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National Semiconductor

August 2000

LF412
Low Offset, Low Drift Dual JFET Input Operational Amplifier

General Description

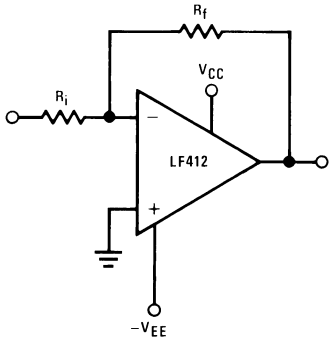
These devices are low cost, high speed, JFET input operational amplifiers with very low input offset voltage and guaranteed input offset voltage drift. They require low supply current yet maintain a large gain bandwidth product and fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents. The LF412 dual is pin compatible with the LM1558, allowing designers to immediately upgrade the overall performance of existing designs.

These amplifiers may be used in applications such as high speed integrators, fast D/A converters, sample and hold circuits and many other circuits requiring low input offset voltage and drift, low input bias current, high input impedance, high slew rate and wide bandwidth.

Features

- Internally trimmed offset voltage: 1 mV (max)
- Input offset voltage drift: 10 µV/°C (max)
- Low input bias current: 50 pA
- Low input noise current: 0.01 pA/√Hz
- Wide gain bandwidth: 3 MHz (min)
- High slew rate: 10V/µs (min)
- Low supply current: 1.8 mA/Amplifier
- High input impedance: $10^{12}\Omega$
- Low total harmonic distortion ≤0.02%
- Low 1/f noise corner: 50 Hz
- Fast settling time to 0.01%: 2 µs

Typical Connection



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Ordering Information

LF412XYZ

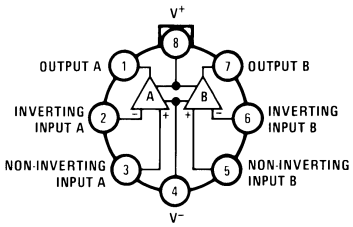
X indicates electrical grade

Y indicates temperature range
- "M" for military
- "C" for commercial

Z indicates package type
- "H" or "N"

Connection Diagrams

Metal Can Package



Note. Pin 4 connected to case.

TOP VIEW

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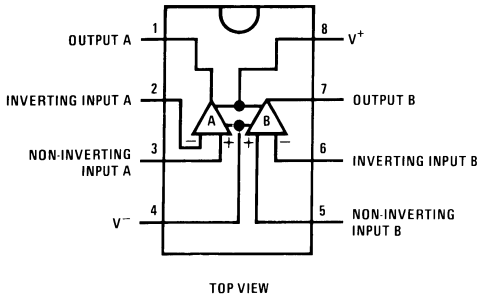
Order Number LF412MH, LF412CH or LF412MH/883 (Note 1)
See NS Package Number H08A

Dual-In-Line Package



TOP VIEW

DS005656-44

Order Number LF412ACN, LF412CN or LF412MJ/883 (Note 1)
See NS Package Number J08A or N08E

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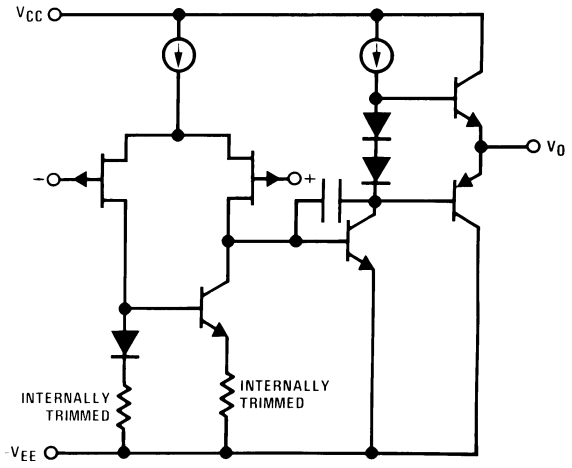
Simplified Schematic

1/2 Dual



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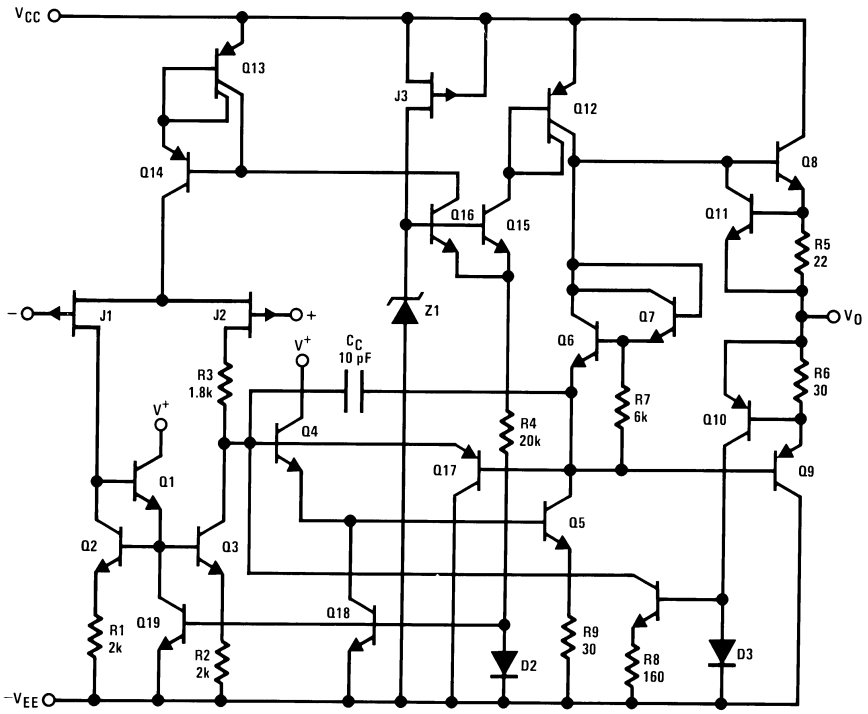
Note 1: Available per JM38510/11905

