

# LF411JAN

## Low Offset, Low Drift JFET Input Operational Amplifier

### General Description

This device is a low cost, high speed, JFET input operational amplifier with very low input offset voltage and guaranteed input offset voltage drift. It requires low supply current yet maintains 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 LF411 is pin compatible with the standard LM741 allowing designers to immediately upgrade the overall performance of existing designs.

This amplifier 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

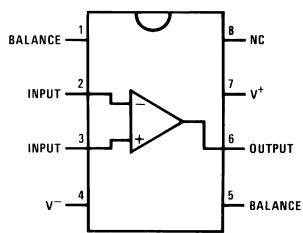
- Internally trimmed offset voltage: 0.5 mV(Typ)
- Input offset voltage drift: 30  $\mu\text{V}/^\circ\text{C}$
- Low input bias current: 50 pA
- Low input noise current: 0.01 pA/ $\sqrt{\text{Hz}}$
- Wide gain bandwidth: 3 MHz Typ.
- High slew rate: 7V/ $\mu\text{s}$  (min.)
- Low supply current: 1.8 mA
- High input impedance:  $10^{12}\Omega$
- Low total harmonic distortion:  $A_V = 10, R_L = 10\text{K}\Omega, V_O = 20\text{V}_{\text{P-P}}, \text{BW} = 20\text{Hz} - 20\text{KHz}$  <0.02%
- Low 1/f noise corner: 50 Hz
- Fast settling time to 0.01%: 1.5  $\mu\text{s}$

### Ordering Information

NS Part Number	JAN Part Number	NS Package Number	Package Description
JL411BPA	JM38510/11904BPA	J08A	8LD CERDIP

### Connection Diagram

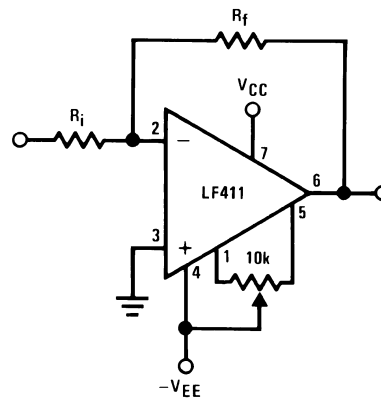
8LD Ceramic Dual-in Line Package



Top View  
See NS Package Number J08A

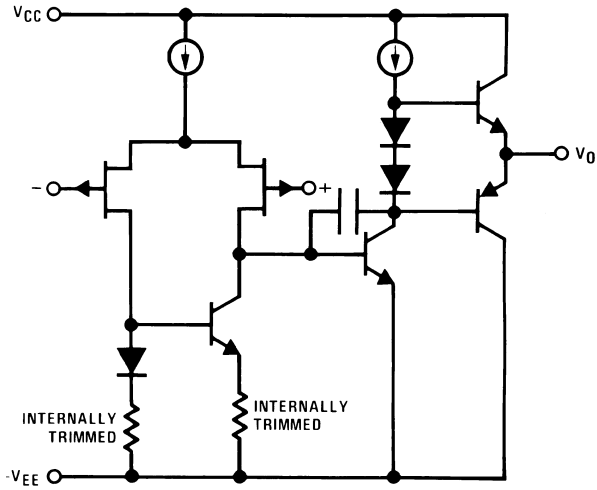
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### Typical Connection



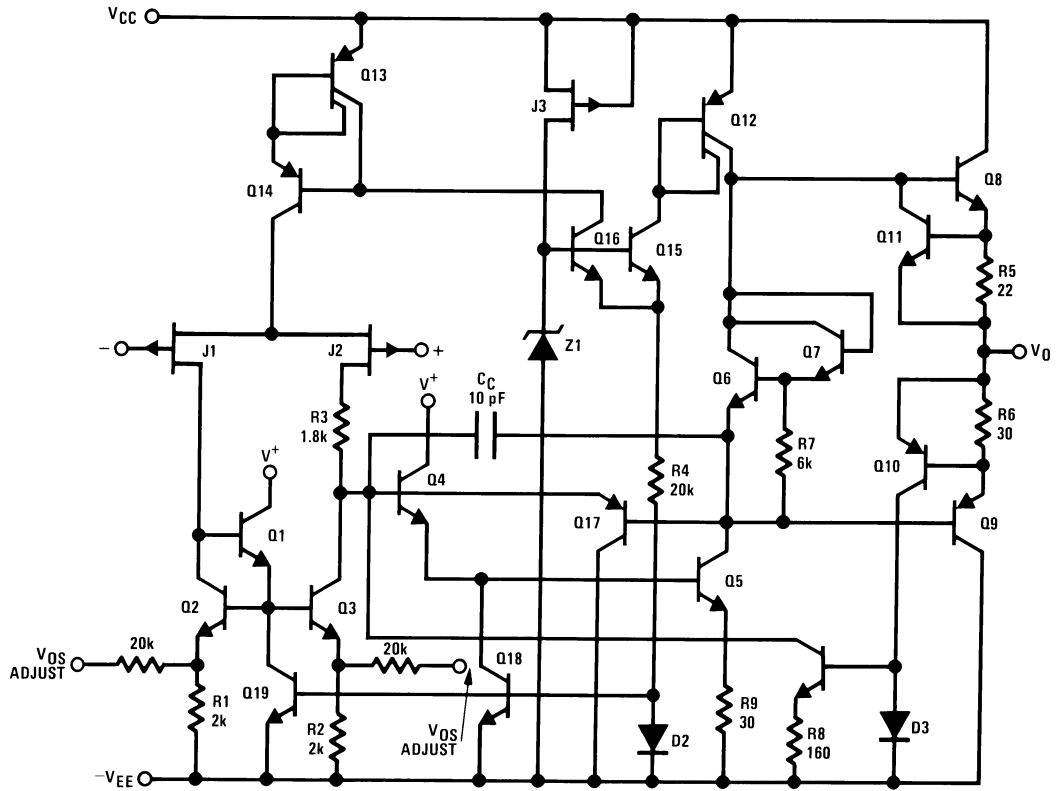
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### Simplified Schematic



