

LF442 Dual Low Power JFET Input Operational Amplifier

1 Features

- 1/10 Supply Current of a LM1458: 400 μA (Max)
- Low Input Bias Current: 50 pA (Max)
- Low Input Offset Voltage: 1 mV (Max)
- Low Input Offset Voltage Drift: 7 $\mu\text{V}/^\circ\text{C}$ (Typ)
- High Gain Bandwidth: 1 MHz
- High Slew Rate: 1 V/ μs
- 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 $V_O = \pm 10\text{V}$, $R_L = 10\text{k}$: 50k (Min)

2 Applications

- High Speed Integrators
- Fast D/A Converters
- Sample and Hold Circuits

3 Description

The LF442 dual low power operational amplifiers provide many of the same AC characteristics as the industry standard LM1458 while greatly improving the DC characteristics of the LM1458. The amplifiers have the same bandwidth, slew rate, and gain (10 k Ω load) as the LM1458 and only draw one tenth the supply current of the LM1458. In addition the well matched high voltage JFET input devices of the LF442 reduce the input bias and offset currents by a factor of 10,000 over the LM1458. A combination of careful layout design and internal trimming ensures very low input offset voltage and voltage drift. The LF442 also has a very low equivalent input noise voltage for a low power amplifier.

The LF442 is pin compatible with the LM1458 allowing an immediate 10 times reduction in power drain in many applications. The LF442 should be used where low power dissipation and good electrical characteristics are the major considerations.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LF442ACN	PDIP (8)	9.59 mm x 6.35 mm
LF442AMH	TO-99 (8)	8.96 mm Diameter

(1) For all available packages, see the orderable addendum at the end of the datasheet.

Inverting Amplifier

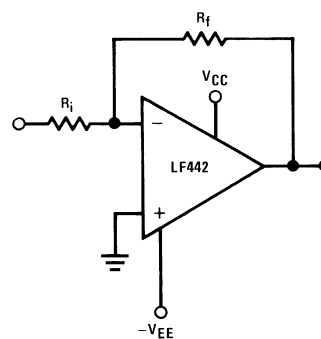


Table of Contents

1 Features 1 2 Applications 1 3 Description 1 4 Revision History 2 5 Pin Configuration and Functions 3 6 Specifications 4 6.1 Absolute Maximum Ratings 4 6.2 Absolute Maximum Ratings ⁽¹⁾⁽²⁾ 4 6.3 Handling Ratings 4 6.4 Recommended Operating Conditions 4 6.5 Thermal Information 4 6.6 DC Electrical Characteristics ⁽²⁾ 5 6.7 AC Electrical Characteristics ⁽³⁾⁽²⁾ 5 6.8 Typical Performance Characteristics 6 7 Detailed Description 11 7.1 Overview 11	7.2 Functional Block Diagram 11 7.3 Feature Description 11 7.4 Device Functional Modes 12 8 Application and Implementation 13 8.1 Application Information 13 8.2 Typical Applications 13 9 Power Supply Recommendations 18 10 Layout 18 10.1 Layout Guidelines 18 10.2 Layout Example 18 11 Device and Documentation Support 19 11.1 Trademarks 19 11.2 Electrostatic Discharge Caution 19 11.3 Glossary 19 12 Mechanical, Packaging, and Orderable Information 19
--	---

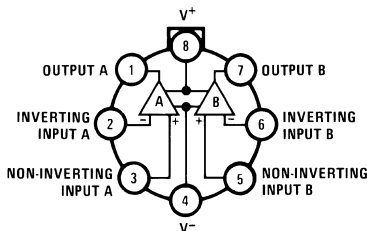
4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision E (October 2013) to Revision F	Page
<ul style="list-style-type: none"> • Deleted Max $\Delta V_{OS/\Delta T}$ specification for LF442A. 5 	5
Changes from Revision D (March 2013) to Revision E	Page
<ul style="list-style-type: none"> • Changed Input Noise Voltage units 5 	5
Changes from Revision C (March 2013) to Revision D	Page
<ul style="list-style-type: none"> • Changed layout of data sheet from National to TI format 1 	1

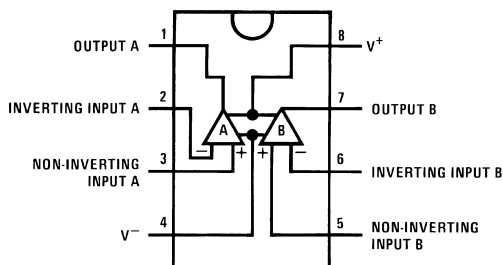
5 Pin Configuration and Functions

TO Package
See Package Number LMC008C
Top View



Pin 4 connected to case

PDIP Package
See Package Number P008E
Top View



Pin Functions

PIN		I/O	DESCRIPTION
NAME	NO.		
Output A	1	Output	Amplifier A Output
Inverting Input A	2	Input	Amplifier A Inverting Input
Non-Inverting Input A	3	Input	Amplifier A Non-Inverting Input
V-	4	Power	Negative Supply
Non-Inverting Input B	5	Input	Amplifier B Non-Inverting Input
Inverting Input B	6	Input	Amplifier B Inverting Input
Output B	7	Output	Amplifier B Output
V+	8	Power	Positive Supply

6 Specifications

6.1 Absolute Maximum Ratings⁽¹⁾⁽²⁾

	LF442A	LF442
Supply Voltage	±22V	±18V
Differential Input Voltage	±38V	±30V
Input Voltage Range ⁽³⁾	±19V	±15V
Output Short Circuit Duration ⁽⁴⁾	Continuous	Continuous

- (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 ensure specific performance limits.
- (2) Refer to RETS442X for LF442MH military specifications.
- (3) Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.
- (4) 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.

6.2 Absolute Maximum Ratings⁽¹⁾⁽²⁾

	LMC0008C Package	P0008E Package
T _j max	150°C	115°C
Operating Temperature Range	See ⁽³⁾⁽⁴⁾	See ⁽³⁾⁽⁴⁾
Lead Temperature (Soldering, 10 sec.)	260°C	260°C

- (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 ensure specific performance limits.
- (2) Refer to RETS442X for LF442MH military specifications.
- (3) These devices are available in both the commercial temperature range $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$ and the military temperature range $-55^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$. The temperature range is designated by the position just before the package type in the device number. A “C” indicates the commercial temperature range and an “M” indicates the military temperature range. The military temperature range is available in “H” package only.
- (4) The value given is in static air.

