

## Features

- Voltage noise of only  $1.3\text{nV}/\sqrt{\text{Hz}}$
- Current noise of only  $1.2\text{pA}/\sqrt{\text{Hz}}$
- $200\mu\text{V}$  offset voltage
- $100\text{MHz}$  -3dB BW for  $A_V=10$
- Very low supply current -  $4.7\text{mA}$
- SOT-23 package
- $\pm 2.5\text{V}$  to  $\pm 15\text{V}$  operation

## Applications

- Ultrasound input amplifiers
- Wideband instrumentation
- Communication equipment
- AGC & PLL active filters
- Wideband sensors

## Ordering Information

Part No	Package	Tape & Reel	Outline #
EL2126CW-T7	5-Pin SOT-23*	7"	MDP0038
EL2126CW-T13	5-Pin SOT-23*	13"	MDP0038
EL2126CS	8-Pin SO	-	MDP0027
EL2126CS-T7	8-Pin SO	7"	MDP0027
EL2126CS-T13	8-Pin SO	13"	MDP0027

\*EL2126CW symbol is .Gxxx where xxx represents date code

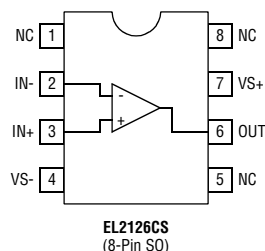
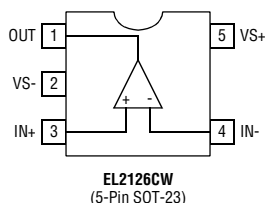
## General Description

The EL2126C is an ultra-low noise, wideband amplifier that runs on half the supply current of competitive parts. It is intended for use in systems such as ultrasound imaging where a very small signal needs to be amplified by a large amount without adding significant noise. Its low power dissipation enables it to be packaged in the tiny SOT-23 package, which further helps systems where many input channels create both space and power dissipation problems.

The EL2126C is stable for gains of 10 and greater and uses traditional voltage feedback. This allows the use of reactive elements in the feedback loop, a common requirement for many filter topologies. It operates from  $\pm 2.5\text{V}$  to  $\pm 15\text{V}$  supplies and is available in the 5-pin SOT-23 and 8-pin SO packages.

The EL2126C is fabricated in Elantec's proprietary complementary bipolar process, and is specified for operation over the full  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  temperature range.

## Connection Diagrams



# EL2126C

## Ultra-Low Noise, Low Power, Wideband Amplifier

### Absolute Maximum Ratings ( $T_A = 25^\circ\text{C}$ )

$V_{S+}$ to $V_{S-}$	33V	Operating Temperature	-40°C to +85°C
Continuous Output Current	40mA	Storage Temperature	-60°C to +150°C
Any Input	$V_{S+} - 0.3\text{V}$ to $V_{S-} + 0.3\text{V}$	Maximum Die Junction Temperature	+150°C
Power Dissipation	See Curves		

#### Important Note:

All parameters having Min/Max specifications are guaranteed. Typ values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore:  $T_J = T_C = T_A$

### Electrical Characteristics

$V_{S+} = +5\text{V}$ ,  $V_{S-} = -5\text{V}$ ,  $T_A = 25^\circ\text{C}$ ,  $R_F = 180\Omega$ ,  $R_G = 20\Omega$ ,  $R_L = 500\Omega$  unless otherwise specified.

Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>DC Performance</b>						
$V_{OS}$	Input Offset Voltage (SO8)			0.2	2	mV
	Input Offset Voltage (SOT23-5)				3	mV
$T_{CVOS}$	Offset Voltage Temperature Coefficient			17		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current		-10	-7		$\mu\text{A}$
$I_{OS}$	Input Bias Current Offset			0.06	0.6	$\mu\text{A}$
$T_{CIB}$	Input Bias Current Temperature Coefficient			0.013		$\mu\text{A}/^\circ\text{C}$
$C_{IN}$	Input Capacitance			2.2		pF
$A_{VOL}$	Open Loop Gain	$V_O = -2.5\text{V}$ to $+2.5\text{V}$	80	87		dB
$PSRR$	Power Supply Rejection Ratio <sup>[1]</sup>		80	100		dB
$CMRR$	Common Mode Rejection Ratio	at CMIR	75	106		dB
$CMIR$	Common Mode Input Range		-4.6		3.8	V
$V_{OUTH}$	Positive Output Voltage Swing	No load, $R_F = 1\text{k}\Omega$	3.8	3.8		V
$V_{OUTL}$	Negative Output Voltage Swing	No load, $R_F = 1\text{k}\Omega$		-4	-3.9	V
$V_{OUTH2}$	Positive Output Voltage Swing	$R_L = 100\Omega$	3.2	3.45		V
$V_{OUTL2}$	Negative Output Voltage Swing	$R_L = 100\Omega$		-3.5	-3.2	V
$I_{OUT}$	Output Short Circuit Current <sup>[2]</sup>		80	100		mA
$I_{SY}$	Supply Current			4.7	5.5	mA
<b>AC Performance - <math>R_G = 20\Omega</math>, <math>C_L = 3\text{pF}</math></b>						
$BW$	-3dB Bandwidth, $R_L = 500\Omega$			100		MHz
$BW_{\pm 0.1\text{dB}}$	$\pm 0.1\text{dB}$ Bandwidth, $R_L = 500\Omega$			17		MHz
$BW_{\pm 1\text{dB}}$	$\pm 1\text{dB}$ Bandwidth, $R_L = 500\Omega$			80		MHz
Peaking	Peaking, $R_L = 500\Omega$			0.6		dB
$SR$	Slew Rate	$V_{OUT} = 2V_{PP}$ , measured at 20% to 80%	80	110		$\text{V}/\mu\text{s}$
$OS$	Overshoot, 4Vpk-pk Output Square Wave	Positive		2.8		%
		Negative		-7		%
$t_S$	Settling Time to 0.1% of $\pm 1\text{V}$ Pulse			51		ns
$V_N$	Voltage Noise Spectral Density			1.3		$\text{nV}/\sqrt{\text{Hz}}$
$I_N$	Current Noise Spectral Density			1.2		$\text{pA}/\sqrt{\text{Hz}}$
$HD_2$	2nd Harmonic Distortion <sup>[3]</sup>			-70		dBc
$HD_3$	3rd Harmonic Distortion <sup>[3]</sup>			-70		dBc

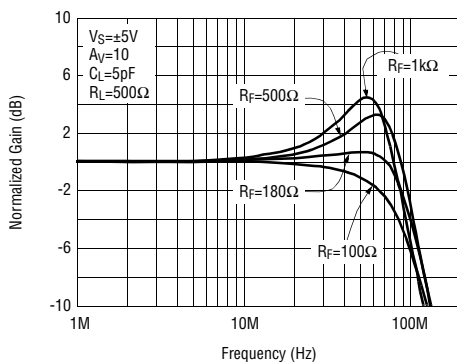
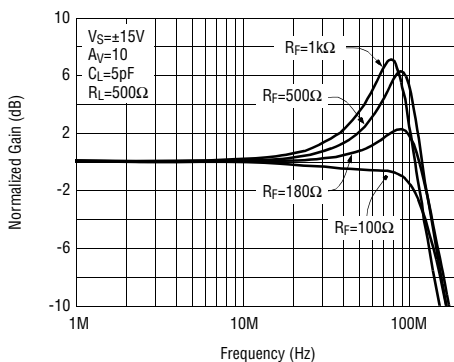
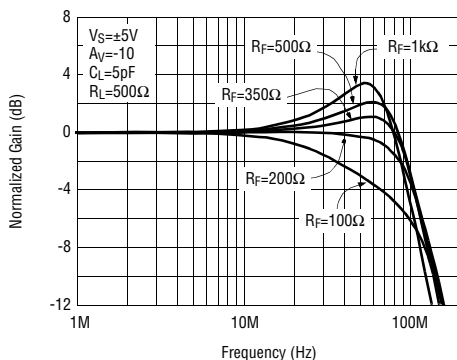
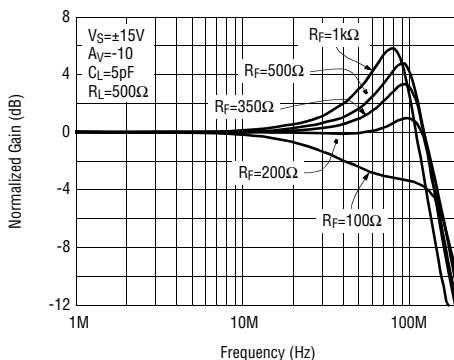
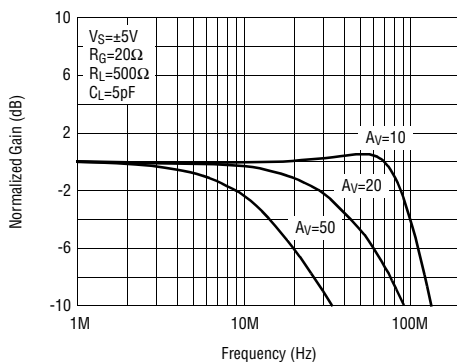
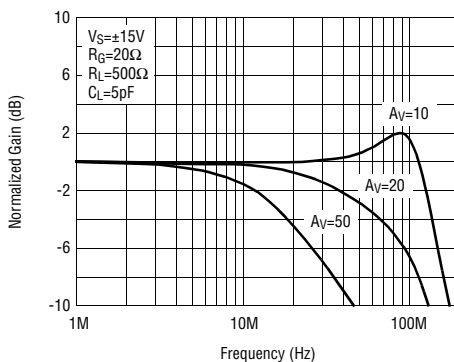
1. Measured by moving the supplies from  $\pm 4\text{V}$  to  $\pm 6\text{V}$
2. Pulse test only and using a  $10\Omega$  load
3. Frequency = 1MHz,  $V_{OUT} = 2\text{Vpk-pk}$ , into  $500\Omega$  and  $5\text{pF}$  load

## Electrical Characteristics

$V_{S+} = +15V$ ,  $V_{S-} = -15V$ ,  $T_A = 25^{\circ}C$ ,  $R_F = 180\Omega$ ,  $R_G = 20\Omega$ ,  $R_L = 500\Omega$  unless otherwise specified.