Detailed Schematic



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Absolute Maximum Ratings (Note 2)

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

(Note 11)

	LF412A	LF412
Supply Voltage	±22V	±18V
Differential Input Voltage	±38V	±30V
Input voltage Range (Note 3)	±19V	±15V
Output Short Circuit Duration (Note 4)	Continuous	Continuous

	H Package	N Package
Power Dissipation (Note 12)	(Note 5)	670 mW

	H Package	N Package
T_j max	150˚C	115˚C
θ_{jA} (Typical)	152˚C/W	115˚C/W
Operating Temp. Range	(Note 6)	(Note 6)
Storage Temp. Range	−65˚C≤T_A≤150˚C	−65˚C≤T_A≤150˚C
Lead Temp. (Soldering, 10 sec.)	260˚C	260˚C
ESD Tolerance (Note 13)	1700V	1700V

DC Electrical Characteristics

(Note 7)

Symbol	Parameter	Conditions		LF412A			LF412			Units
				Min	Typ	Max	Min	Typ	Max	
V_{OS}	Input Offset Voltage	R_S=10 kΩ, T_A=25˚C			0.5	1.0		1.0	3.0	mV
$\Delta V_{OS}/\Delta T$	Average TC of Input Offset Voltage	R_S=10 kΩ (Note 8)			7	10		7	20	µV/˚C
I_{OS}	Input Offset Current	V_S=±15V (Notes 7, 9)	T_j=25˚C		25	100		25	100	pA
			T_j=70˚C			2			2	nA
			T_j=125˚C			25			25	nA
I_B	Input Bias Current	V_S=±15V (Notes 7, 9)	T_j=25˚C		50	200		50	200	pA
			T_j=70˚C			4			4	nA
			T_j=125˚C			50			50	nA
R_{IN}	Input Resistance	T_j=25˚C			10^{12}			10^{12}		Ω
A_{VOL}	Large Signal Voltage Gain	V_S=±15V, V_O=±10V, R_L=2k, T_A=25˚C		50	200		25	200		V/mV
		Over Temperature		25	200		15	200		V/mV
V_O	Output Voltage Swing	V_S=±15V, R_L=10k		±12	±13.5		±12	±13.5		V
V_{CM}	Input Common-Mode Voltage Range			±16	+19.5		±11	+14.5		V
					−16.5			−11.5		V
CMRR	Common-Mode Rejection Ratio	R_S≤10k		80	100		70	100		dB
PSRR	Supply Voltage Rejection Ratio	(Note 10)		80	100		70	100		dB
I_S	Supply Current	V_O = 0V, R_L = ∞			3.6	5.6		3.6	6.5	mA

Note 2: "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.

AC Electrical Characteristics

(Note 7)

Symbol	Parameter	Conditions	LF412A			LF412			Units
			Min	Typ	Max	Min	Typ	Max	
	Amplifier to Amplifier Coupling	T_A=25˚C, f=1 Hz-20 kHz (Input Referred)		−120			−120		dB
SR	Slew Rate	V_S=±15V, T_A=25˚C	10	15		8	15		V/µs
GBW	Gain-Bandwidth Product	V_S=±15V, T_A=25˚C	3	4		2.7	4		MHz

AC Electrical Characteristics (Continued)

(Note 7)

Symbol	Parameter	Conditions	LF412A			LF412			Units
			Min	Typ	Max	Min	Typ	Max	
THD	Total Harmonic Dist	A_V=+10, R_L=10k, V_O=20 Vp-p, BW=20 Hz-20 kHz		≤0.02			≤0.02		%
e_n	Equivalent Input Noise Voltage	T_A=25˚C, R_S=100Ω, f=1 kHz		25			25		$nV/\sqrt{Hz}$
i_n	Equivalent Input Noise Current	T_A=25˚C, f=1 kHz		0.01			0.01		$pA/\sqrt{Hz}$

Note 3: Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

Note 4: Any of the amplifier outputs can be shorted to ground indefintely, however, more than one should not be simultaneously shorted as the maximum junction temperature will be exceeded.

Note 5: For operating at elevated temperature, these devices must be derated based on a thermal resistance of θ_{jA}.

Note 6: These devices are available in both the commercial temperature range 0˚C≤T_A≤70˚C and the military temperature range −55˚C≤T_A≤125˚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. In all cases the maximum operating temperature is limited by internal junction temperature T_j max.