6.3 Handling Ratings

		MIN	MAX	UNIT
T _{stg}	Storage temperature range	-65	150	°C

6.4 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

	MIN	NOM	MAX	UNIT
Supply Voltage LF442A			±20	V
Supply Voltage LF442			±15	V

6.5 Thermal Information

THERMAL METRIC ⁽¹⁾		LF442		UNIT
		LMC0008C	P0008E	
		8 PINS	8 PINS	
R _{θJA} (Typical)	Junction-to-ambient thermal resistance	400 linear feet/min air flow		°C/W
		Static air		
R _{θJC} (Typical)	Junction-to-case thermal resistance	21		

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](http://www.ti.com/lit/zip/spra953).

6.6 DC Electrical Characteristics⁽¹⁾⁽²⁾

PARAMETER	TEST CONDITIONS	LF442A			LF442			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
V_{OS} Input Offset Voltage	$R_S = 10\text{ k}\Omega$, $T_A = 25^\circ\text{C}$		0.5	1.0		1.0	5.0	mV
	Over Temperature						7.5	mV
$\Delta V_{OS}/\Delta T$ Average TC of Input Offset Voltage	$R_S = 10\text{ k}\Omega$		7			7		$\mu\text{V}/^\circ\text{C}$
I_{OS} Input Offset Current	$V_S = \pm 15\text{V}^{(1)(3)}$	$T_j = 25^\circ\text{C}$	5	25	5	50		pA
		$T_j = 70^\circ\text{C}$		1.5		1.5		nA
		$T_j = 125^\circ\text{C}$		10				nA
I_B Input Bias Current	$V_S = \pm 15\text{V}^{(1)(3)}$	$T_j = 25^\circ\text{C}$	10	50	10	100		pA
		$T_j = 70^\circ\text{C}$		3		3		nA
		$T_j = 125^\circ\text{C}$		20				nA
R_{IN} Input Resistance	$T_j = 25^\circ\text{C}$		10^{12}		10^{12}			Ω
A_{VOL} Large Signal Voltage Gain	$V_S = \pm 15\text{V}$, $V_O = \pm 10\text{V}$, $R_L = 10\text{ k}\Omega$, $T_A = 25^\circ\text{C}$	50	200		25	200		V/mV
	Over Temperature	25	200		15	200		V/mV
V_O Output Voltage Swing	$V_S = \pm 15\text{V}$, $R_L = 10\text{ k}\Omega$	± 12	± 13		± 12	± 13		V
V_{CM} Input Common-Mode Voltage Range		± 16	+18		± 11	+14		V
			-17			-12		V
CMRR Common-Mode Rejection Ratio	$R_S \leq 10\text{ k}\Omega$	80	100		70	95		dB
PSRR Supply Voltage Rejection Ratio	See ⁽⁴⁾	80	100		70	90		dB
I_S Supply Current			300	400		400	500	μA

- Unless otherwise specified, the specifications apply over the full temperature range and for $V_S = \pm 20\text{V}$ for the LF442A and for $V_S = \pm 15\text{V}$ for the LF442. V_{OS} , I_B , and I_{OS} are measured at $V_{CM} = 0$.
- Refer to RETS442X for LF442MH military specifications.
- The input bias currents are junction leakage currents which approximately double for every 10°C increase in the junction temperature, T_j . Due to limited production test time, the input bias currents measured are correlated to junction temperature. In normal operation the junction temperature rises above the ambient temperature as a result of internal power dissipation, P_D . $T_j = T_A + \theta_{jA}P_D$ where θ_{jA} is the thermal resistance from junction to ambient. Use of a heat sink is recommended if input bias current is to be kept to a minimum.
- Supply voltage rejection ratio is measured for both supply magnitudes increasing or decreasing simultaneously in accordance with common practice from $\pm 15\text{V}$ to $\pm 5\text{V}$ for the LF442 and $\pm 20\text{V}$ to $\pm 5\text{V}$ for the LF442A.

6.7 AC Electrical Characteristics⁽¹⁾⁽²⁾

PARAMETER	TEST CONDITIONS	LF442A			LF442			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
Amplifier to Amplifier Coupling	$T_A = 25^\circ\text{C}$, $f = 1\text{ Hz-20 kHz}$ (Input Referred)		-120			-120		dB
SR Slew Rate	$V_S = \pm 15\text{V}$, $T_A = 25^\circ\text{C}$	0.8	1		0.6	1		V/ μs
GBW Gain-Bandwidth Product	$V_S = \pm 15\text{V}$, $T_A = 25^\circ\text{C}$	0.8	1		0.6	1		MHz
e_n Equivalent Input Noise Voltage	$T_A = 25^\circ\text{C}$, $R_S = 100\Omega$, $f = 1\text{ kHz}$		35			35		$\text{nV}/\sqrt{\text{Hz}}$
i_n Equivalent Input Noise Current	$T_A = 25^\circ\text{C}$, $f = 1\text{ kHz}$		0.01			0.01		$\text{pA}/\sqrt{\text{Hz}}$

- Unless otherwise specified, the specifications apply over the full temperature range and for $V_S = \pm 20\text{V}$ for the LF442A and for $V_S = \pm 15\text{V}$ for the LF442. V_{OS} , I_B , and I_{OS} are measured at $V_{CM} = 0$.
- Refer to RETS442X for LF442MH military specifications.

