous
Power Dissipation <i>(Note 2)</i> , <i>(Note 3)</i>	900 mW
T_{Jmax}	150°C
θ_{JA} (Typical)	100°C/W
Operating Temperature Range	$-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$
Storage Temperature Range	$-65^{\circ}\text{C} \leq T_A \leq 150^{\circ}\text{C}$
ESD Tolerance <i>(Note 6)</i>	Rating to be determined

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	Settling time at	+25
13	Settling time at	+125
14	Settling time at	-55

LF444 Electrical Characteristics

DC Parameters

The following conditions apply, unless otherwise specified. $V_S = \pm 15V$, $V_{CM} = 0V$, $R_S = 0\Omega$, $R_L = 0\Omega$

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{IO}	Input Offset Voltage	$R_S = 10K\Omega$		-10	10	mV	1
				-14	14	mV	2, 3
I_{IO}	Input Offset Current	$R_L = 10K\Omega$		-0.05	0.05	nA	1
				-10	10	nA	2
$+I_{IB}$	Input Bias Current	$R_L = 10K\Omega$		-0.10	0.10	nA	1
				-20	20	nA	2
$-I_{IB}$	Input Bias Current	$R_L = 10K\Omega$		-0.10	0.10	nA	1
				-20	20	nA	2
$+A_{VS}$	Large Signal Voltage Gain	$V_O = 0$ to $+10V$, $R_L = 10K\Omega$, $R_S = 10K\Omega$	(Note 8)	25		V/mV	1
				15		V/mV	2, 3
$-A_{VS}$	Large Signal Voltage Gain	$V_O = 0$ to $-10V$, $R_L = 10K\Omega$, $R_S = 10K\Omega$	(Note 8)	25		V/mV	1
				15		V/mV	2, 3
$+V_O$	Output Voltage Swing	$R_L = 10K\Omega$, $V_I = +1V$		12		V	1, 2, 3
$-V_O$	Output Voltage Swing	$R_L = 10K\Omega$, $V_I = -1V$			-12	V	1, 2, 3
V_{CM}	Input Common Mode Voltage Range		(Note 7)	9	-9	V	1, 2, 3
CMRR	Common Mode Rejection Ratio	$R_S = 10K\Omega$, $V_{CM} = \pm 9V$		70		dB	1, 2, 3
PSRR+	Power Supply Rejection Ratio	$V_S = \pm 15V$ to $V_S = \pm 6V$		70		dB	1, 2, 3
PSRR-	Power Supply Rejection Ratio	$V_S = \pm 15V$ to $V_S = \pm 6V$		70		dB	1, 2, 3
I_S	Supply Current				1.0	mA	1, 2, 3
$+I_{OS}$	Output Short Circuit Current	$V_I = 1V$		-3.0	-20	mA	1
				-3.0	-40	mA	2, 3
$-I_{OS}$	Output Short Circuit Current	$V_I = -1V$		3.0	20	mA	1
				3.0	40	mA	2, 3

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} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $P_{Dmax} = (T_{Jmax} - T_A) / \theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower.

Note 3: Max. Power Dissipation is defined by the package characteristics. Operating the part near the Max. Power Dissipation may cause the part to operate outside guaranteed limits.

Note 4: Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

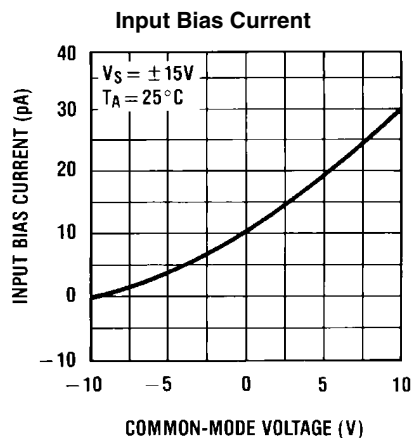
Note 5: Any of the amplifier outputs can be shorted to ground indefinitely, however, more than one should not be simultaneously shorted as the maximum junction temperature will be exceeded.

Note 6: Human body model, 1.5 k Ω in series with 100 pF.