Note 7: Unless otherwise specified, the specifications apply over the full temperature range and for V_S=±20V for the LF412A and for V_S=±15V for the LF412. V_{OS}, I_B, and I_{OS} are measured at V_{CM}=0.

Note 8: The LF412A is 100% tested to this specification. The LF412 is sample tested on a per amplifier basis to insure at least 85% of the amplifiers meet this specification.

Note 9: 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+θ_{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.

Note 10: Supply voltage rejection ratio is measured for both supply magnitudes increasing or decreasing simultaneously in accordance with common practice. V_S = ±6V to ±15V.

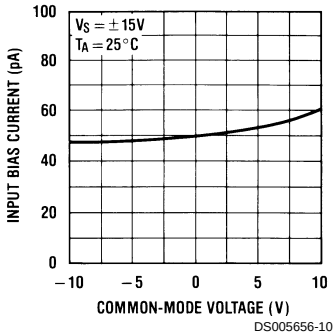
Note 11: Refer to RETS412X for LF412MH and LF412MJ military specifications.

Note 12: 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 13: Human body model, 1.5 kΩ in series with 100 pF.

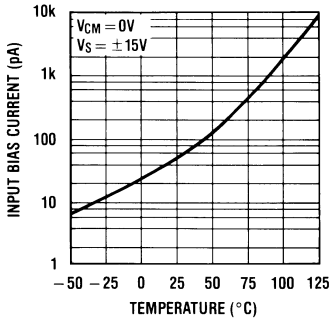
Typical Performance Characteristics

Input Bias Current



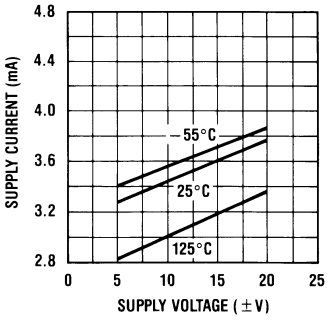
DS005656-10

Input Bias Current



DS005656-11

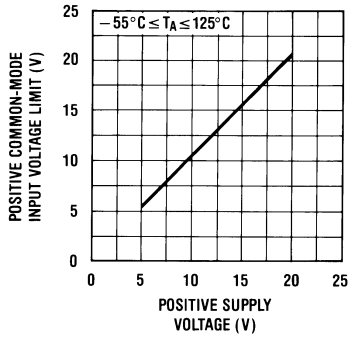
Supply Current



DS005656-12

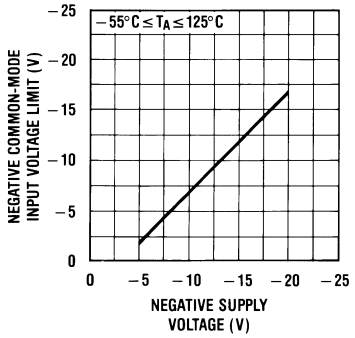
Typical Performance Characteristics (Continued)