6.8 Typical Performance Characteristics

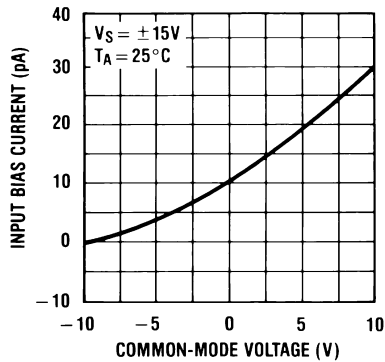


Figure 1. Input Bias Current

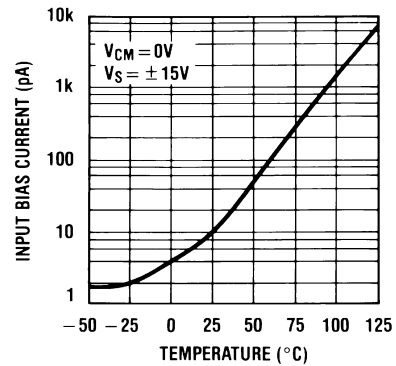


Figure 2. Input Bias Current

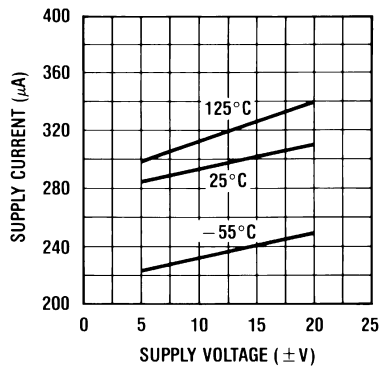


Figure 3. Supply Current

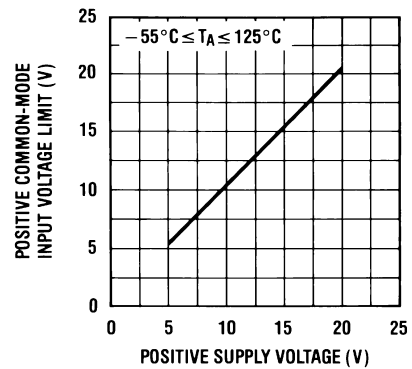


Figure 4. Positive Common-Mode Input Voltage Limit

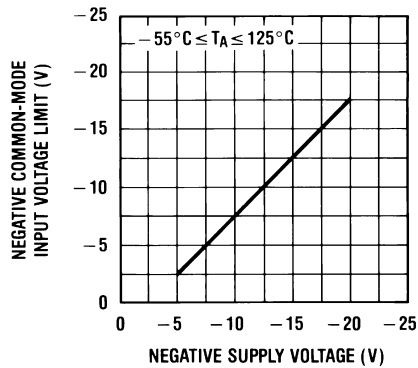


Figure 5. Negative Common-Mode Input Voltage Limit

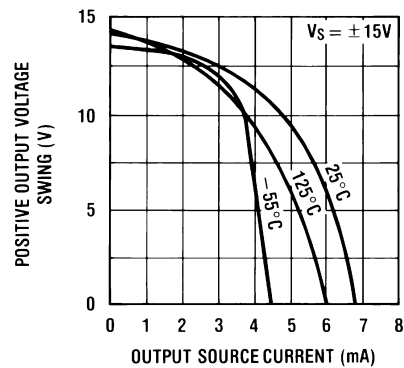


Figure 6. Positive Current Limit

Typical Performance Characteristics (continued)

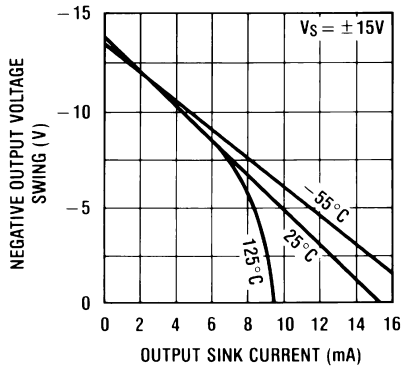


Figure 7. Negative Current Limit

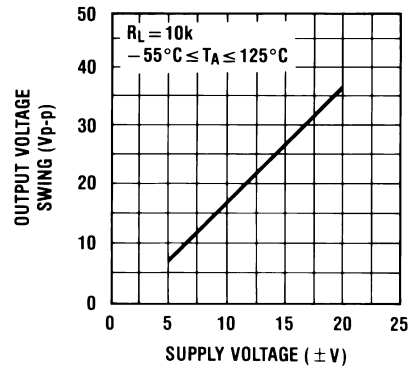


Figure 8. Output Voltage Swing

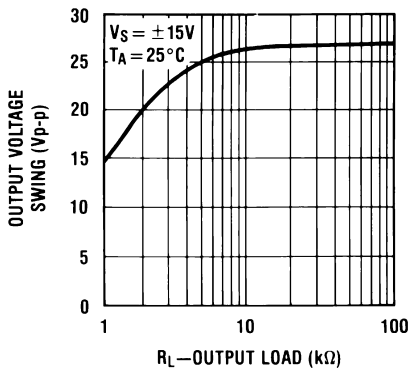


Figure 9. Output Voltage Swing

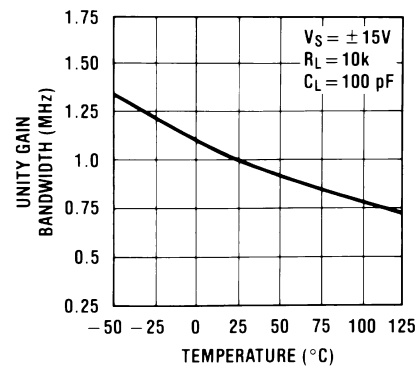


Figure 10. Gain Bandwidth

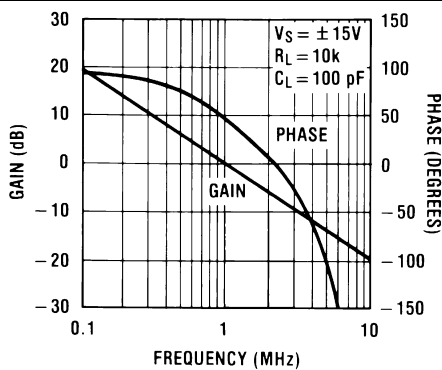


Figure 11. Bode Plot

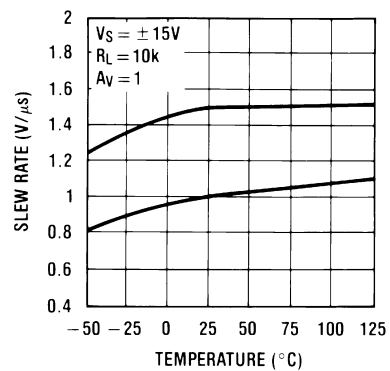


Figure 12. Slew Rate

Typical Performance Characteristics (continued)