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### Detailed Schematic



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## Absolute Maximum Ratings (Note 1)

Supply Voltage	±18V
Differential Input Voltage	±30V
Input Voltage Range (Note 4)	±15V
Output Short Circuit Duration	Continuous
Power Dissipation (Note 2), (Note 3)	400mW
$T_{Jmax}$	175°C
Thermal Resistance	
$\theta_{JA}$	
Still Air	162°C/W
400LF/Min Air Flow	65°C/W
$\theta_{JC}$	20°C/W
Operating Temperature Range	-55°C ≤ T <sub>A</sub> ≤ 125°C
Storage Temperature Range	-65°C ≤ T <sub>A</sub> ≤ 150°C
Lead Temperature (Soldering, 10 seconds)	300°C
Package Weight (Typical)	TBD
ESD Tolerance (Note 5)	750V

## 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

## Electrical Characteristics

### DC Parameters

The following conditions apply to all the following parameters, unless otherwise specified.

DC:  $V_{CC} = \pm 15V$ ,  $V_{CM} = 0V$

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
$V_{IO}$	Input Offset Voltage	$+V_{CC} = 26V$ , $-V_{CC} = -4V$ , $V_{CM} = -11V$		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
		$+V_{CC} = 4V$ , $-V_{CC} = -26V$ , $V_{CM} = 11V$		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
		$\pm V_{CC} = \pm 5V$		-5.0	5.0	mV	1
				-7.0	7.0	mV	2, 3
$\pm I_{IB}$	Input Bias Current	$+V_{CC} = 26V$ , $-V_{CC} = -4V$ , $V_{CM} = -11V$ , $t \leq 25mS$		-0.4	0.2	nA	1
				-10	50	nA	2
		$t \leq 25mS$		-0.2	0.2	nA	1
				-10	50	nA	2
		$+V_{CC} = 4V$ , $-V_{CC} = -26V$ , $V_{CM} = 11V$ , $t \leq 25mS$		-0.2	1.2	nA	1
				-10	70	nA	2
$I_{IO}$	Input Offset Current	$t \leq 25mS$		-0.1	0.1	nA	1
				-20	20	nA	2
+PSRR	Power Supply Rejection Ratio	$+V_{CC} = 10V$ to $20V$ , $-V_{CC} = -15V$		80		dB	1, 2, 3
-PSRR	Power Supply Rejection Ratio	$+V_{CC} = 15V$ , $-V_{CC} = -10V$ to $-20V$		80		dB	1, 2, 3
CMR	Input Voltage Common Mode Rejection	$V_{CM} = -11V$ to $+11V$		80		dB	1, 2, 3
$V_{IO\ Adj+}$	Adjustment for Input Offset Voltage			8.0		mV	1, 2, 3
$V_{IO\ Adj-}$	Adjustment for Input Offset Voltage				-8.0	mV	1, 2, 3
$I_{OS+}$	Output Short Circuit Current	$t \leq 25mS$		-80		mA	1, 2, 3
$I_{OS-}$	Output Short Circuit Current	$t \leq 25mS$			80	mA	1, 2, 3
$I_{CC}$	Supply Current				3.5	mA	1, 2
					4.0	mA	3
$\Delta V_{IO} / \Delta T$	Input Offset Voltage	$25^{\circ}C \leq T_A \leq +125^{\circ}C$	(Note 6)	-30	30	$\mu V/^{\circ}C$	2
		$-55^{\circ}C \leq T_A \leq 25^{\circ}C$	(Note 6)	-30	30	$\mu V/^{\circ}C$	3
$+V_{OP}$	Output Voltage Swing	$R_L = 10K\Omega$		12		V	4, 5, 6
		$R_L = 2K\Omega$		10		V	4, 5, 6
$-V_{OP}$	Output Voltage Swing	$R_L = 10K\Omega$			-12	V	4, 5, 6
		$R_L = 2K\Omega$			-10	V	4, 5, 6
$+A_{VS}$	Open Loop Voltage Gain	$R_L = 2K\Omega$ , $V_O = 0$ to $10V$	(Note 7)	50		K	4
			(Note 7)	25		K	5, 6
$-A_{VS}$	Open Loop Voltage Gain	$R_L = 2K\Omega$ , $V_O = 0$ to $-10V$	(Note 7)	50		K	4
			(Note 7)	25		K	5, 6
$A_{VS}$	Open Loop Voltage Gain	$R_L = 10K\Omega$ , $V_O = \pm 2V$ , $\pm V_{CC} = \pm 5V$	(Note 7)	20		K	4, 5, 6