Positive Common-Mode Input Voltage Limit



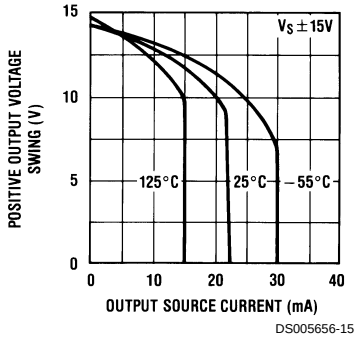
DS005656-13

Negative Common-Mode Input Voltage Limit



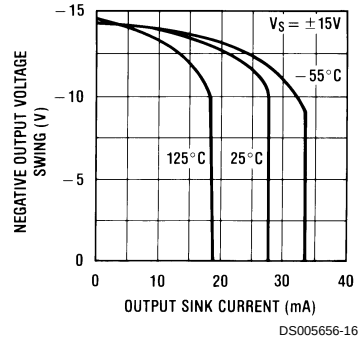
DS005656-14

Positive Current Limit



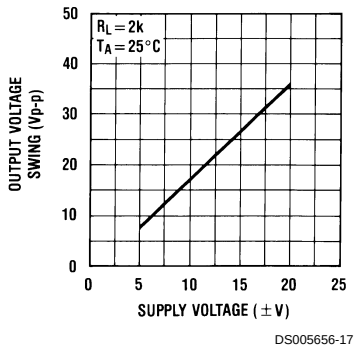
DS005656-15

Negative Current Limit



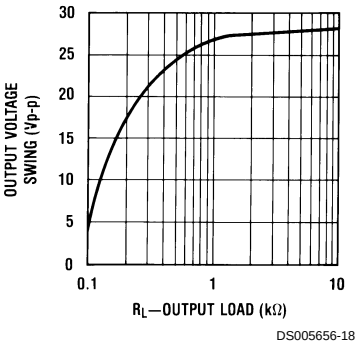
DS005656-16

Output Voltage Swing



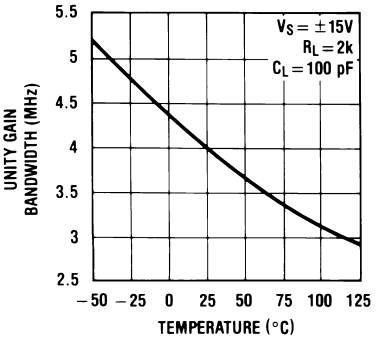
DS005656-17

Output Voltage Swing



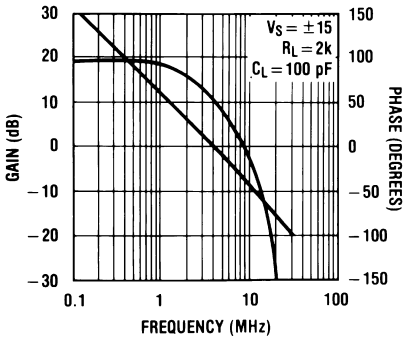
DS005656-18

Gain Bandwidth



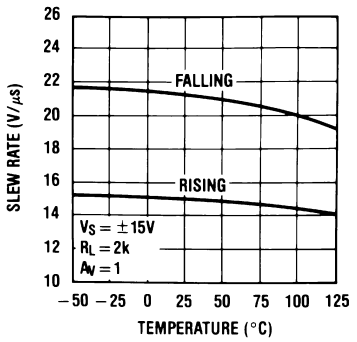
DS005656-19

Bode Plot



DS005656-20

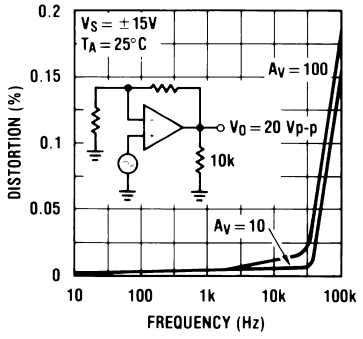
Slew Rate



DS005656-21

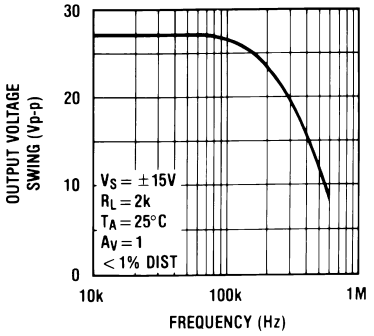
Typical Performance Characteristics (Continued)