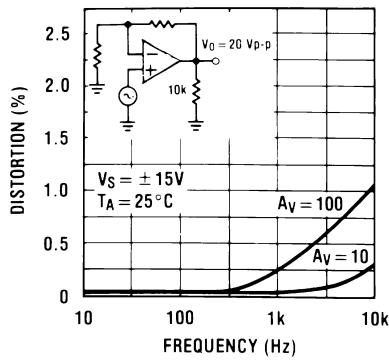


Figure 13. Distortion vs Frequency

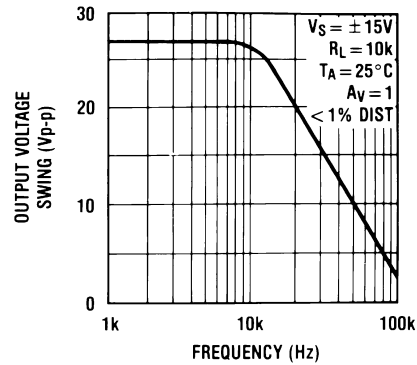


Figure 14. Undistorted Output Voltage Swing

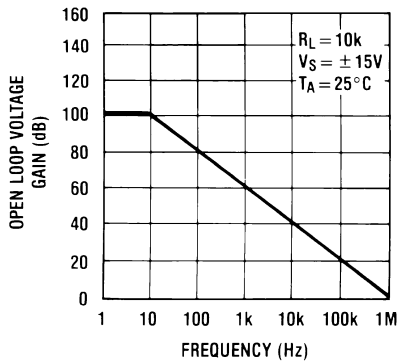


Figure 15. Open Loop Frequency Response

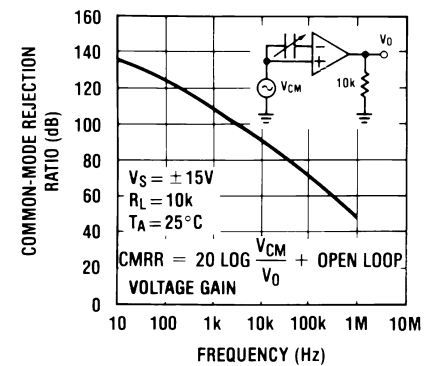


Figure 16. Common-Mode Rejection Ratio

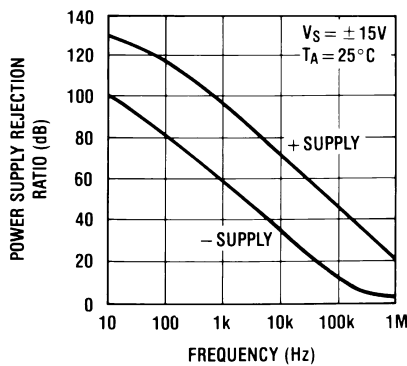


Figure 17. Power Supply Rejection Ratio

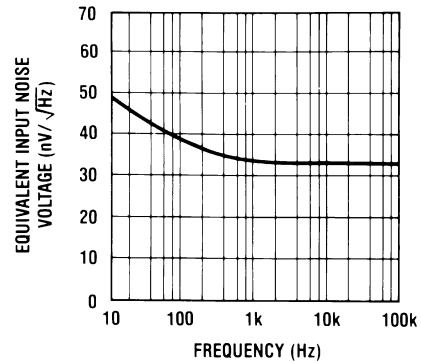


Figure 18. Equivalent Input Noise Voltage

Typical Performance Characteristics (continued)

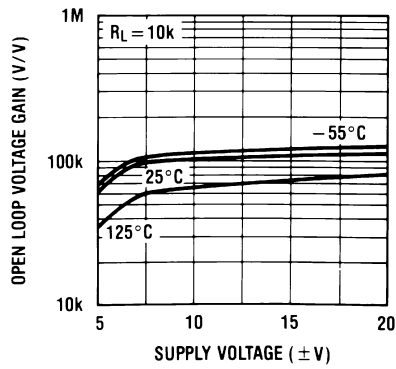


Figure 19. Open Loop Voltage Gain

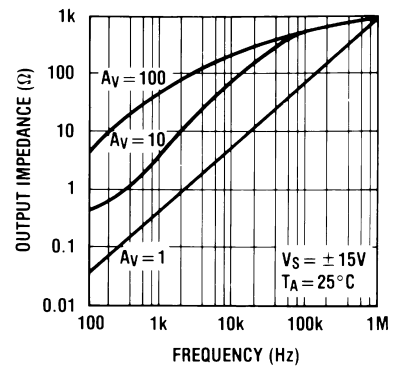


Figure 20. Output Impedance

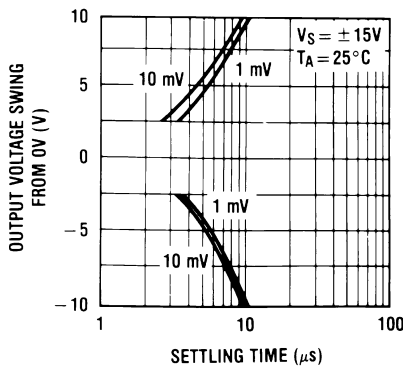


Figure 21. Inverter Settling Time

6.8.1 Pulse Response

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

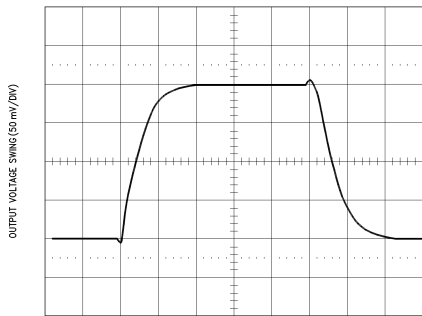
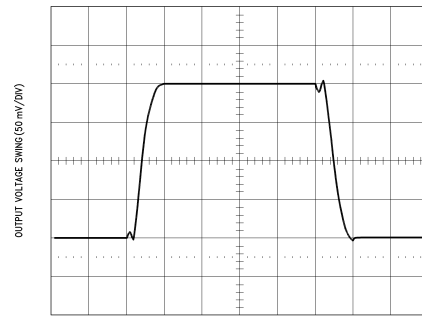
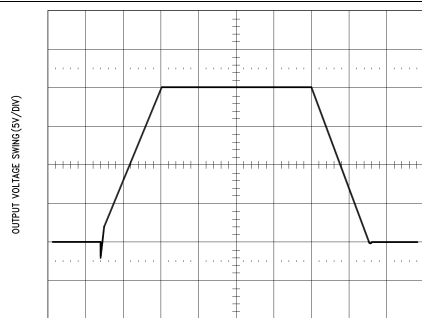


