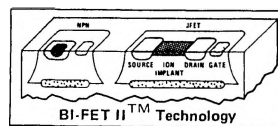


# LF411A/LF411 Low Offset, Low Drift JFET Input Operational Amplifier



## General Description

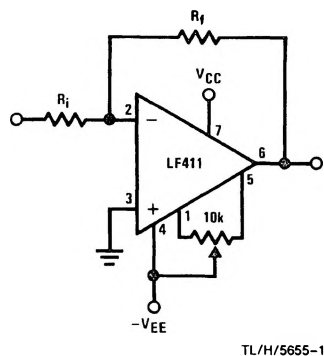
These devices are low cost, high speed, JFET input operational amplifiers with very low input offset voltage and guaranteed input offset voltage drift. They require low supply current yet maintain a large gain bandwidth product and fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents. The LF411 is pin compatible with the standard LM741 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 0.5 mV(max)
- Input offset voltage drift 10  $\mu\text{V}/^\circ\text{C}(\text{max})$
- Low input bias current 50 pA
- Low input noise current 0.01 pA/ $\sqrt{\text{Hz}}$
- Wide gain bandwidth 3 MHz(min)
- High slew rate 10V/ $\mu\text{s}(\text{min})$
- Low supply current 1.8 mA
- High input impedance  $10^{12}\Omega$
- Low total harmonic distortion  $A_V = 10$ ,  $R_L = 10\text{k}$ ,  $V_O = 20\text{ Vp-p}$ ,  $\text{BW} = 20\text{ Hz} - 20\text{ kHz}$  <0.02%
- Low 1/f noise corner 50 Hz
- Fast settling time to 0.01% 2  $\mu\text{s}$

## Typical Connection



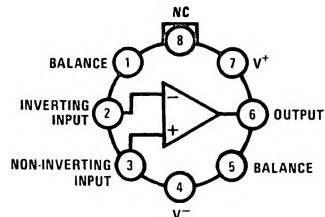
## Ordering Information

### LF411XYZ

- 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

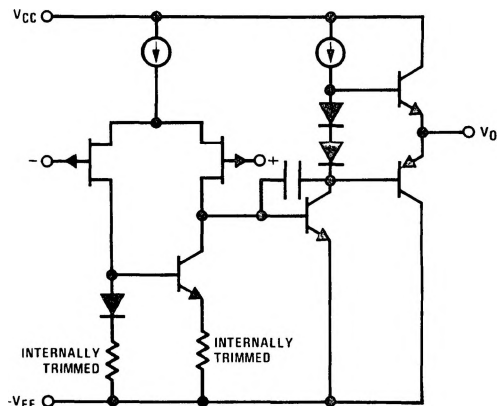


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### Top View

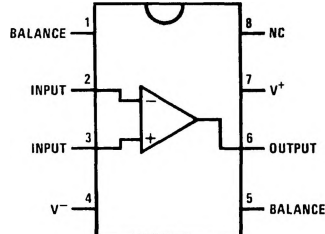
Note: Pin 4 connected to case.  
Order Number LF411AMH,  
LF411MH, LF411ACH or LF411CH  
See NS Package Number H08B

## Simplified Schematic



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### Dual-In-Line Package



TL/H/5655-7

### Top View

Order Number  
LF411ACN or LF411CN  
See NS Package Number N08E

# Absolute Maximum Ratings

If Military/Aerospace specified devices are required, contact the National Semiconductor Sales Office/ Distributors for availability and specifications. (Note 8)

	LF411A	LF411
Supply Voltage	± 22V	± 18V
Differential Input Voltage	± 38V	± 30V
Input Voltage Range (Note 1)	± 19V	± 15V
Output Short Circuit Duration	Continuous	Continuous

	H Package	N Package
Power Dissipation (Notes 2 and 9)	670 mW	670 mW
$T_{jmax}$	150°C	115°C
$\theta_{JA}$	225°C/W (Still Air) 160°C/W (400 LF/min Air Flow)	120°C/W
$\theta_{JC}$	25°C/W	
Operating Temp. Range	(Note 3)	(Note 3)
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 rating to be determined.		