Distortion vs Frequency



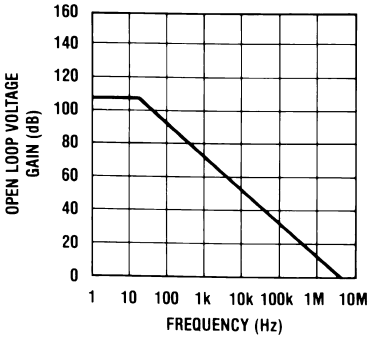
DS005656-22

Undistorted Output Voltage Swing



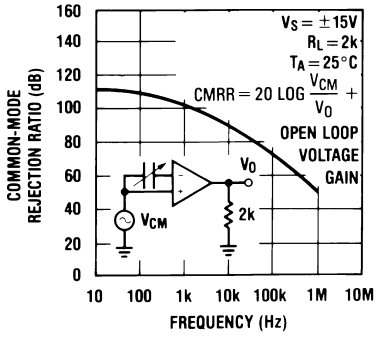
DS005656-23

Open Loop Frequency Response



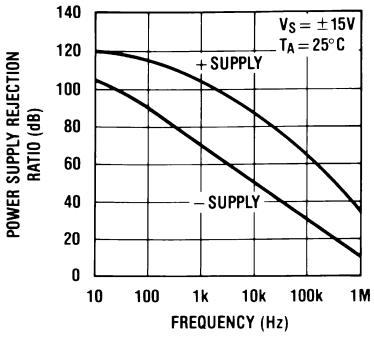
DS005656-24

Common-Mode Rejection Ratio



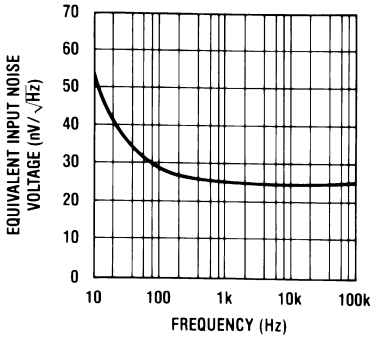
DS005656-25

Power Supply Rejection Ratio



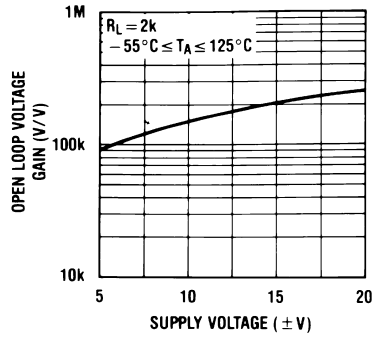
DS005656-26

Equivalent Input Noise Voltage



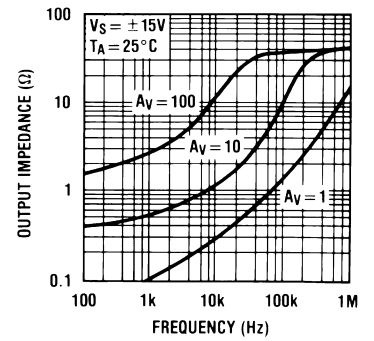
DS005656-27

Open Loop Voltage Gain



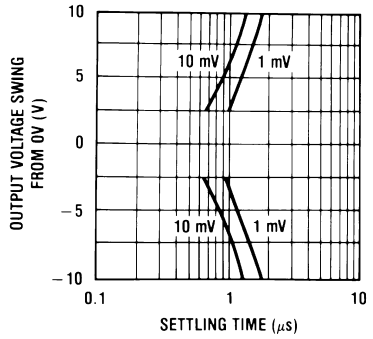
DS005656-28

Output Impedance



DS005656-29

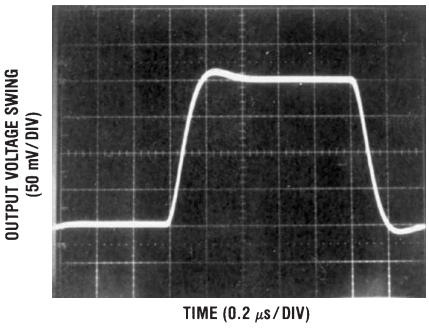
Inverter Settling Time



DS005656-30

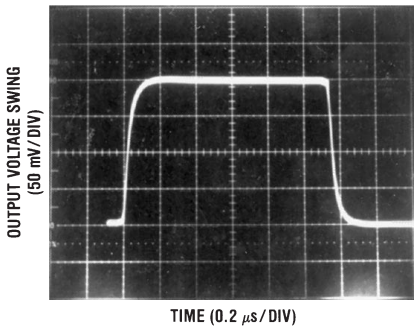
Pulse Response R_L=2 kΩ, C_L=10 pF

Small Signal Inverting



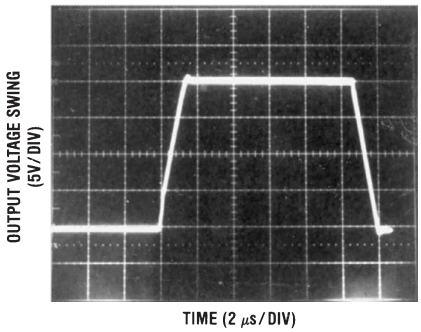
DS005656-36

Small Signal Non-Inverting



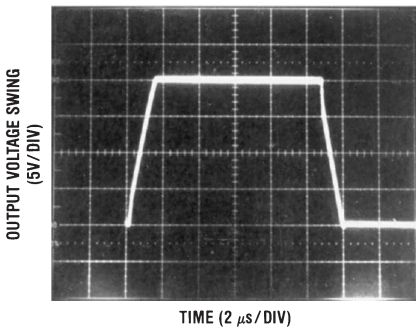
DS005656-37

Large Signal Inverting



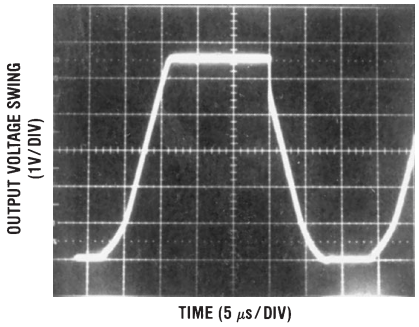
DS005656-38

Large Signal Non-Inverting



DS005656-39

Current Limit (R_L=100Ω)



DS005656-40

Application Hints

The LF412 series of JFET input dual op amps are internally trimmed (BI-FET II™) providing very low input offset voltages and guaranteed input offset voltage drift. 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 cause a reversal of the phase to the output and force the amplifier output to the corresponding high or low state.

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 may 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.

Application Hints (Continued)

Each amplifier is individually biased by a zener reference which allows normal circuit operation on ±6.0V power supplies. Supply voltages less than these may result in lower gain bandwidth and slew rate.

The amplifiers will drive a 2 kΩ load resistance to ±10V 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.

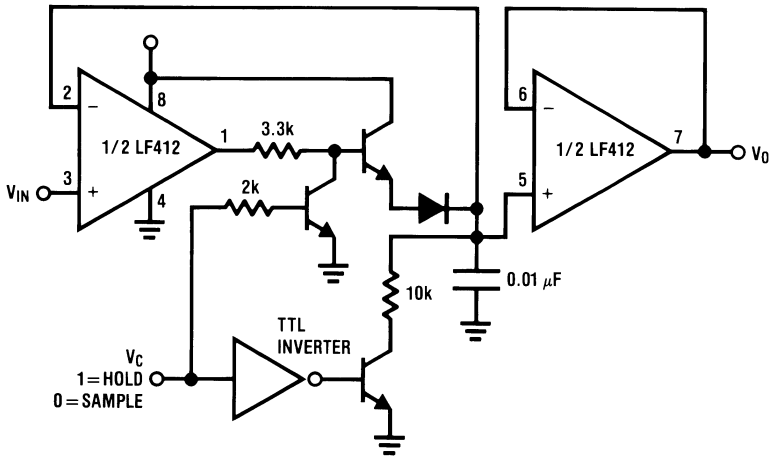
Precautions should be taken to ensure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal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