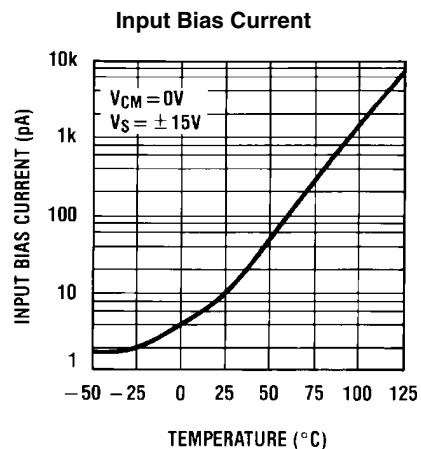
Note 7: Parameter tested go-no-go only. Guaranteed by the CMRR test.

Note 8: Datalog in K = V/mV.

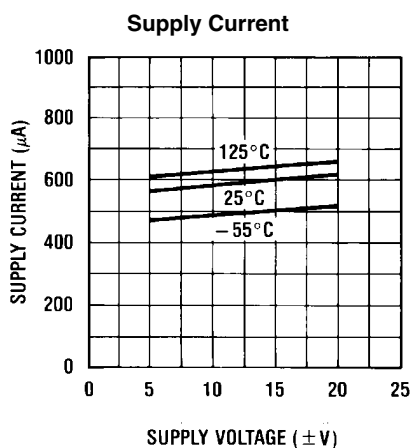
Typical Performance Characteristics



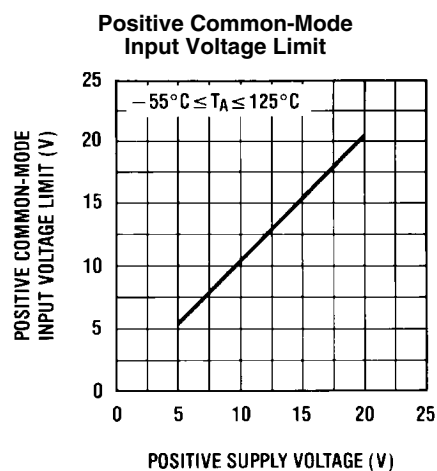
20149512



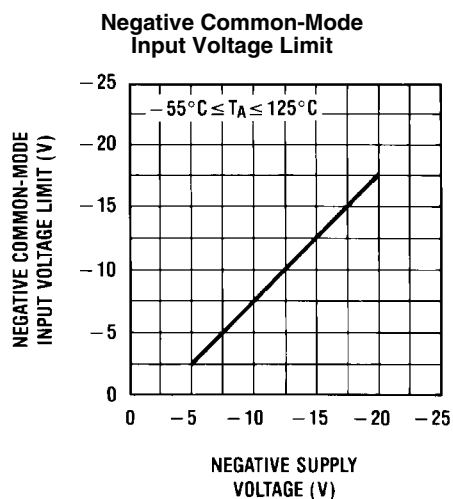
20149513



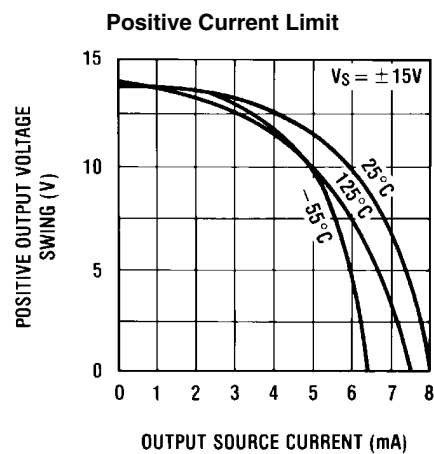
20149514



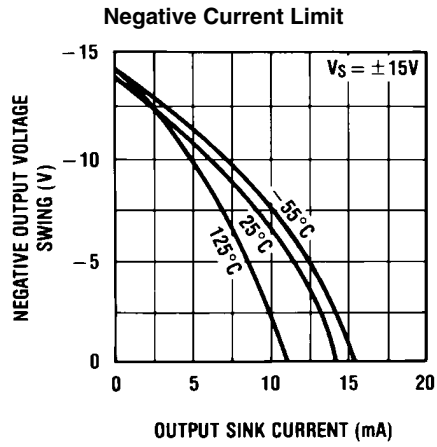
20149515



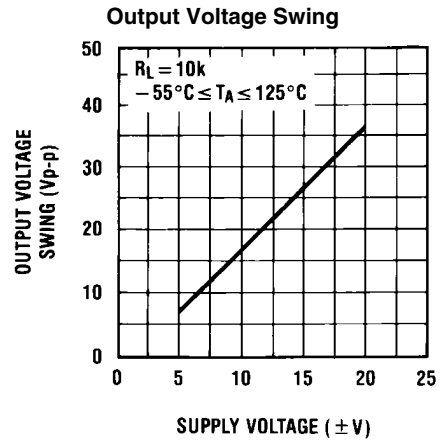
20149516



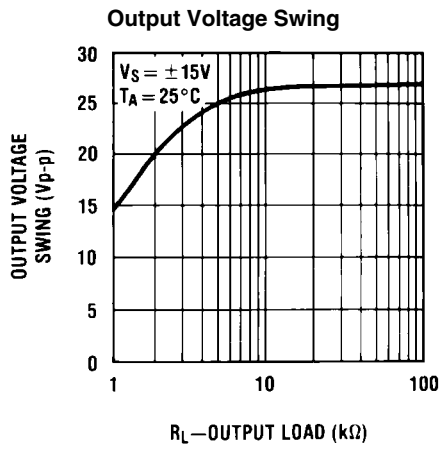
20149517



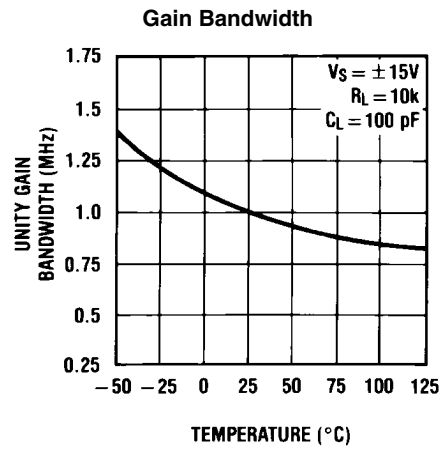
20149518



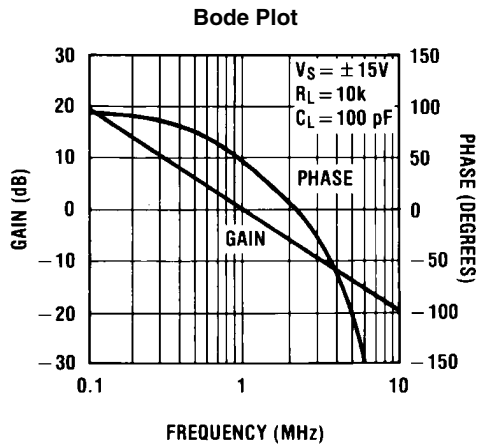
20149519



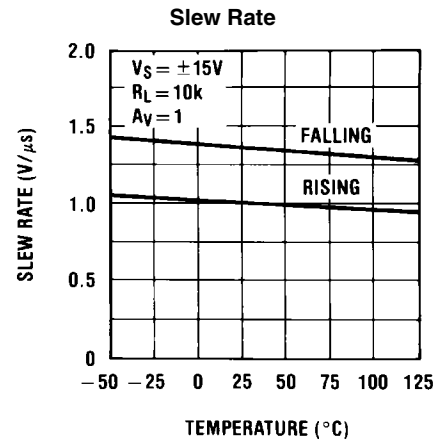
20149520



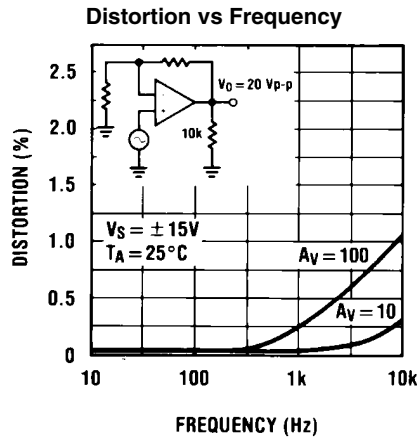
20149521



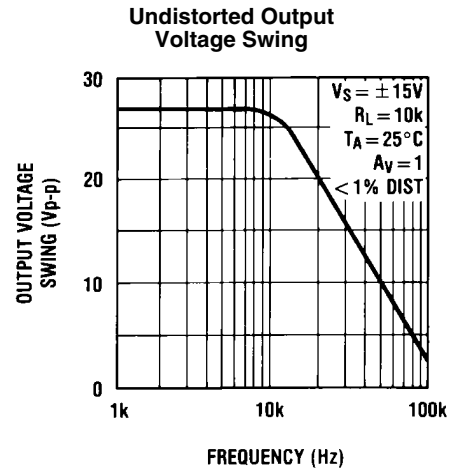
20149522



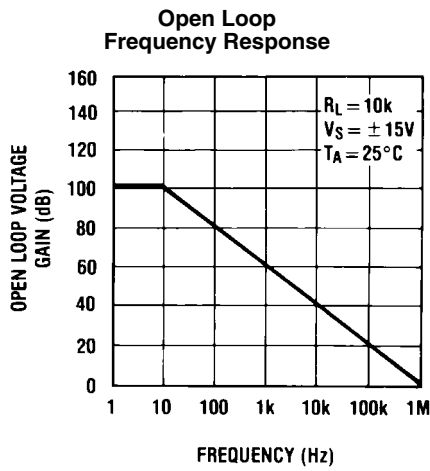
20149523



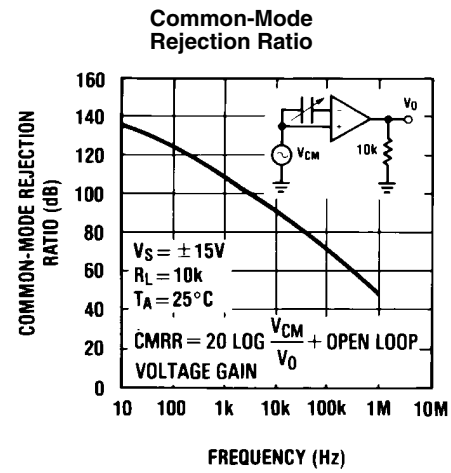
20149524



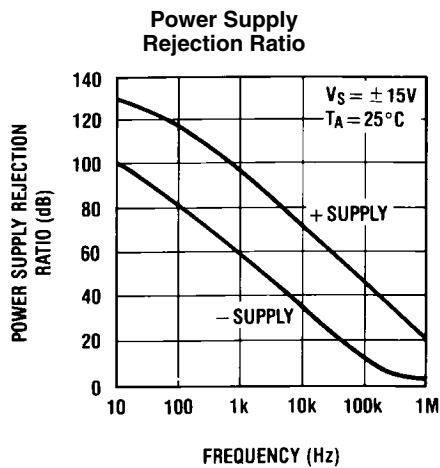