## Electrical Characteristics (Continued)

### AC Parameters

The following conditions apply to all the following parameters, unless otherwise specified.

AC:  $V_{CC} = \pm 15V$ ,  $V_{CM} = 0V$

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
SR+	Slew Rate	$V_I = -5V$ to $+5V$		7.0		V/ $\mu$ S	7
				5.0		V/ $\mu$ S	8A, 8B
SR-	Slew Rate	$V_I = +5V$ to $-5V$		7.0		V/ $\mu$ S	7
				5.0		V/ $\mu$ S	8A, 8B
TR <sub>TR</sub>	Transient Response Rise Time	$A_V = 1$ , $V_I = 50mV$ , $C_L = 100pF$ , $R_L = 2K\Omega$			200	nS	7, 8A, 8B
TR <sub>OS</sub>	Transient Response Overshoot	$A_V = 1$ , $V_I = 50mV$ , $C_L = 100pF$ , $R_L = 2K\Omega$			40	%	7, 8A, 8B
NI <sub>BB</sub>	Noise Broadband	BW of 10Hz to 15KHz			15	$\mu V_{RMS}$	7
NI <sub>PC</sub>	Noise Popcorn	BW of 10Hz to 15KHz, $R_S = 100K\Omega$			80	$\mu V_{PK}$	7
+tS	Settling Time	$A_V = 1$			1,500	nS	12
-tS	Settling Time	$A_V = 1$			1,500	nS	12

### DC Drift Parameters

The following conditions apply to all the following parameters, unless otherwise specified.

DC:  $V_{CC} = \pm 15V$ ,  $V_{CM} = 0V$

Delta Calculations performed at Group B, subgroup 5, Only

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V <sub>IO</sub>	Input Offset Voltage			-1.0	1.0	mV	1
$\pm I_{IB}$	Input Bias Current			-0.1	0.1	nA	1

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

**Note 2:** The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{Jmax}$  (maximum junction temperature),  $\theta_{JA}$  (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.

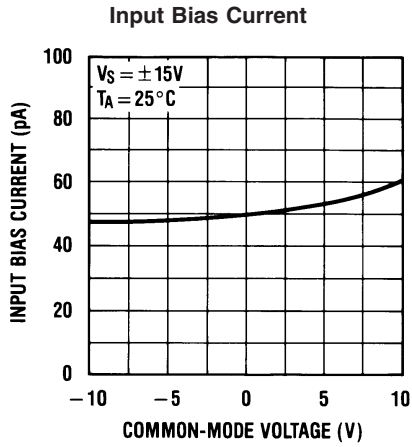
**Note 4:** Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

**Note 5:** Human body model, 100pF discharged through 1.5K $\Omega$ .

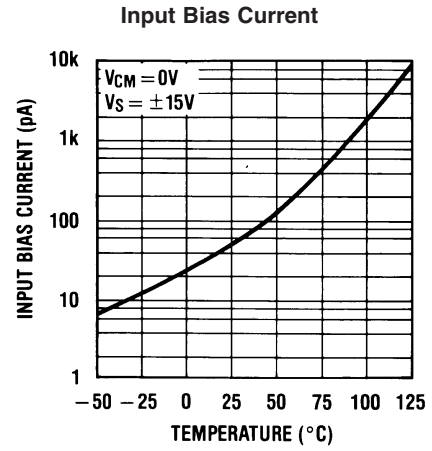
**Note 6:** Calculated parameter. For calculation use V<sub>IO</sub> test at  $\pm V_{CC} = \pm 15V$