## DC Electrical Characteristics (Note 4)

Symbol	Parameter	Conditions	LF411A			LF411			Units
			Min	Typ	Max	Min	Typ	Max	
$V_{OS}$	Input Offset Voltage	$R_S = 10\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$		0.3	0.5		0.8	2.0	mV
$\Delta V_{OS}/\Delta T$	Average TC of Input Offset Voltage	$R_S = 10\text{ k}\Omega$ (Note 5)		7	10		7	20 (Note 5)	$\mu\text{V}/^\circ\text{C}$
$I_{OS}$	Input Offset Current	$V_S = \pm 15\text{V}$ (Notes 4, 6)	$T_j = 25^\circ\text{C}$			$T_j = 25^\circ\text{C}$			pA
			$T_j = 70^\circ\text{C}$			$T_j = 70^\circ\text{C}$			nA
			$T_j = 125^\circ\text{C}$			$T_j = 125^\circ\text{C}$			nA
$I_B$	Input Bias Current	$V_S = \pm 15\text{V}$ (Notes 4, 6)	$T_j = 25^\circ\text{C}$			$T_j = 25^\circ\text{C}$			pA
			$T_j = 70^\circ\text{C}$			$T_j = 70^\circ\text{C}$			nA
			$T_j = 125^\circ\text{C}$			$T_j = 125^\circ\text{C}$			nA
$R_{IN}$	Input Resistance	$T_j = 25^\circ\text{C}$		$10^{12}$			$10^{12}$		$\Omega$
$A_{VOL}$	Large Signal Voltage Gain	$V_S = \pm 15\text{V}$ , $V_O = \pm 10\text{V}$ , $R_L = 2\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$	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	± 13.5		± 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	$R_S \leq 10\text{ k}\Omega$	80	100		70	100		dB
PSRR	Supply Voltage Rejection Ratio	(Note 7)	80	100		70	100		dB
$I_S$	Supply Current			1.8	2.8		1.8	3.4	mA

## AC Electrical Characteristics (Note 4)

Symbol	Parameter	Conditions	LF411A			LF411			Units
			Min	Typ	Max	Min	Typ	Max	
SR	Slew Rate	$V_S = \pm 15\text{V}$ , $T_A = 25^\circ\text{C}$	10	15		8	15		V/ $\mu\text{s}$
GBW	Gain-Bandwidth Product	$V_S = \pm 15\text{V}$ , $T_A = 25^\circ\text{C}$	3	4		2.7	4		MHz
$e_n$	Equivalent Input Noise Voltage	$T_A = 25^\circ\text{C}$ , $R_S = 100\Omega$ , $f = 1\text{ kHz}$		25			25		nV/ $\sqrt{\text{Hz}}$
$i_n$	Equivalent Input Noise Current	$T_A = 25^\circ\text{C}$ , $f = 1\text{ kHz}$		0.01			0.01		pA/ $\sqrt{\text{Hz}}$

**Note 1:** Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

**Note 2:** For operating at elevated temperature, these devices must be derated based on a thermal resistance of  $\theta_{JA}$ .

**Note 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.

**Note 4:** Unless otherwise specified, the specifications apply over the full temperature range and for  $V_S = \pm 20\text{V}$  for the LF411A and for  $V_S = \pm 15\text{V}$  for the LF411.  $V_{OS}$ ,  $I_B$ , and  $I_{OS}$  are measured at  $V_{CM} = 0$ .

**Note 5:** The LF411A is 100% tested to this specification. The LF411 is sample tested to insure at least 90% of the units meet this specification.