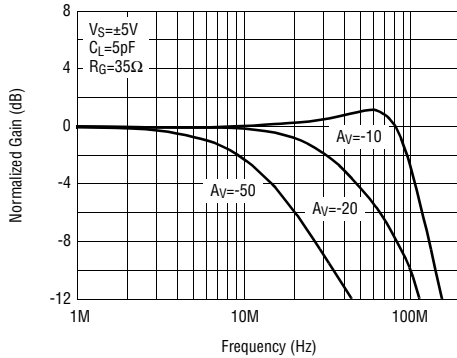
Parameter	Description	Conditions	Min	Typ	Max	Unit
<b>DC Performance</b>						
$V_{OS}$	Input Offset Voltage (SO8)			0.5	3	mV
	Input Offset Voltage (SOT23-5)				3	mV
$T_{CVOS}$	Offset Voltage Temperature Coefficient			4.5		$\mu V/^{\circ}C$
$I_B$	Input Bias Current		-10	-7		$\mu A$
$I_{OS}$	Input Bias Current Offset			0.12	0.7	$\mu A$
$T_{CIB}$	Input Bias Current Temperature Coefficient			0.016		$\mu A/^{\circ}C$
$C_{IN}$	Input Capacitance			2.2		pF
$A_{VOL}$	Open Loop Gain		80	90		dB
PSRR	Power Supply Rejection Ratio <sup>[1]</sup>		65	80		dB
CMRR	Common Mode Rejection Ratio	at CMIR	70	85		dB
CMIR	Common Mode Input Range		-14.6		13.8	V
$V_{OUTH}$	Positive Output Voltage Swing	No load, $R_F = 1k\Omega$	13.6	13.7		V
$V_{OUTL}$	Negative Output Voltage Swing	No load, $R_F = 1k\Omega$		-13.8	-13.7	V
$V_{OUTH2}$	Positive Output Voltage Swing	$R_L = 100\Omega$ , $R_F = 1k\Omega$	10.2	11.2		V
$V_{OUTL2}$	Negative Output Voltage Swing	$R_L = 100\Omega$ , $R_F = 1k\Omega$		-10.3	-9.5	V
$I_{OUT}$	Output Short Circuit Current <sup>[2]</sup>		140	220		mA
$I_{SY}$	Supply Current			5	6	mA
<b>AC Performance - <math>R_G = 20\Omega</math>, <math>C_L = 3pF</math></b>						
BW	-3dB Bandwidth, $R_L = 500\Omega$			135		MHz
BW $\pm 0.1dB$	$\pm 0.1dB$ Bandwidth, $R_L = 500\Omega$			26		MHz
BW $\pm 1dB$	$\pm 1dB$ Bandwidth, $R_L = 500\Omega$			60		MHz
Peaking	Peaking, $R_L = 500\Omega$			2.1		dB
SR	Slew Rate ( $\pm 2.5V$ Square Wave, Measured 25%-75%)		130	150		V/ $\mu S$
OS	Overshoot, 4Vpk-pk Output Square Wave	Positive		1.6		%
		Negative		-4.4		%
$T_S$	Settling Time to 0.1% of $\pm 1V$ Pulse			48		ns
$V_N$	Voltage Noise Spectral Density			1.4		nV/ $\sqrt{Hz}$
$I_N$	Current Noise Spectral Density			1.1		pA/ $\sqrt{Hz}$
HD2	2nd Harmonic Distortion <sup>[3]</sup>			-72		dBc
HD3	3rd Harmonic Distortion <sup>[3]</sup>			-73		dBc

1. Measured by moving the supplies from  $\pm 13.5V$  to  $\pm 16.5V$
2. Pulse test only and using a  $10\Omega$  load
3. Frequency = 1MHz,  $V_{OUT} = 2V_{pk-pk}$ , into  $500\Omega$  and  $5pF$  load