Figure 22. Small Signal Inverting



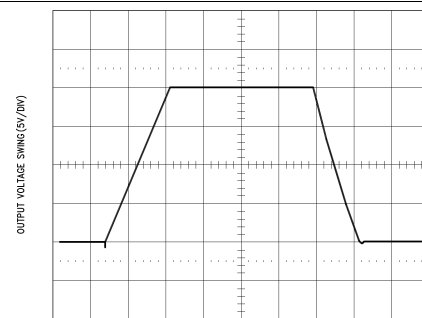
TIME (0.5 μs/DIV)

Figure 23. Small Signal Non-Inverting



TIME (10 μs/DIV)

Figure 24. Large Signal Inverting



TIME (10 μs/DIV)

Figure 25. Large Signal Non-Inverting

7 Detailed Description

7.1 Overview

The LF442 dual low power operational amplifiers provide many of the same AC characteristics as the industry standard LM1458 while greatly improving the DC characteristics of the LM1458. The amplifiers have the same bandwidth, slew rate, and gain (10 k Ω load) as the LM1458 and only draw one tenth the supply current of the LM1458. In addition the well matched high voltage JFET input devices of the LF442 reduce the input bias and offset currents by a factor of 10,000 over the LM1458. A combination of careful layout design and internal trimming ensures very low input offset voltage and voltage drift. The LF442 also has a very low equivalent input noise voltage for a low power amplifier.

The LF442 is pin compatible with the LM1458 allowing an immediate 10 times reduction in power drain in many applications. The LF442 should be used where low power dissipation and good electrical characteristics are the major considerations.

7.2 Functional Block Diagram

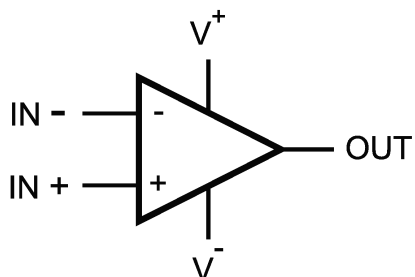


Figure 26. Each Amplifier

7.3 Feature Description

The amplifier's differential inputs consist of a non-inverting input (+IN) and an inverting input (-IN). The amplifier amplifies only the difference in voltage between the two inputs, which is called the differential input voltage. The output voltage of the op-amp V_{OUT} is given by the equation $V_{OUT} = A_{OL}(IN+ - IN-)$.

7.4 Device Functional Modes

7.4.1 Input and Output Stage

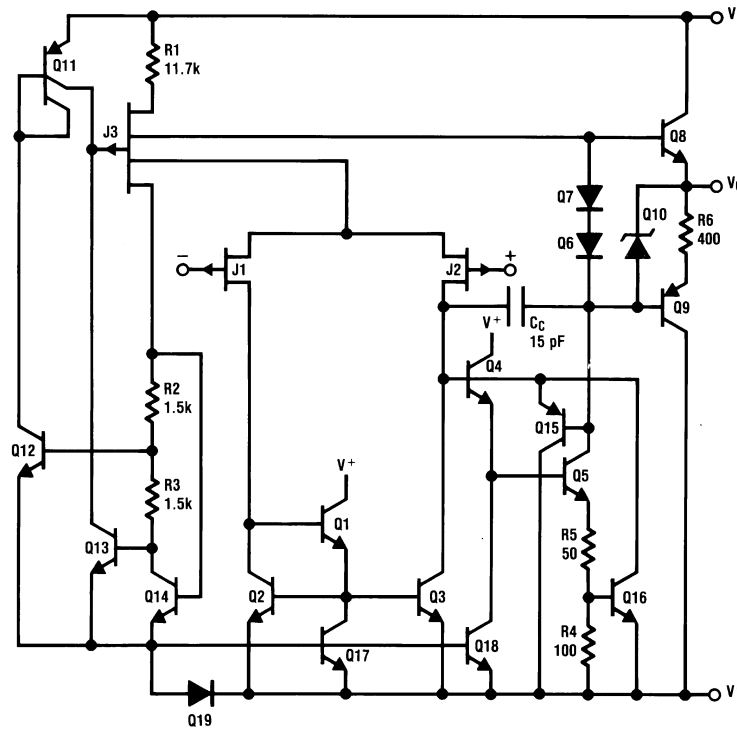


Figure 27. 1/2 Dual LF442

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LF442 uses a combination of careful layout design and internal trimming to ensure very low input offset voltage and voltage drift. The LF442 also has a very low equivalent input noise voltage for a low power amplifier. The LF442 should be used where low power dissipation and good electrical characteristics are the major considerations.

8.2 Typical Applications

1. Battery Powered Strip Chart Pre-amplifier
2. "No FET" Low Power V to F Converter
3. High Efficiency Crystal Oven Controller
4. Conventional Log Amplifier
5. Unconventional Log Amplifier

8.2.1 Battery Powered Strip Chart Pre-amplifier

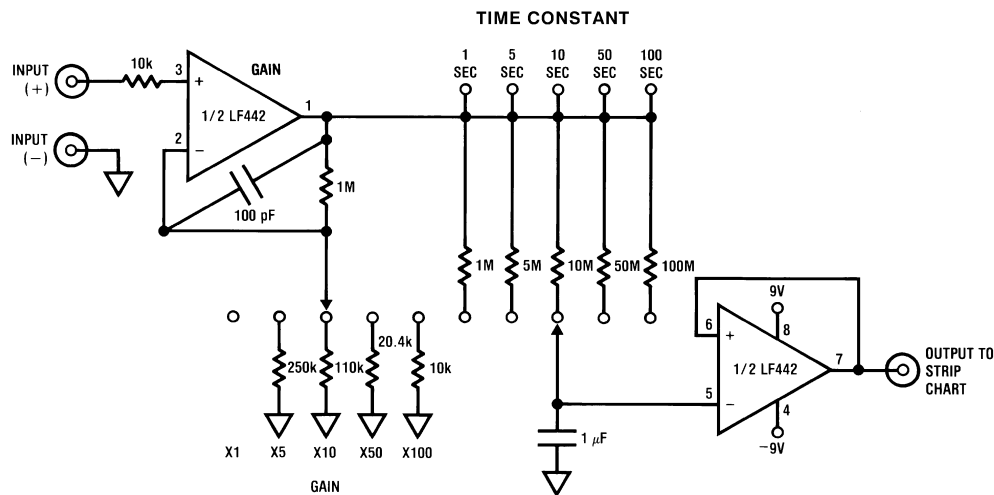


Figure 28. Battery Powered Strip Chart Pre-amplifier

8.2.1.1 Design Requirements

Runs from 9V batteries ($\pm 9V$ supplies).