**Note 7:** Datalog in K = V/mV.

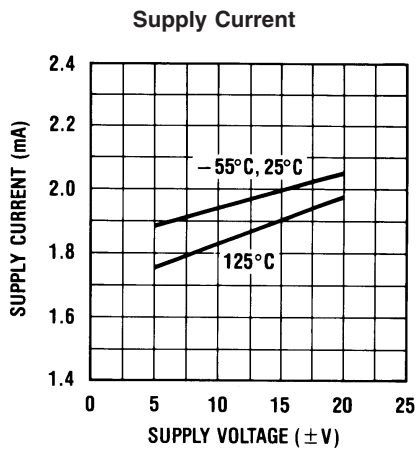
# Typical Performance Characteristics



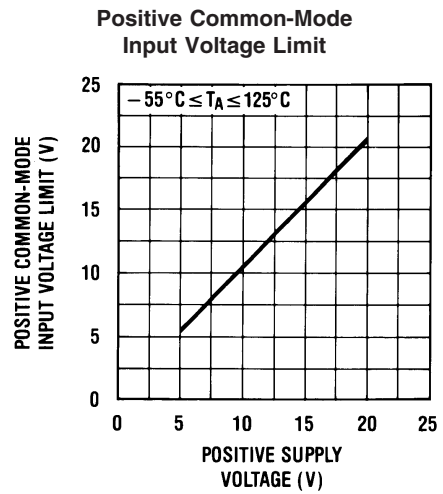
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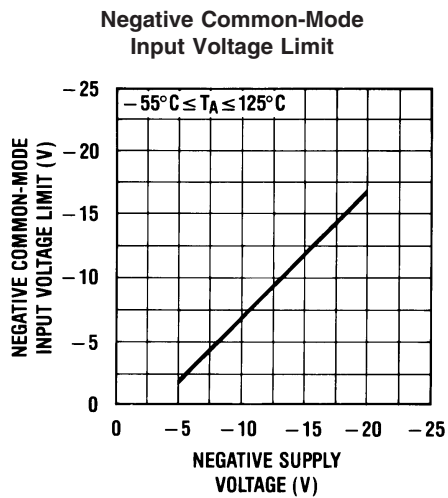
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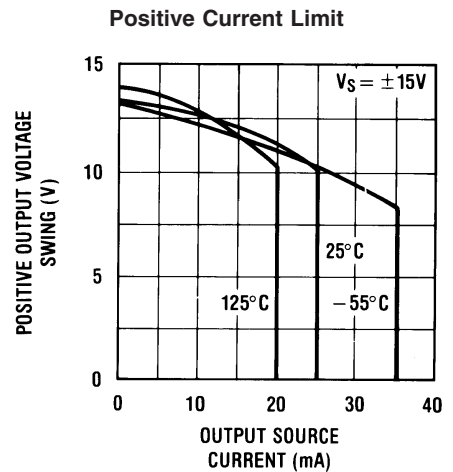
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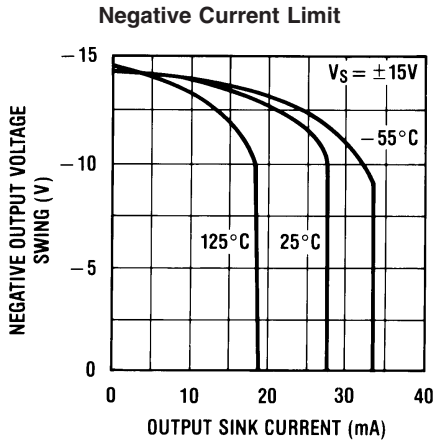


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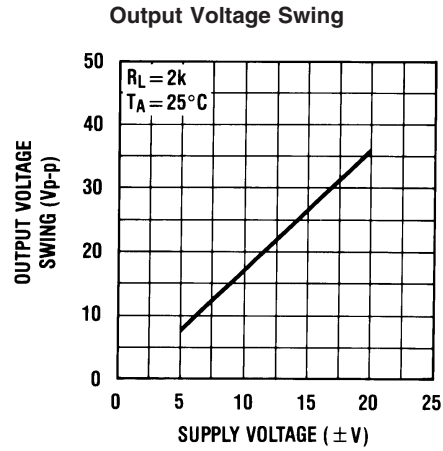


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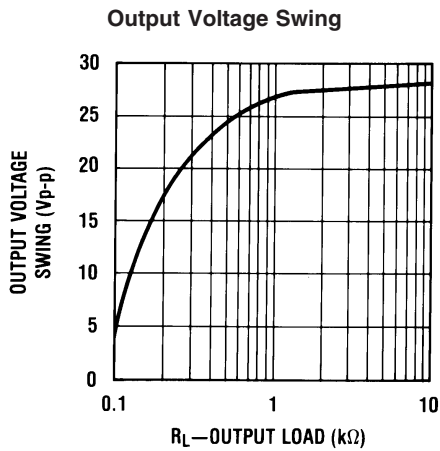
Typical Performance Characteristics (Continued)