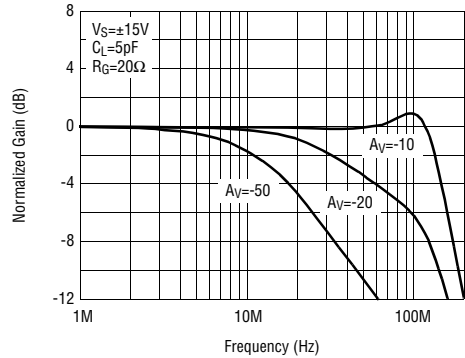
**EL2126C***Ultra-Low Noise, Low Power, Wideband Amplifier***Typical Performance Curves****Non-Inverting Frequency Response for Various  $R_F$** **Non-Inverting Frequency Response for Various  $R_F$** **Inverting Frequency Response for Various  $R_F$** **Inverting Frequency Response for Various  $R_F$** **Non-Inverting Frequency Response for Various Gain****Non-Inverting Frequency Response for Various Gain**

## Typical Performance Curves

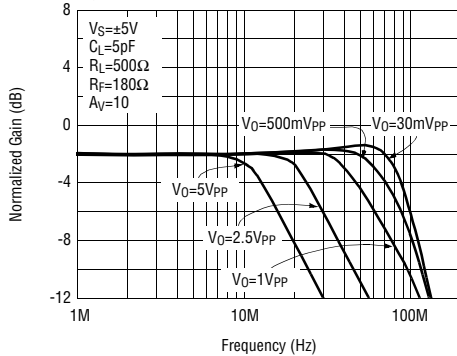
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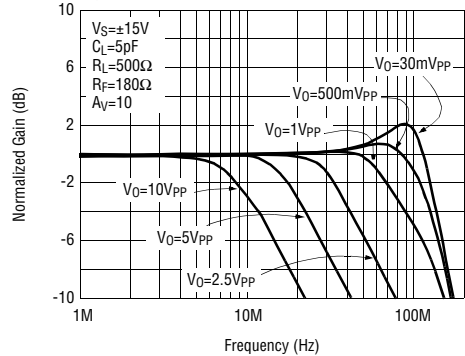
**Inverting Frequency Response for Various  $R_F$**



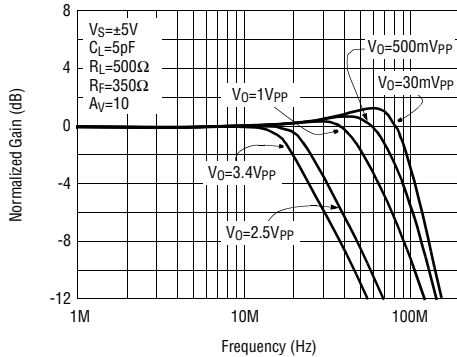
**Non-Inverting Frequency Response for Various Output Signal Levels**



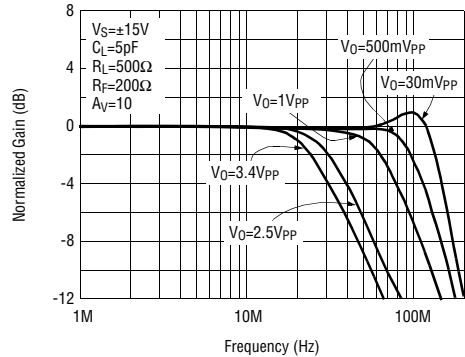
**Non-Inverting Frequency Response for Various Output Signal Levels**

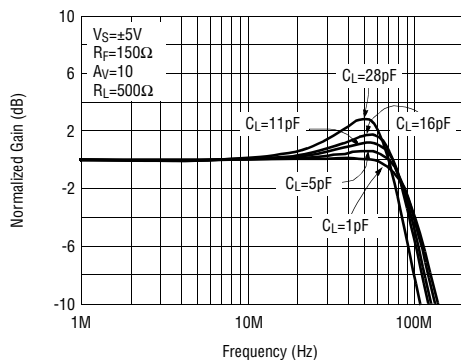
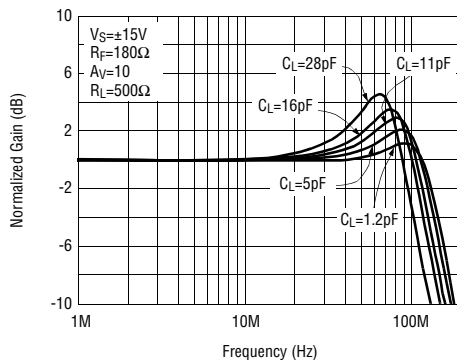
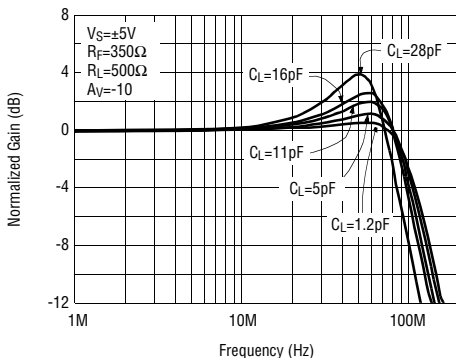
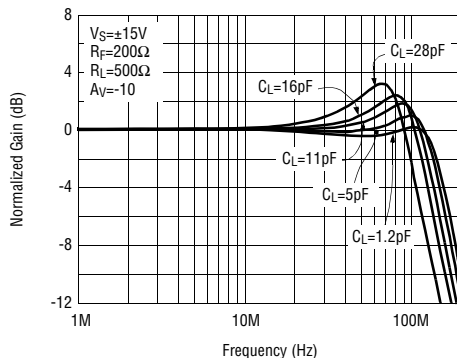
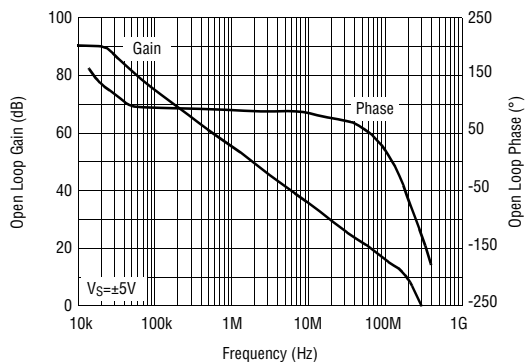
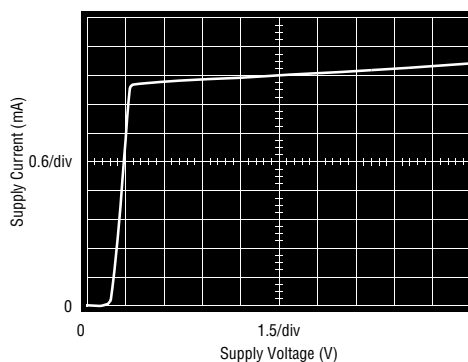