Fully settable gain and time constant.

Battery powered supply allows direct plug-in interface to strip chart recorder without common-mode problems.

Typical Applications (continued)

8.2.1.2 Detailed Design Procedure

This device is a dual low power op amp with internally trimmed input offset voltages and JFET input devices (BI-FET II). 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.

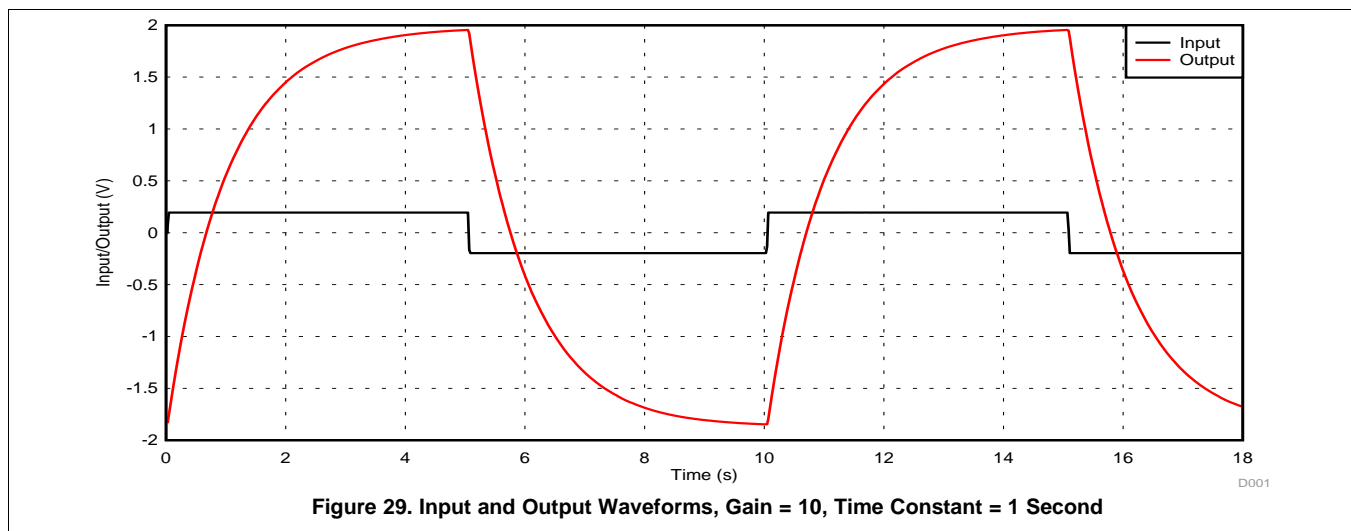
Each amplifier is individually biased to allow normal circuit operation with power supplies of $\pm 3.0V$. Supply voltages less than these may degrade the common-mode rejection and restrict the output voltage swing.

The amplifiers will drive a 10 k Ω load resistance to $\pm 10V$ over the full temperature range.

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.

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.

8.2.1.3 Application Curves



Typical Applications (continued)