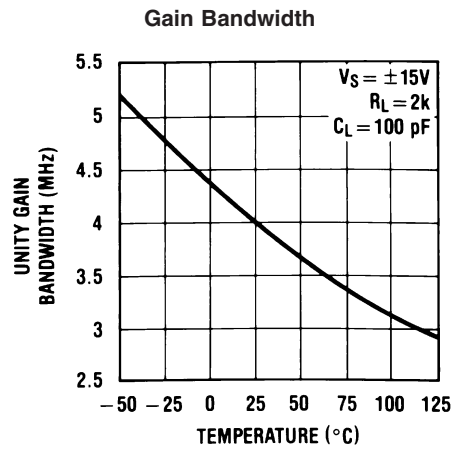
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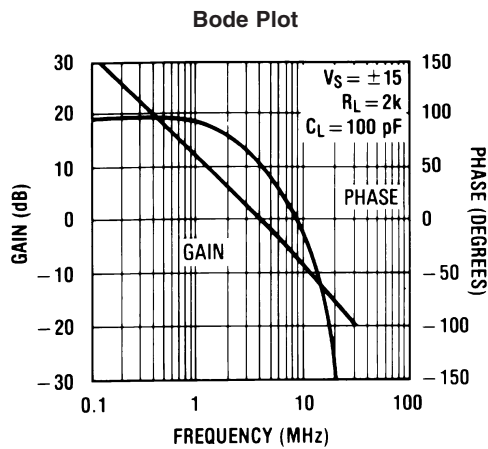
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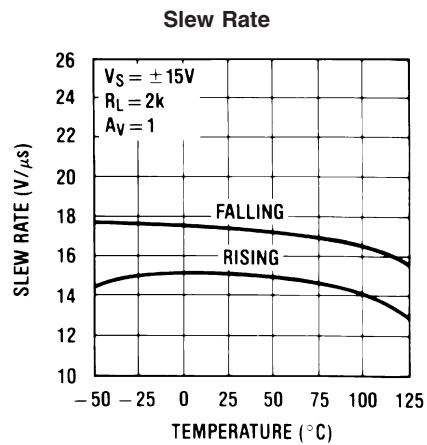
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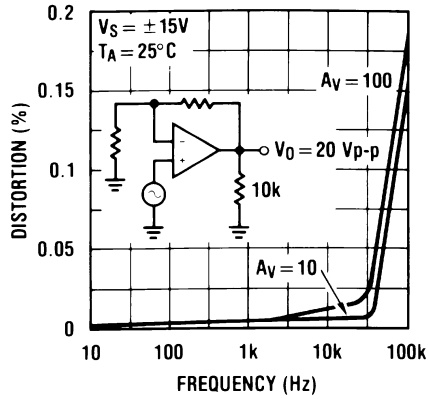
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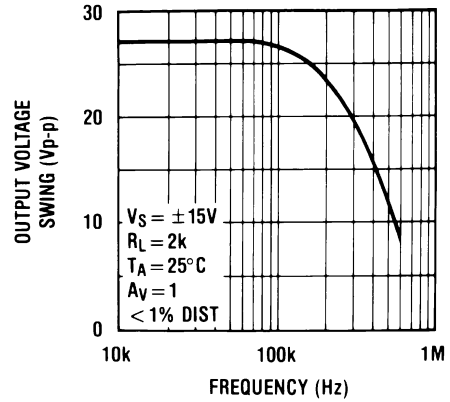
Typical Performance Characteristics (Continued)

Distortion vs Frequency



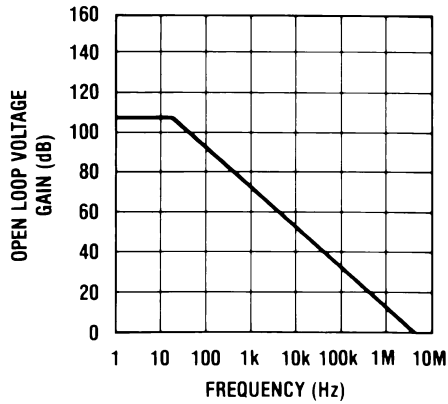
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Undistorted Output Voltage Swing



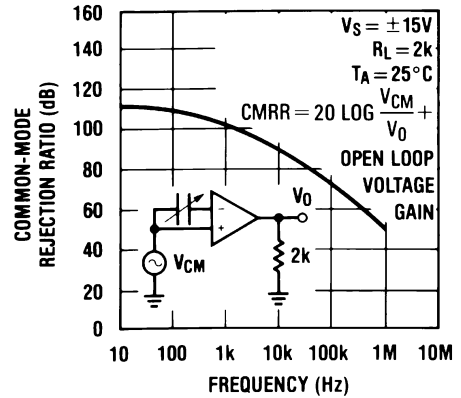
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Open Loop Frequency Response



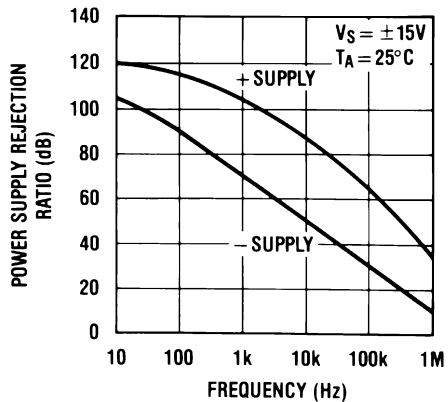
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Common-Mode Rejection Ratio