**Inverting Frequency Response for Various Output Signal Levels**

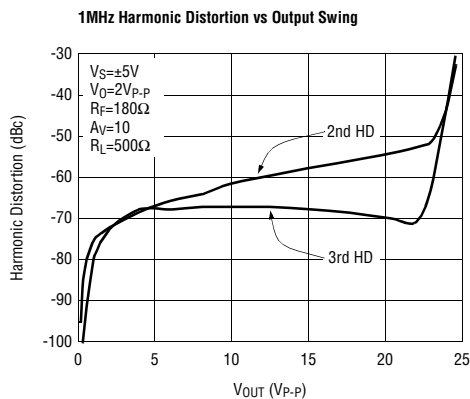
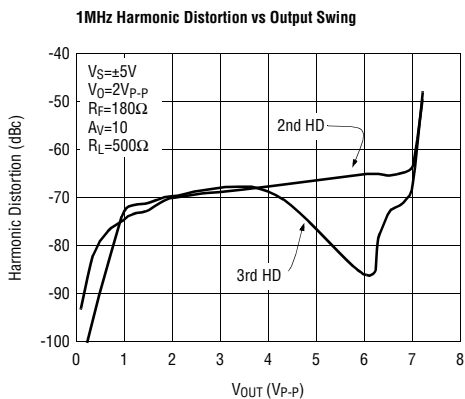
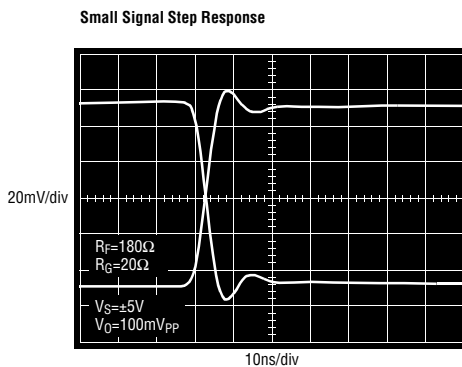
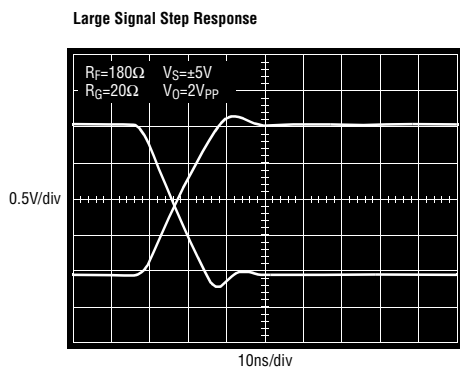
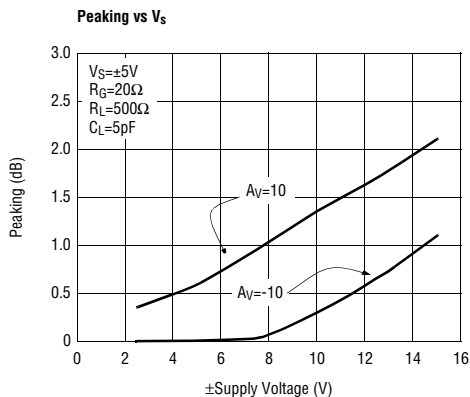
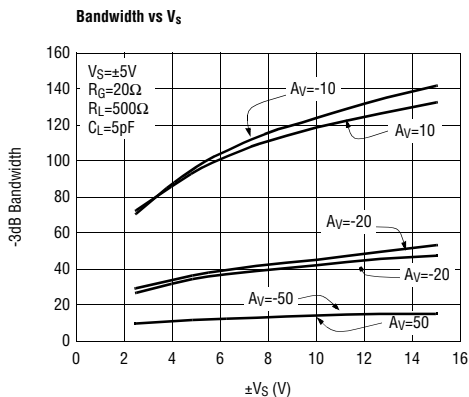