8.2.2 "No FET" Low Power V to F Converter

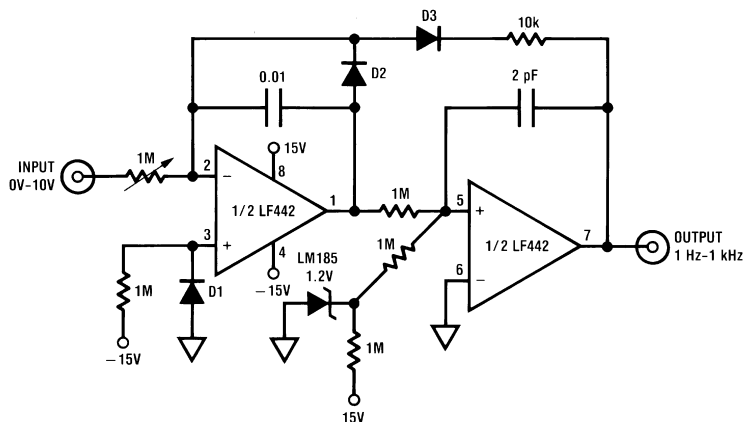


Figure 30. "No FET" Low Power V to F Converter

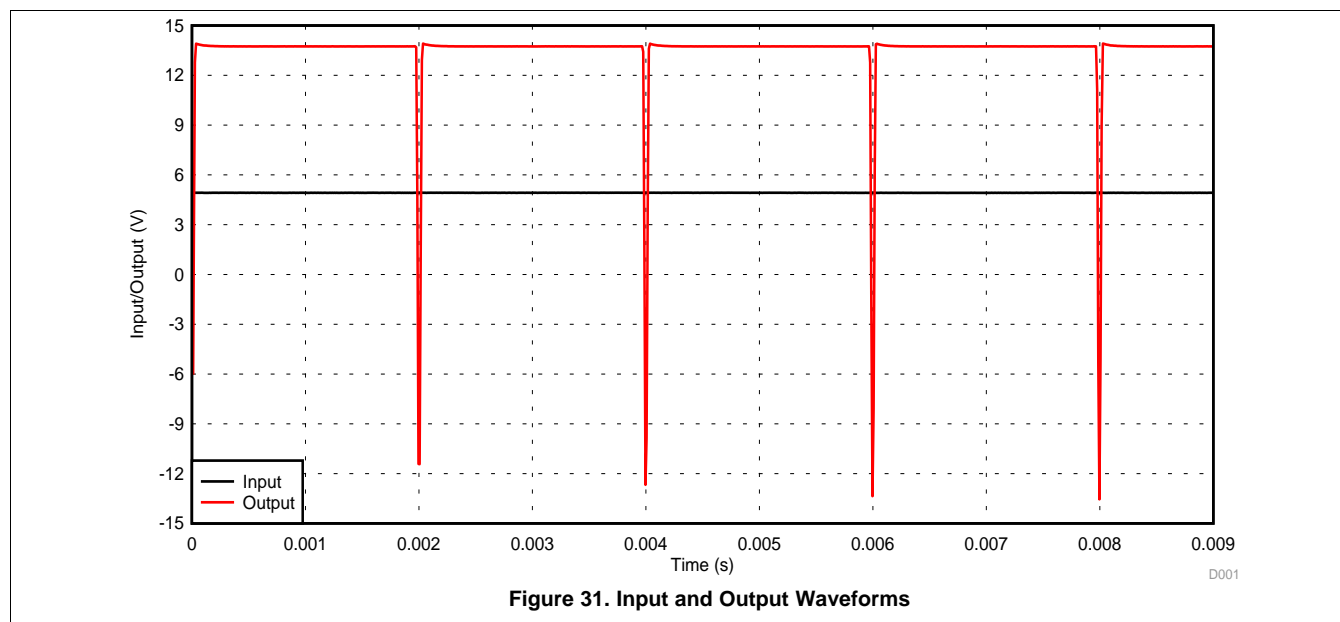
8.2.2.1 Design Requirements

1. Trim 1M pot for 1 kHz full-scale output.
2. 15 mW power drain.
3. No integrator reset FET required.
4. Mount D1 and D2 in close proximity.
5. 1% linearity to 1 kHz.

8.2.2.2 Detailed Design Procedure

See Section 8.2.1.2.

8.2.2.3 Application Curves



Typical Applications (continued)

8.2.3 High Efficiency Crystal Oven Controller

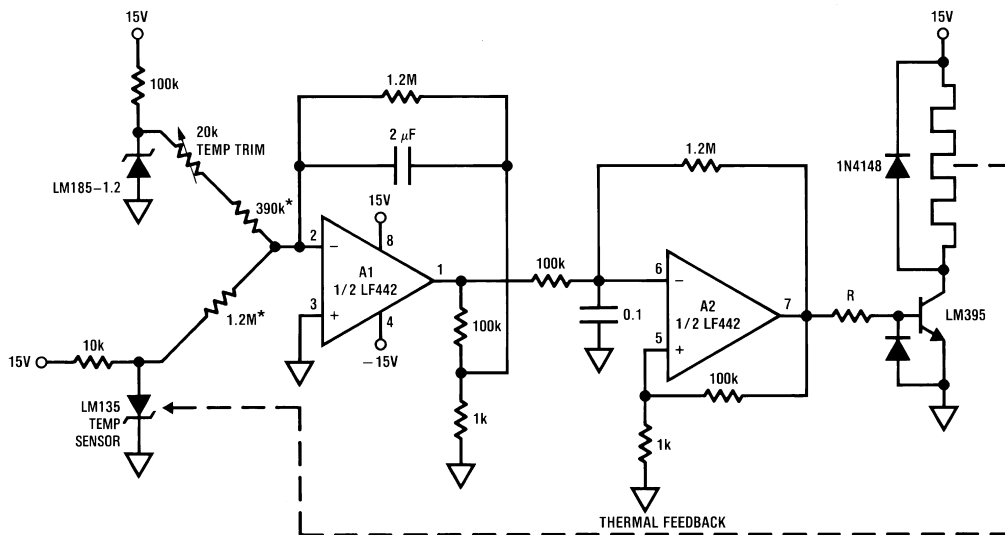


Figure 32. High Efficiency Crystal Oven Controller

8.2.3.1 Design Requirements

1. $T_{control} = 75^{\circ}C$
2. A1's output represents the amplified difference between the LM335 temperature sensor and the crystal oven's temperature.
3. A2, a free running duty cycle modulator, drives the LM395 to complete a servo loop.
4. Switched mode operation yields high efficiency.
5. 1% metal film resistor.

8.2.3.2 Detailed Design Procedure

See Section 8.2.1.2.

8.2.4 Conventional Log Amplifier

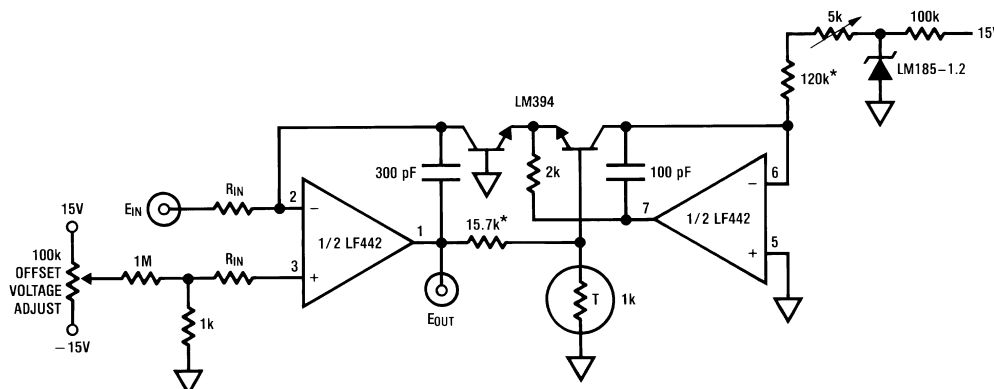


Figure 33. Conventional Log Amplifier

$$E_{OUT} = - \left[\log_{10} \left(\frac{E_{IN}}{R_{IN}} \right) + 5 \right]$$

Typical Applications (continued)

8.2.4.1 Design Requirements

1. $R_T =$ Tel Labs type Q81.
2. Trim 5k for 10 μ A through the 5k–120k combination.
3. *1% film resistor

8.2.4.2 Detailed Design Procedure

See Section 8.2.1.2.