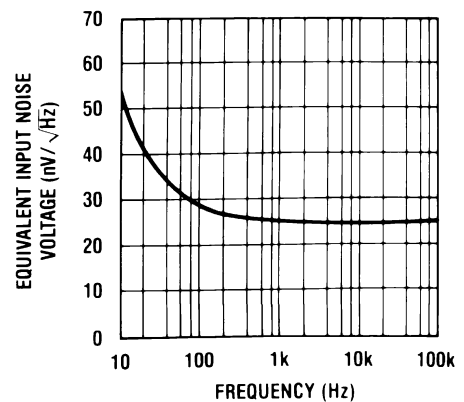
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Power Supply Rejection Ratio



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Equivalent Input Noise Voltage

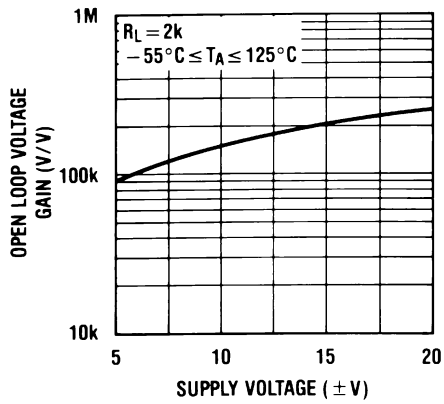


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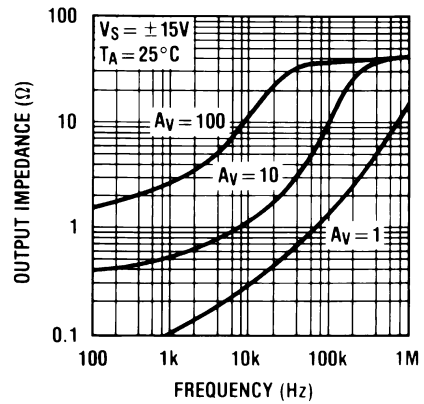
Typical Performance Characteristics (Continued)

Open Loop Voltage Gain



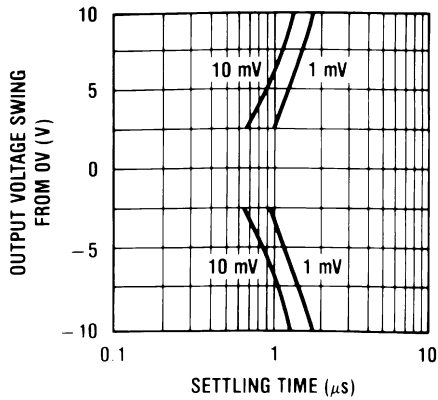
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Output Impedance



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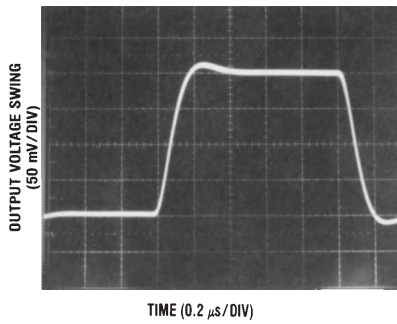
Inverter Settling Time



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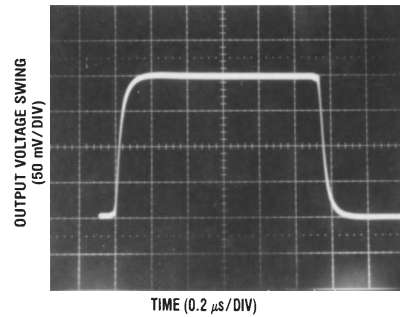
Pulse Response  $R_L=2\text{ k}\Omega$ ,  $C_L=10\text{ pF}$

Small Signal Inverting



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Small Signal Non-Inverting

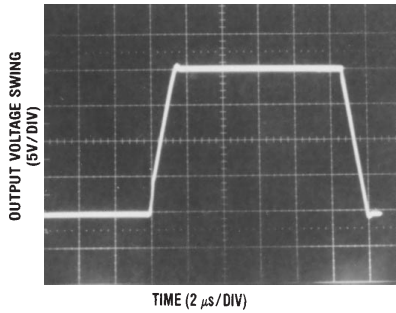


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## Pulse Response $R_L=2\text{ k}\Omega, C_L10\text{ pF}$

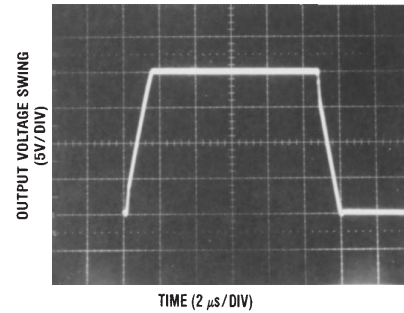
pF (Continued)

Large Signal Inverting



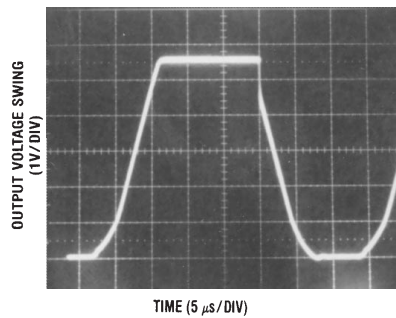
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Large Signal Non-Inverting



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Current Limit ( $R_L=100\Omega$ )



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### Application Hints

The LF411JAN series of internally trimmed JFET input op amps (BI-FET II™) provide very low input offset voltage 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 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 may be forced to a high state.