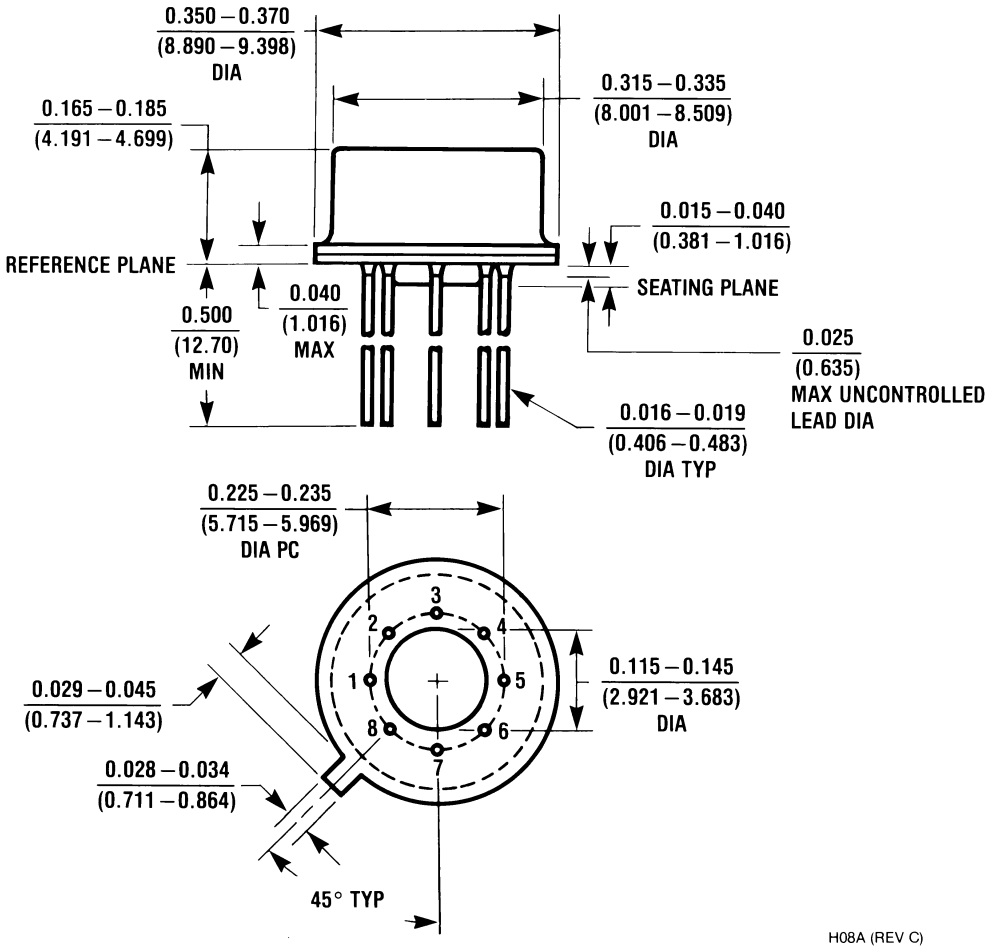
Typical Application

Single Supply Sample and Hold



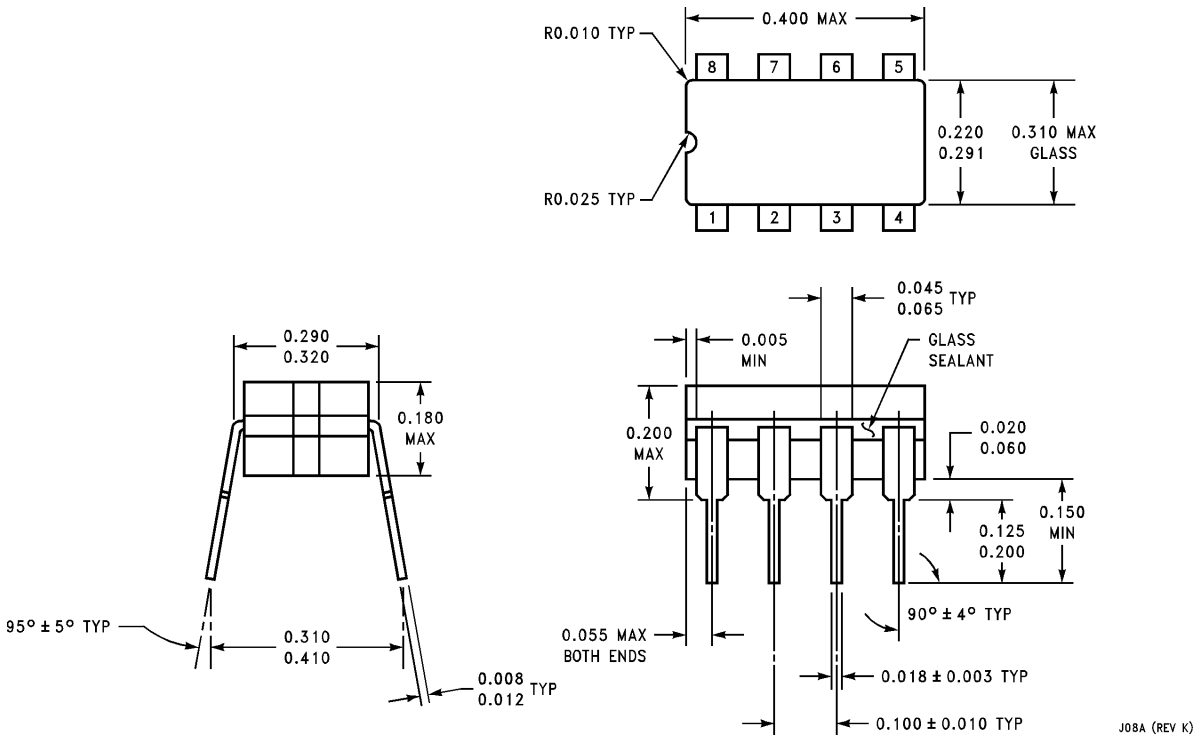
DS005656-31

Physical Dimensions inches (millimeters) unless otherwise noted

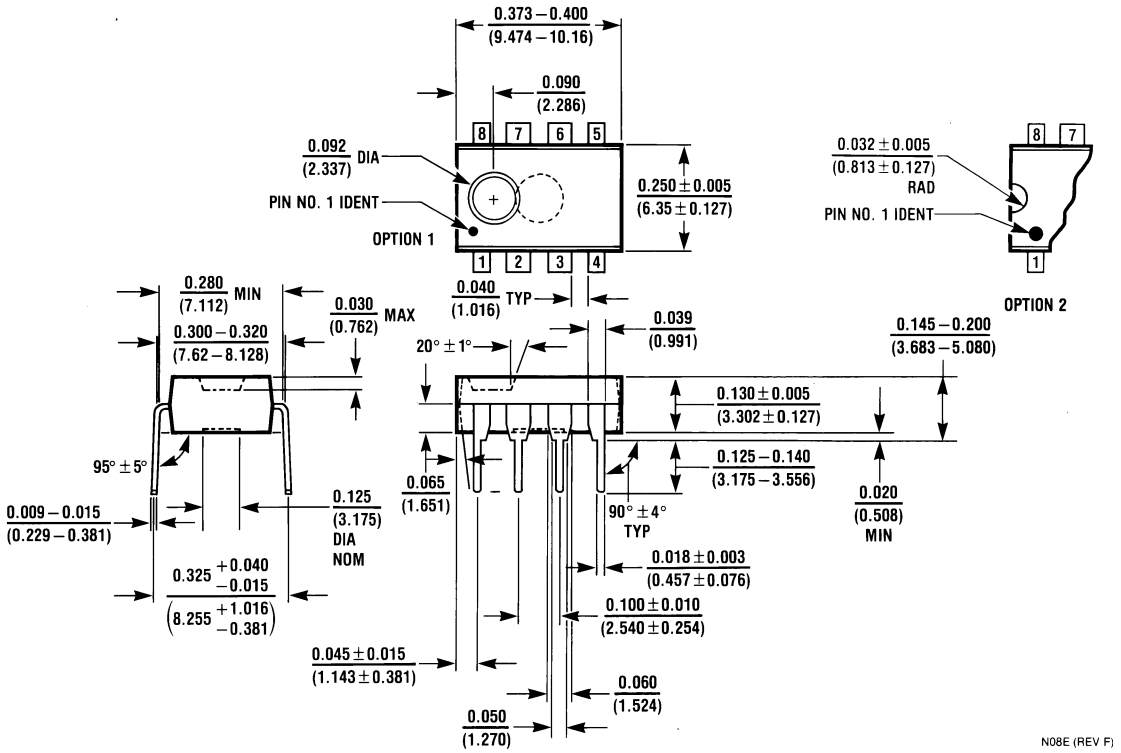


Metal Can Package (H)
Order Number LF412MH, LF412MH/883 or LF412CH
NS Package Number H08A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



Dual-In-Line Package (J)
Order Number LF412MJ/883
NS Package Number J08A



Dual-In-Line Package (N)
Order Number LF412ACN or LF412CN
NS Package Number N08E

Notes

LIFE SUPPORT POLICY

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

1. Life support devices or systems are devices or systems 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.
2. A critical component is any component of 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.

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See A/D Converters Products

LF412 Product Folder

Low Offset, Low Drift Dual JFET Input Operational Amplifier