**Inverting Frequency Response for Various Output Signal Levels**



**EL2126C***Ultra-Low Noise, Low Power, Wideband Amplifier***Typical Performance Curves****Non-Inverting Frequency Response for Various  $C_L$** **Non-Inverting Frequency Response for Various  $C_L$** **Inverting Frequency Response for Various  $C_L$** **Inverting Frequency Response for Various  $C_L$** **Open Loop Gain/Phase****Supply Current vs Supply Voltage**

### Typical Performance Curves

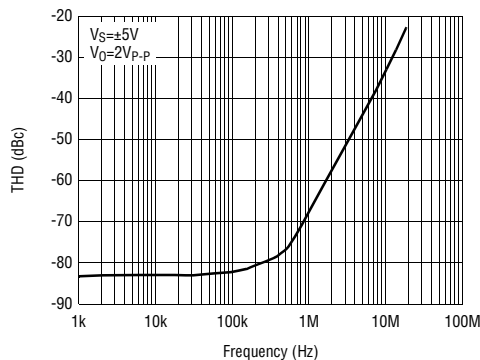


# EL2126C

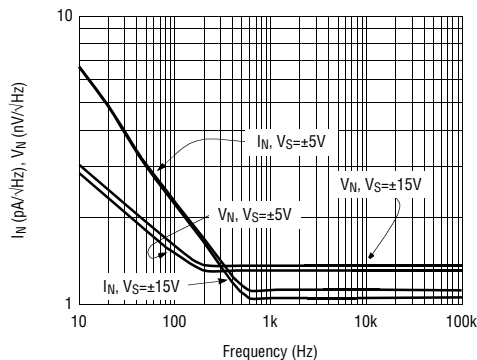
Ultra-Low Noise, Low Power, Wideband Amplifier