The amplifier 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.

The LF411 is biased by a zener reference which allows normal circuit operation on  $\pm 4.5\text{V}$  power supplies. Supply voltages less than these may result in lower gain bandwidth and slew rate.

The LF411 will drive a  $2\text{ k}\Omega$  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 ex-

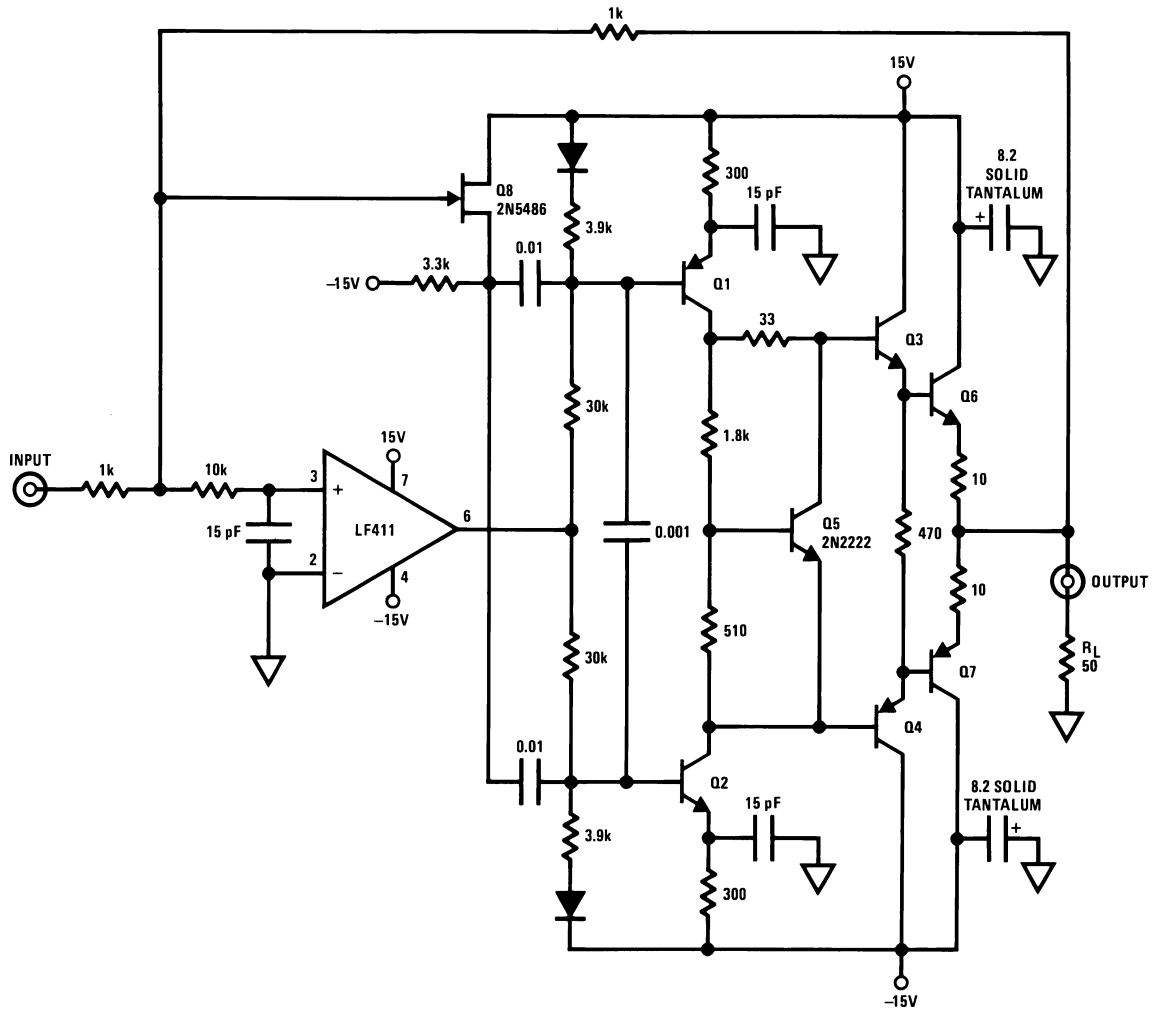
**Application Hints** (Continued)