8.2.5 Unconventional Log Amplifier

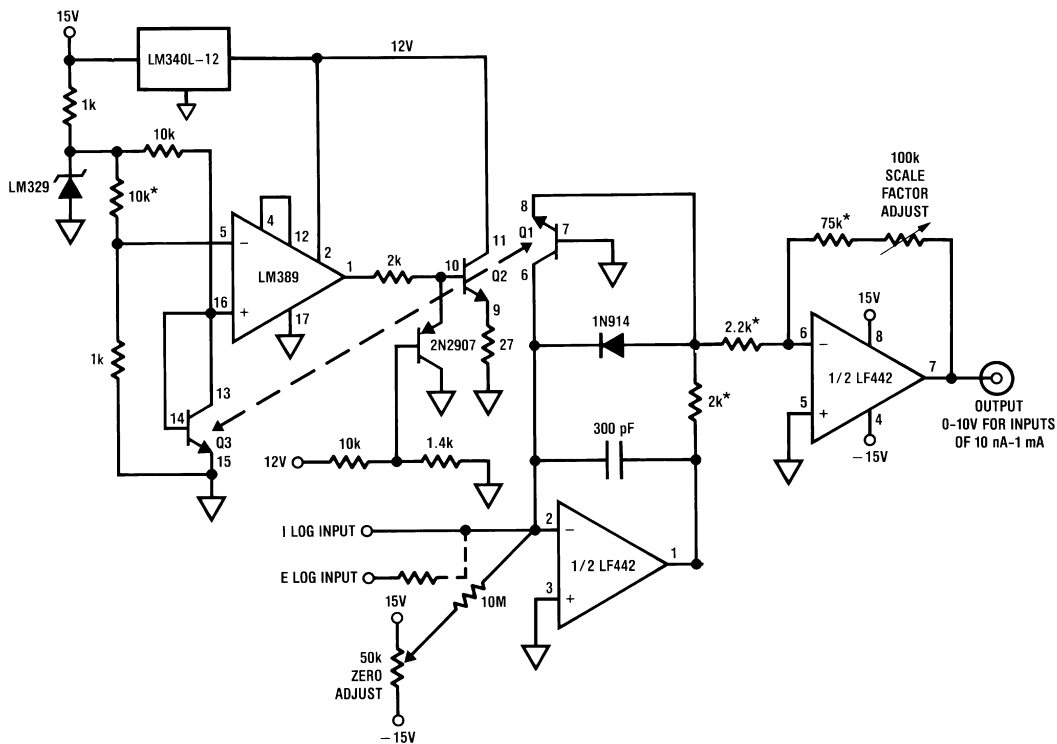


Figure 34. Unconventional Log Amplifier

8.2.5.1 Design Requirements

1. Q1, Q2, Q3 are included on LM389 amplifier chip which is temperature-stabilized by the LM389 and Q2-Q3, which act as a heater-sensor pair.
2. Q1, the logging transistor, is thus immune to ambient temperature variation and requires no temperature compensation at all.

8.2.5.2 Detailed Design Procedure

See Section 8.2.1.2.

9 Power Supply Recommendations

For proper operation, the power supplies must be properly decoupled. For decoupling the supply lines it is suggested that 0.1 μ F capacitors be placed as close as possible to the op amp power supply pins. The minimum power supply voltage is ± 5 V.

10 Layout

10.1 Layout Guidelines

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.

10.2 Layout Example

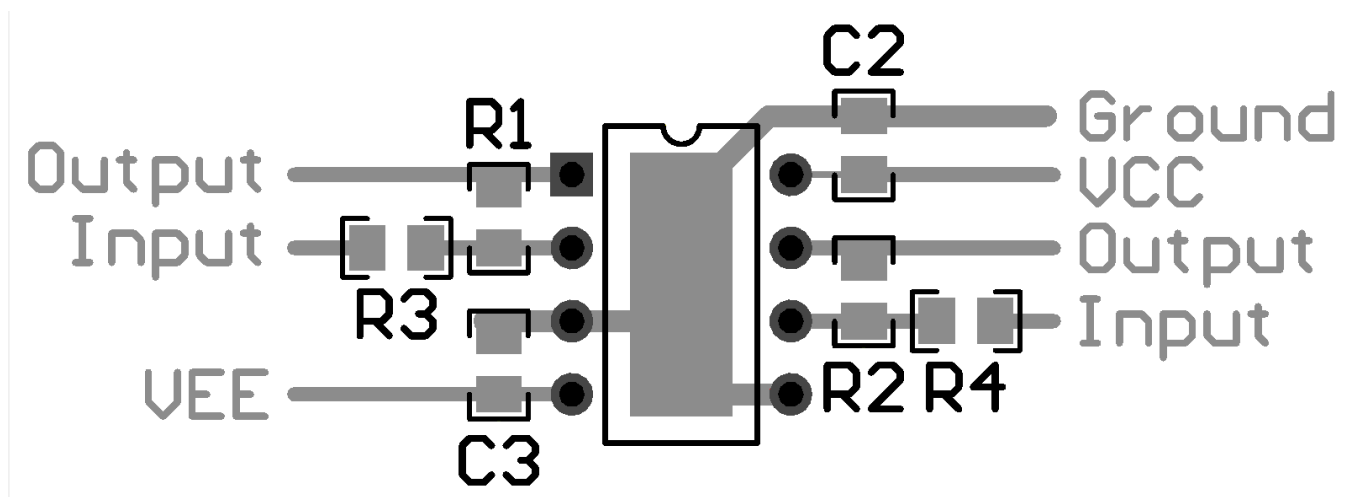


Figure 35. LF442 Layout

11 Device and Documentation Support

11.1 Trademarks

All trademarks are the property of their respective owners.

11.2 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.3 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LF442ACN	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	0 to 70	LF 442ACN	
LF442ACN/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LF 442ACN	Samples
LF442AMH	ACTIVE	TO-99	LMC	8	500	TBD	Call TI	Call TI	-55 to 125	(LF442AMH ~ LF442AMH)	Samples
LF442AMH/NOPB	ACTIVE	TO-99	LMC	8	500	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125	(LF442AMH ~ LF442AMH)	Samples
LF442CN	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	0 to 70	LF 442CN	
LF442CN/NOPB	ACTIVE	PDIP	P	8	40	Green (RoHS & no Sb/Br)	CU SN	Level-1-NA-UNLIM	0 to 70	LF 442CN	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

LMC (O-MBCY-W8)

METAL CYLINDRICAL PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Leads in true position within 0.010 (0,25) R @ MMC at seating plane.
 - D. Pin numbers shown for reference only. Numbers may not be marked on package.
 - E. Falls within JEDEC MO-002/TO-99.

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MS-001 variation BA.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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 Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
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
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com