## Typical Performance Curves

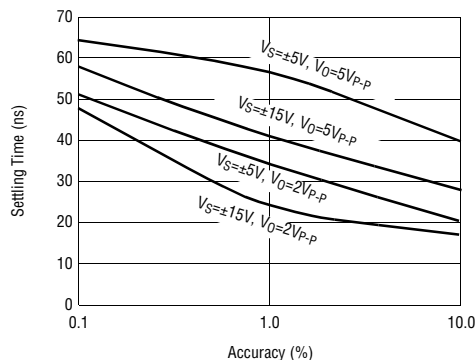
Total Harmonic Distortion vs Frequency



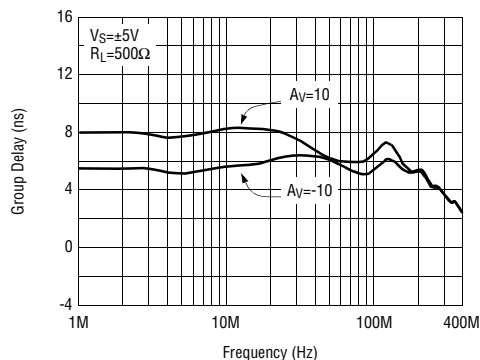
Noise vs Frequency



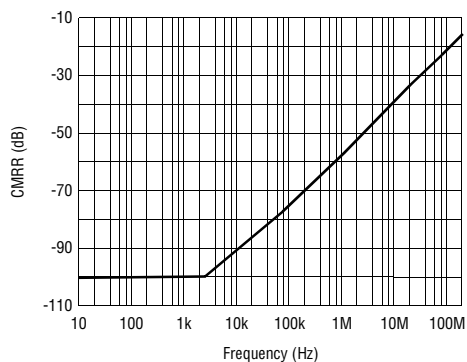
Settling Time vs Accuracy



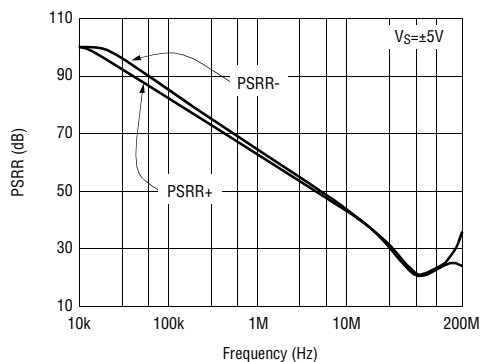
Group Delay vs Frequency



CMRR vs Frequency

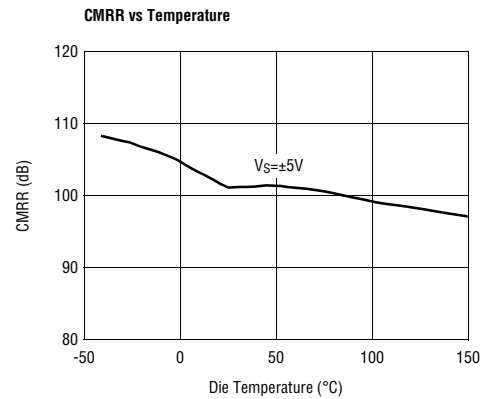
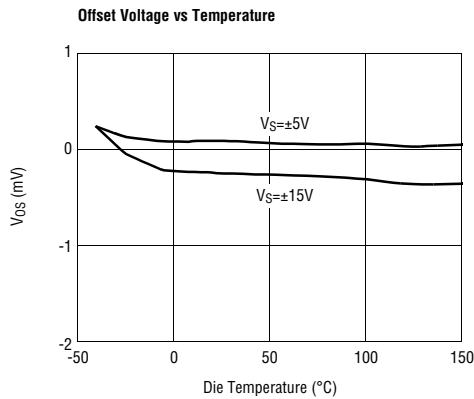
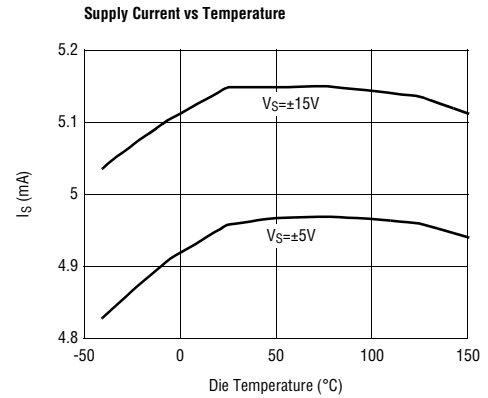
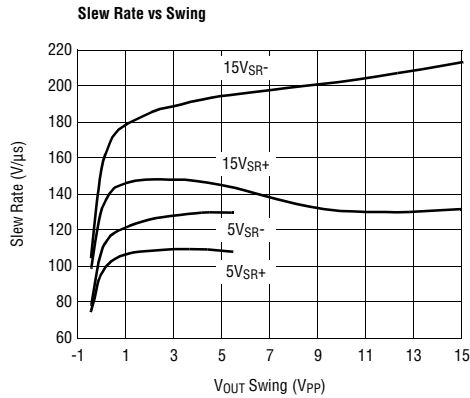
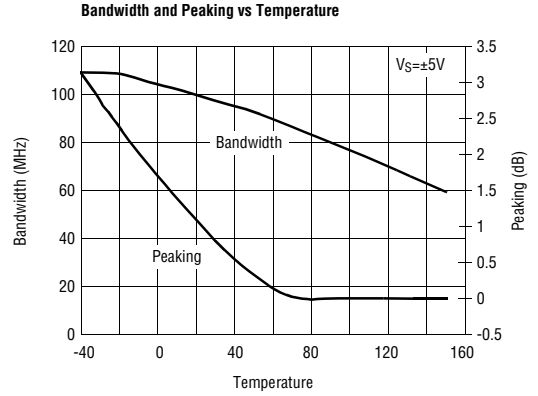
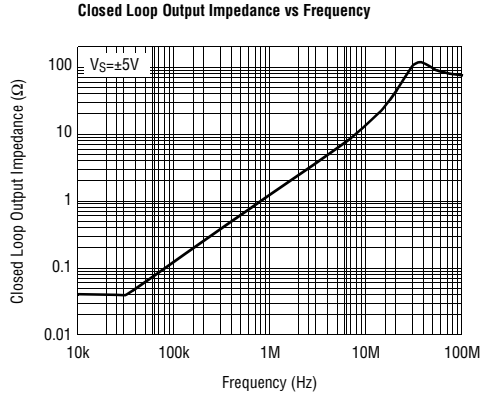


PSRR vs Frequency





## Typical Performance Curves

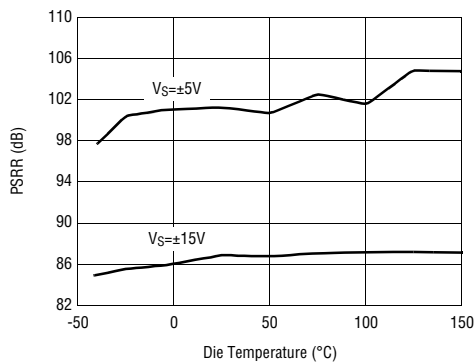


# EL2126C

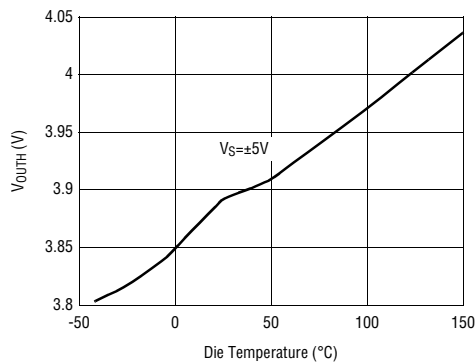
Ultra-Low Noise, Low Power, Wideband Amplifier