General Description | Features | Datasheet | Package & Models | Samples & Pricing | Design Tools | Application Notes

Parametric Table

Channels (Channels)	2
Input Output Type	Not Rail to Rail
Bandwidth, typ (MHz)	4
Slew Rate, typ (Volts/usec)	15
Supply Current per Channel, typ (mA)	1.80
Minimum Supply Voltage (Volt)	10

Parametric Table

Maximum Supply Voltage (Volt)	44, 36
Offset Voltage, Max (mV)	1, 3
Input Bias Current, Temp Max (nA)	4
Output Current, typ (mA)	25
Voltage Noise, typ (nV/Hz)	25
Shut down	No
Special Features	Undefined

Datasheet

Title	Size in Kbytes	Date	View Online	Download	Receive via Email
LF412 Low Offset, Low Drift Dual JFET Input Operational Amplifier	485 Kbytes	29-Aug-00	View Online	Download	Receive via Email
LF412 Low Offset, Low Drift Dual JFET Input Operational Amplifier (**JAPANESE**)	344 Kbytes		View Online	Download	Receive via
LF412 Mil-Aero (JAN) Datasheet MJLF412-X	138 Kbytes		View Online	Download	Receive via Email
LF412 Mil-Aero Datasheet MNLF412-X	135 Kbytes		View Online	Download	Receive via Email

If you have trouble printing or viewing PDF file(s), see Printing Problems.