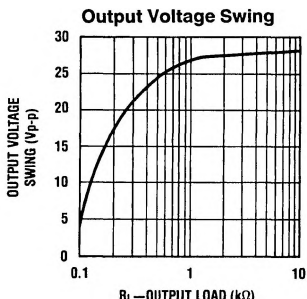
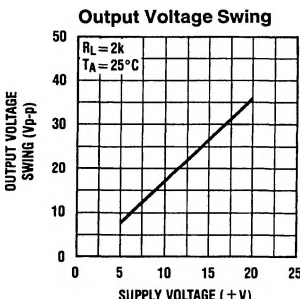
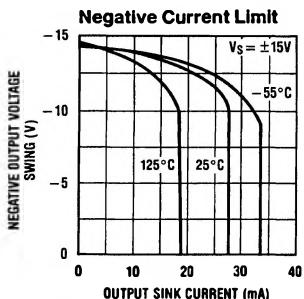
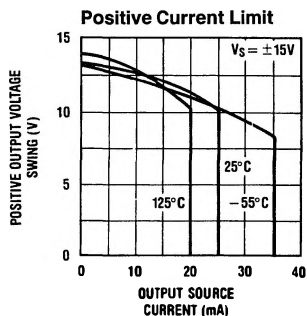
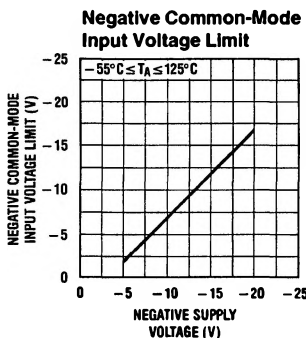
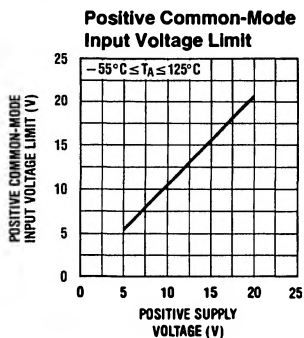
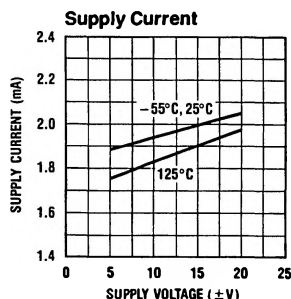
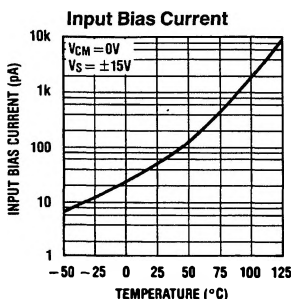
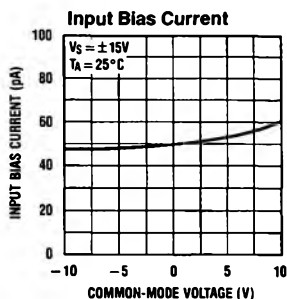
**Note 6:** The input bias currents are junction leakage currents which approximately double for every  $10^{\circ}\text{C}$  increase in the junction temperature,  $T_J$ . Due to limited production test time, the input bias currents measured are correlated to junction temperature. In normal operation 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  $\theta_{JA}$  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 7:** 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 LF411 and from  $\pm 20\text{V}$  to  $\pm 5\text{V}$  for the LF411A.