20149525



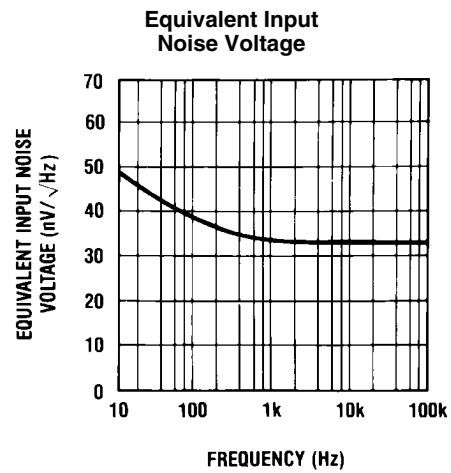
20149526



20149527

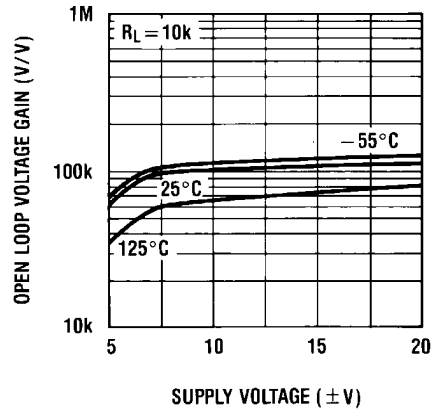


20149528



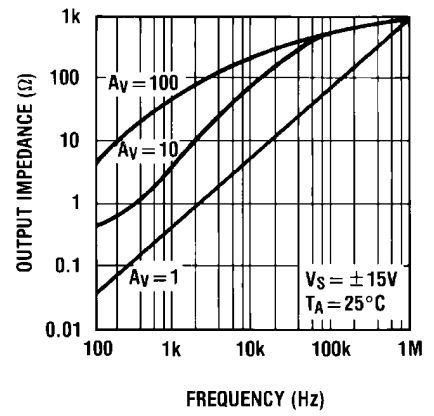
20149529

Open Loop Voltage Gain



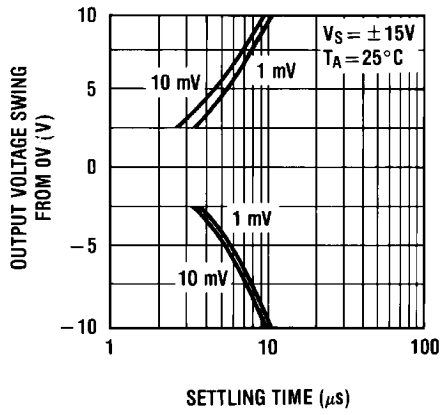
20149530

Output Impedance



20149531

Inverter Settling Time

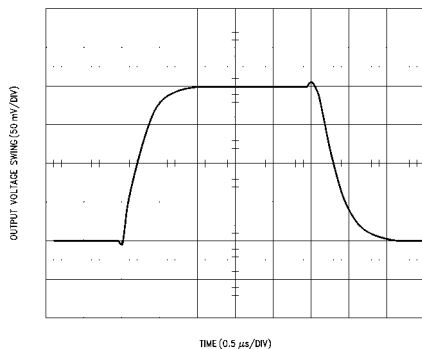


20149532

Pulse Response

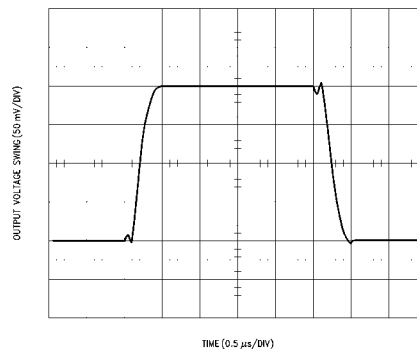
$R_L = 10\text{ k}\Omega$, $C_L = 10\text{ pF}$

Small Signal Inverting



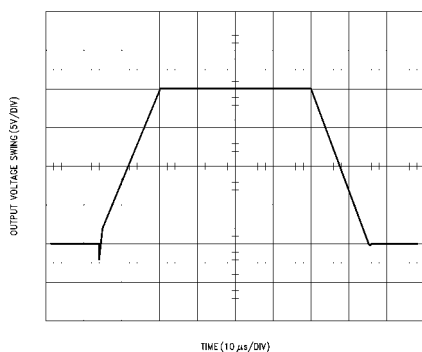
20149506

Small Signal Non-Inverting



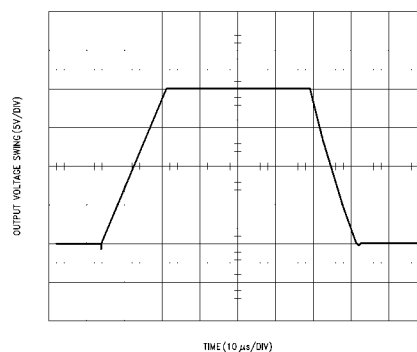
20149507

Large Signal Inverting



20149508

Large Signal Non-Inverting



20149509

Application Hints

This device is a quad low power op amp with JFET input devices (BI-FET®). These JFETs have large reverse breakdown voltages from gate to source and drain eliminating the need for clamps across