Package Availability, Models, Samples & Pricing

Part Number	Package			Status	Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking
	Type	Pins	MSL		SPICE	IBIS		Qty	$US each		

LF412ACN	MDIP	8	MSL	Full production	LF412.MOD	N/A	24 Hour Buy Now	1K+	$2.5100	rail of 40	[logo]¢U¢Z¢2¢T LF 412ACN
LF412CN	MDIP	8	MSL	Full production	LF412.MOD	N/A	Buy Now	1K+	$0.3650	rail of 40	[logo]¢U¢Z¢2¢T LF 412CN
LF412CH	TO-5	8	MSL	Full production	LF412.MOD	N/A	Buy Now	1K+	$1.3100	box of 500	[logo]¢Z¢2¢T LF412CH
LF412MH	TO-5	8	MSL	Full production	LF412.MOD	N/A	Buy Now	1K+	$4.7200	box of 500	[logo]¢Z¢2¢T LF412MH
LF412MH/883	TO-5	8	MSL	Full production	LF412.MOD	N/A	Buy Now	50+	$7.8500	tray of 20	[logo]¢Z¢S¢4¢A$E LF412MH/883Q
LF412MJ/883	CERDIP	8	MSL	Full production	LF412.MOD	N/A	Buy Now	50+	$7.5000	rail of 40	[logo]¢Z¢S¢4¢A LF412MJ/ 883Q $E
JM38510/11905BG	TO-5	8	MSL	Full production	N/A	N/A		50+	$13.4000	tray of 20	[logo] ¢Z¢S¢4¢A 27014 QS JM38510/11905BGA $E
JM38510/11905BP	CERDIP	8	MSL	Full production	N/A	N/A		50+	$13.4000	rail of 40	[logo] JM38510 /11905BPA 27014 Q ¢Z¢S¢4¢A$E
LF412 MDC	Die			Full production	LF412.MOD	N/A	Samples			tray of N/A	-
LF412A MDC	Die			Full production	LF412.MOD	N/A	Samples			tray of N/A	-
LF412 MWC	Wafer			Full production	LF412.MOD	N/A				wafer jar of N/A	-
LF412A MWC	Wafer			Full production	LF412.MOD	N/A				wafer jar of N/A	-
LF412 MD8	Die			Full production	LF412.MOD	N/A	Samples			tray of N/A	-
LF412 MW8	Wafer			Full production	LF412.MOD	N/A				wafer jar of N/A	-

General Description

These devices are low cost, high speed, JFET input operational amplifiers with very low input offset voltage and guaranteed input offset voltage drift. They require low supply current yet maintain a large gain bandwidth product and fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents. The LF412 dual is pin compatible with the LM1558, allowing designers to immediately upgrade the overall performance of existing designs.

These amplifiers may be used in applications such as high speed integrators, fast D/A converters, sample and hold circuits and many other circuits requiring low input offset voltage and drift, low input bias current, high input impedance, high slew rate and wide bandwidth.

Features

- Internally trimmed offset voltage: 1 mV (max)
- Input offset voltage drift: 10 µV/°C (max)
- Low input bias current: 50 pA
- Low input noise current:
- Wide gain bandwidth: 3 MHz (min)
- High slew rate: 10V/µs (min)
- Low supply current: 1.8 mA/Amplifier
- High input impedance: 10^{12}Ohm
- Low total harmonic distortion $\leq$0.02%
- Low 1/f noise corner: 50 Hz
- Fast settling time to 0.01%: 2 µs

Design Tools

Title	Size in Kbytes	Date	View Online	Download	Receive via Email
Amplifiers Selection Guide software for Windows	7 Kbytes	12-Jun-2002	View		

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Application Notes

Title	Size in Kbytes	Date	View Online	Download	Receive via Email
AN-299: Application Note 299 Audio Applications of Linear Integrated Circuits	232 Kbytes	24-Feb-99	View Online	Download	Receive via Email
AN-301: Signal Conditioning for Sophisticated Transducers	270 Kbytes	4-Nov-95	View Online	Download	Receive via Email
AN-311: Application Note 311 Theory and Applications of Logarithmic Amplifiers	206 Kbytes	24-Feb-99	View Online	Download	Receive via Email
AN-344: LF13006/LF13007 Precision Digital Gain Set Applications	129 Kbytes	4-Nov-95	View Online	Download	Receive via Email
AN-272: Op Amp Booster Designs	171 Kbytes	9-Apr-96	View Online	Download	Receive via Email
AN-447: Protection Schemes for BI-FET Amplifiers and Switches	76 Kbytes	4-Nov-95	View Online	Download	Receive via Email

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[Information as of 5-Aug-2002]