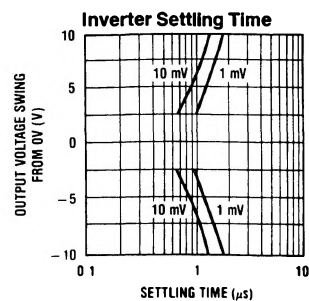
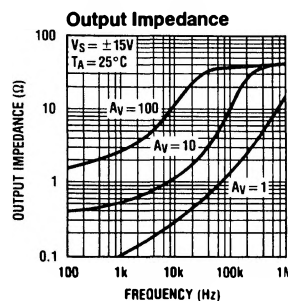
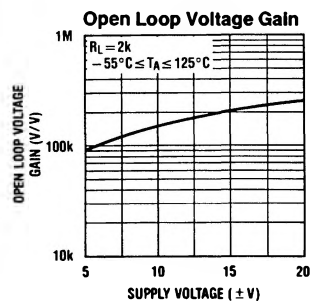
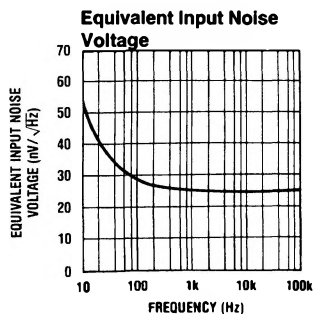
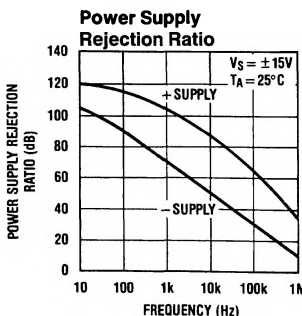
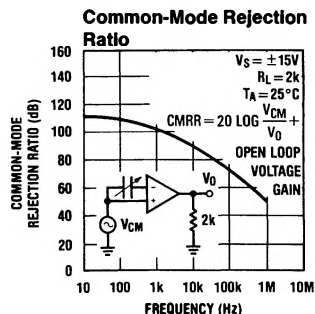
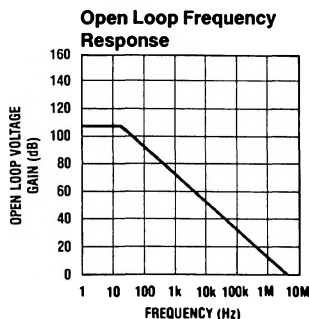
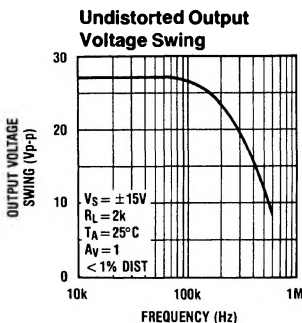
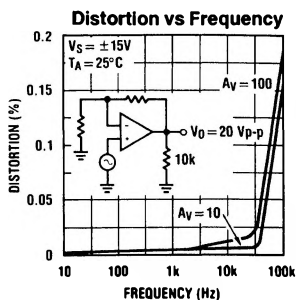
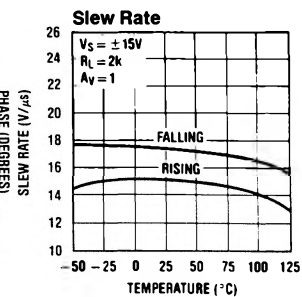
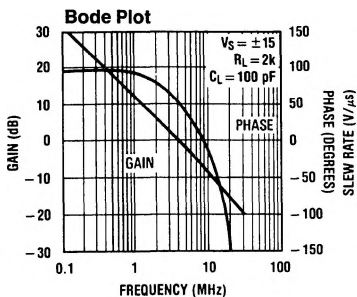
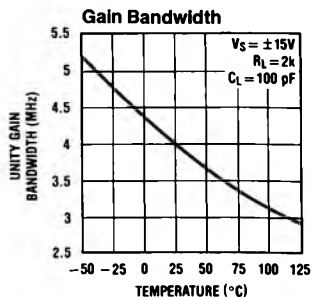
**Note 8:** Refer to RETS 411AX for LF411AMH military specifications and to RETS 411X for LF411MH military specifications.

**Note 9:** 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.

## Typical Performance Characteristics

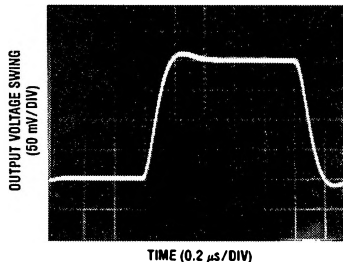


# Typical Performance Characteristics (Continued)

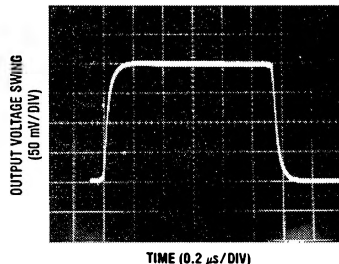


## Pulse Response $R_L = 2\text{ k}\Omega$ , $C_L = 10\text{ pF}$

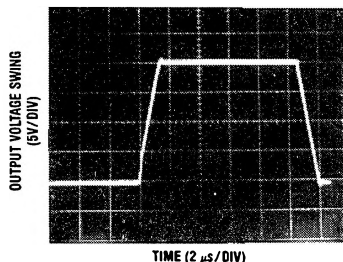
### Small Signal Inverting



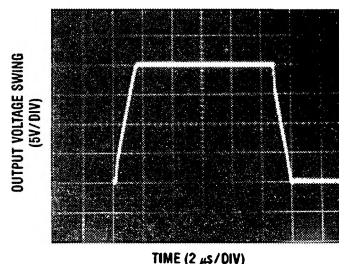
### Small Signal Non-Inverting



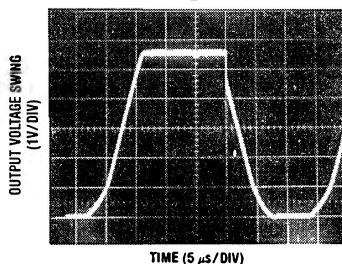
### Large Signal Inverting



### Large Signal Non-Inverting



### Current Limit ( $R_L = 100\Omega$ )



TL/H/5655-4

## Application Hints

The LF411 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.