the inputs. Therefore, large differential input voltages can easily be accommodated without a large increase in input current. The maximum differential input voltage is independent of the supply voltages. However, neither of the input voltages should be allowed to exceed the negative supply as this will cause large currents to flow which can result in a destroyed unit.

Exceeding the negative common-mode limit on either input will force the output to a high state, potentially causing a reversal of phase to the output. Exceeding the negative common-mode limit on both inputs will force the amplifier output to a high state. In neither case does a latch occur since raising the input back within the common-mode range again puts the input stage and thus the amplifier in a normal operating mode.

Exceeding the positive common-mode limit on a single input will not change the phase of the output; however, if both inputs exceed the limit, the output of the amplifier will be forced to a high state.

The amplifiers will operate with a common-mode input voltage equal to the positive supply; however, the gain bandwidth and slew rate may be decreased in this condition. When the negative common-mode voltage swings to within 3V of the negative supply, an increase in input offset voltage may occur.

Each amplifier is individually biased to allow normal circuit operation with power supplies of $\pm 3.0\text{V}$. Supply voltages less than these may degrade the common-mode rejection and restrict the output voltage swing.

The amplifiers will drive a $10\text{ k}\Omega$ load resistance to $\pm 10\text{V}$ over the full temperature range. If the amplifier is forced to drive heavier load currents, however, an increase in input offset voltage may occur on the negative voltage swing and finally reach an active current limit on both positive and negative swings.