pected 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 Applications**

High Speed Current Booster

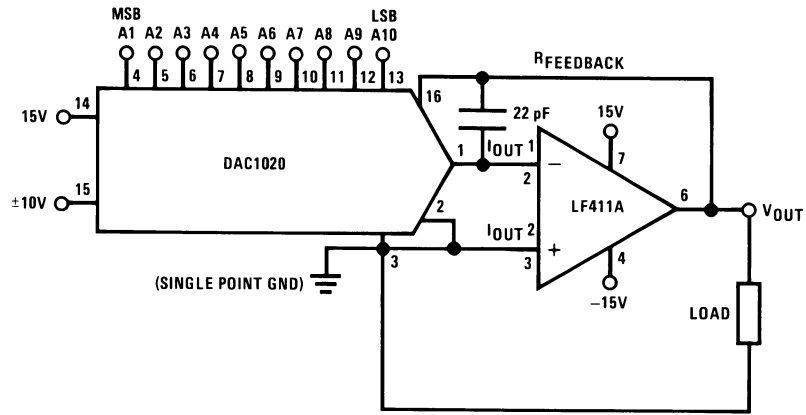


PNP=2N2905  
 NPN=2N2219 unless noted  
 TO-5 heat sinks for Q6-Q7

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Typical Applications (Continued)

10-Bit Linear DAC with No  $V_{OS}$  Adjust



20152432

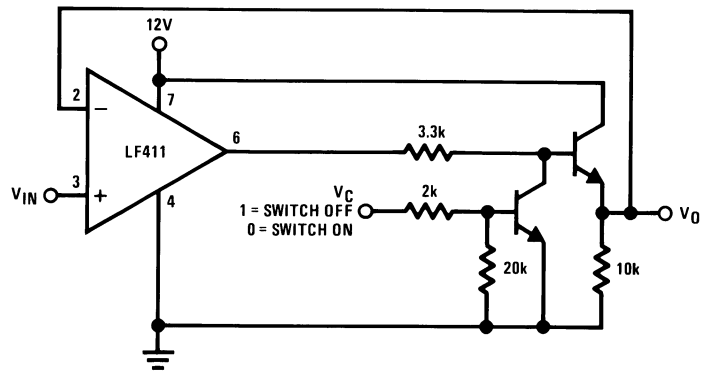
$$V_{OUT} = -V_{REF} \left( \frac{A_1}{2} + \frac{A_2}{4} + \frac{A_3}{8} + \dots + \frac{A_{10}}{1024} \right)$$

$$-10V \leq V_{REF} \leq 10V$$

$$0 \leq V_{OUT} \leq -\frac{1023}{1024} V_{REF}$$

where  $A_N=1$  if the  $A_N$  digital input is high  
 $A_N=0$  if the  $A_N$  digital input is low

Single Supply Analog Switch with Buffered Output

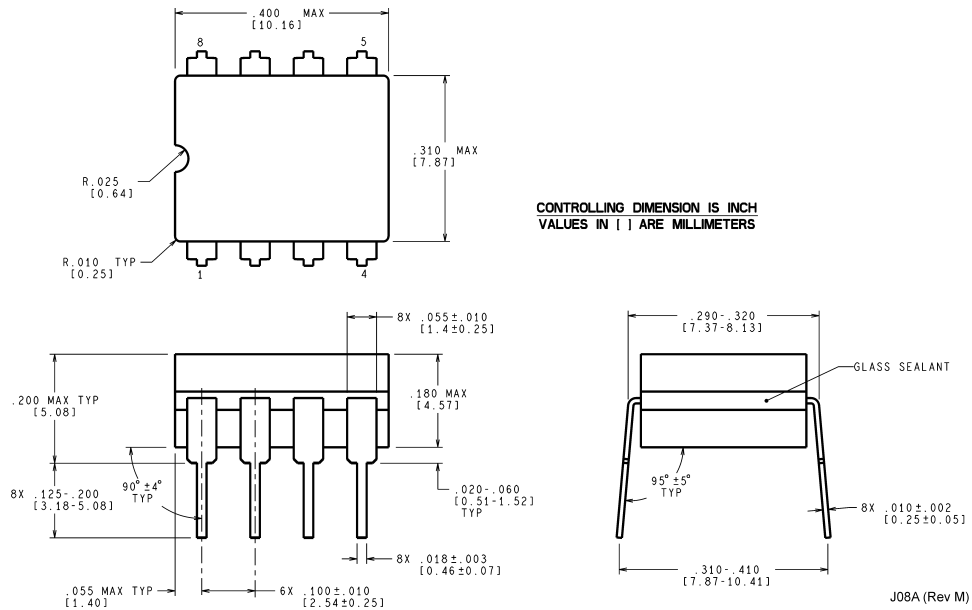


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**Revision History**

Date Released	Revision	Section	Originator	Changes
10/11/05	A	New Release to corporate format	L. Lytle	1 MDS data sheet was converted into the corporate data sheet format. MDS MJLF411-X Rev 0C1 will be archived.

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



**Ceramic Dual-in-Line Package (J)  
NS Package Number J08A**

J08A (Rev M)

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