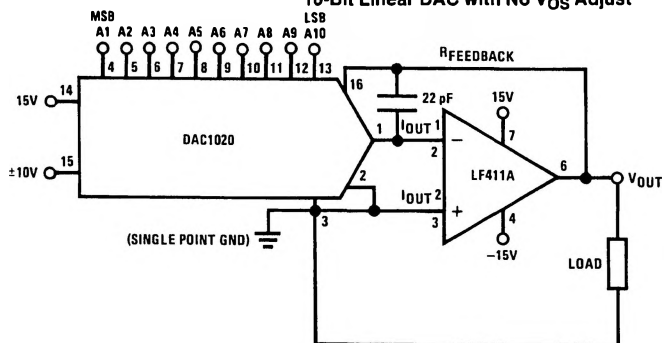
Exceeding the negative common-mode limit on either input will force the output to a high state, potentially causing a reversal of phase to the output. Exceeding the negative common-mode limit on both inputs will force the amplifier output to a high state. In neither case does a latch occur since raising 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.



## Typical Applications (Continued)

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



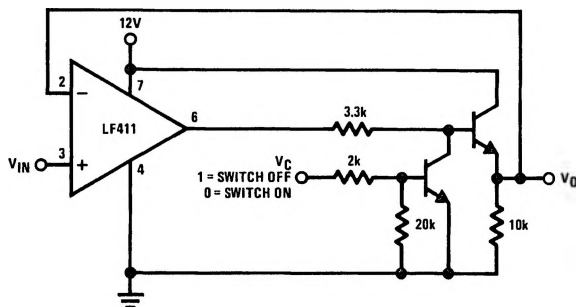
$$V_{OUT} = -V_{REF} \left( \frac{A1}{2} + \frac{A2}{4} + \frac{A3}{8} + \dots + \frac{A10}{1024} \right)$$

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

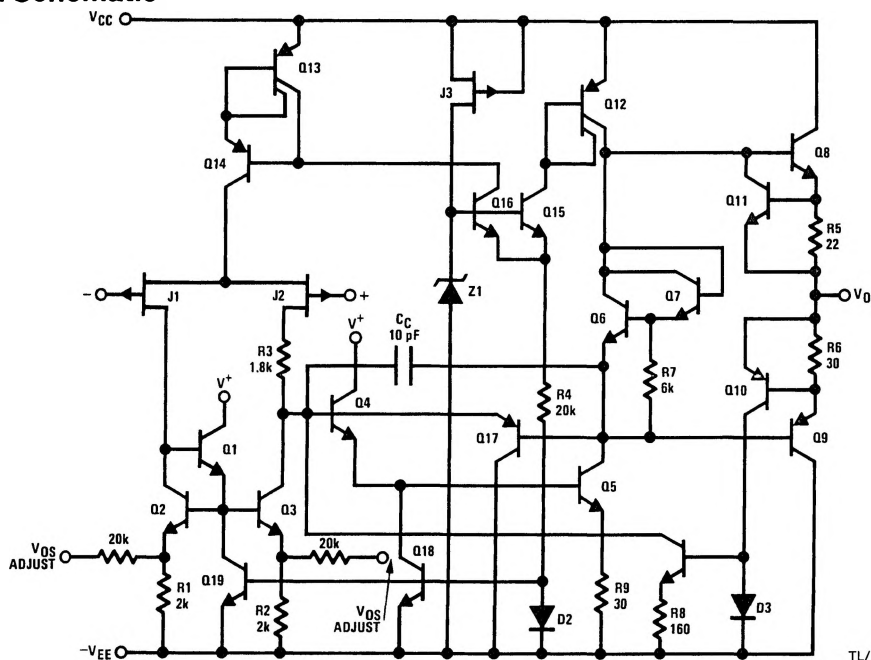
$$0 \leq V_{OUT} \leq -\frac{1023}{1024} V_{REF}$$

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



### Detailed Schematic



TL/H/5655-10