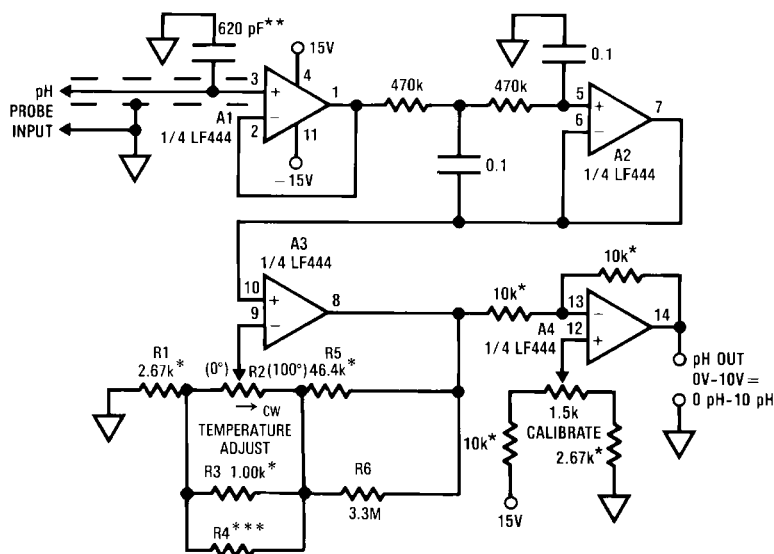
Precautions should be taken to ensure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

As with most amplifiers, care should be taken with lead dress, component placement and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize "pick-up" and maximize the frequency of the feedback pole by minimizing the capacitance from the input to ground.

A feedback pole is created when the feedback around any amplifier is resistive. The parallel resistance and capacitance from the input of the device (usually the inverting input) to AC ground set the frequency of the pole. In many instances the frequency of this pole is much greater than the expected 3 dB frequency of the closed loop gain and consequently there is negligible effect on stability margin. However, if the feedback pole is less than approximately 6 times the expected 3 dB frequency a lead capacitor should be placed from the output to the input of the op amp. The value of the added capacitor should be such that the RC time constant of this capacitor and the resistance it parallels is greater than or equal to the original feedback pole time constant.

Typical Application

pH Probe Amplifier/Temperature Compensator



20149510

***For R2 = 50kΩ, R4 = 330k ±1%

For R2 = 100k, R4 = 75k ±1%

For R2 = 200k, R4 = 56k ±1%

**Polystyrene

*Film resistor type RN60C

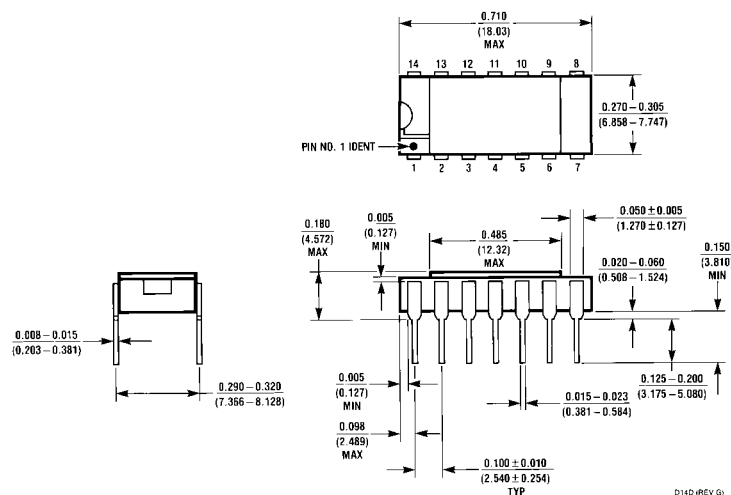
To calibrate, insert probe in pH =7 solution. Set the "TEMPERATURE ADJUST" pot, R2, to correspond to the solution temperature: full clockwise for 0°C, and proportionately for intermediate temperatures, using a turns-counting dial. Then set "CALIBRATE" pot so output reads 7V.

Typical probe = Ingold Electrodes #465-35

Revision History

Date Released	Revision	Section	Changes
12/16/2010	A	New release to corporate format	1 MDS datasheet converted to standard corporate format. MDS MNLF444M-X Rev 0AL will be archived.

Physical Dimensions inches (millimeters) unless otherwise noted



See NS Package Number D14D

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/adc	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