## Typical Performance Curves

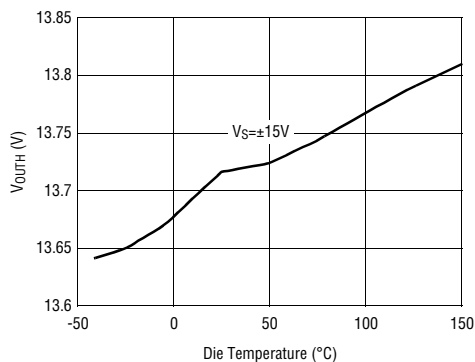
PSRR vs Temperature



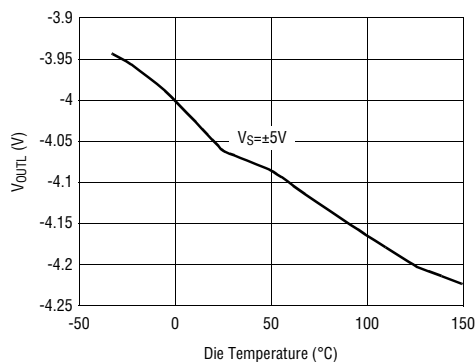
Positive Output Swing vs Temperature



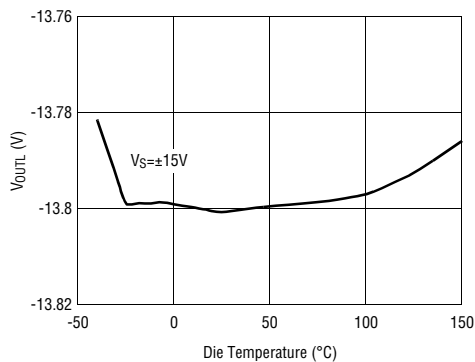
Positive Output Swing vs Temperature



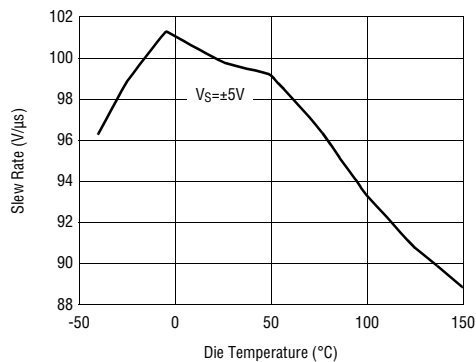
Negative Output Swing vs Temperature



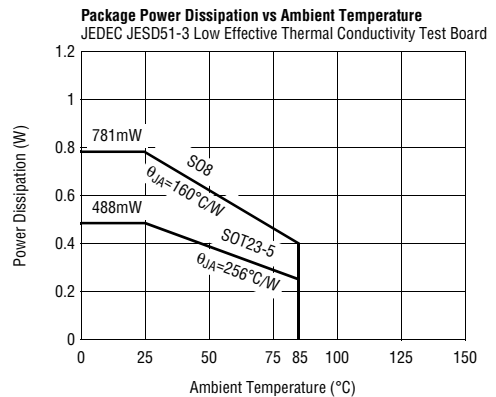
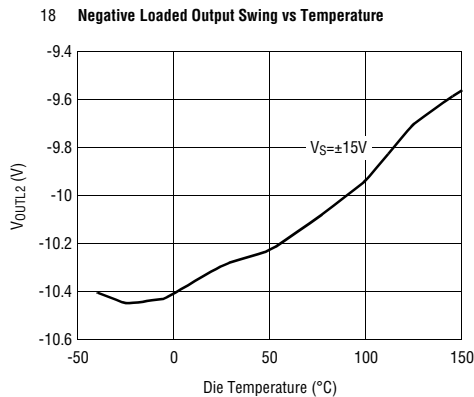
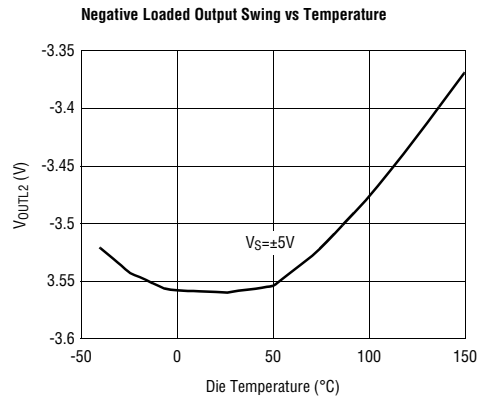
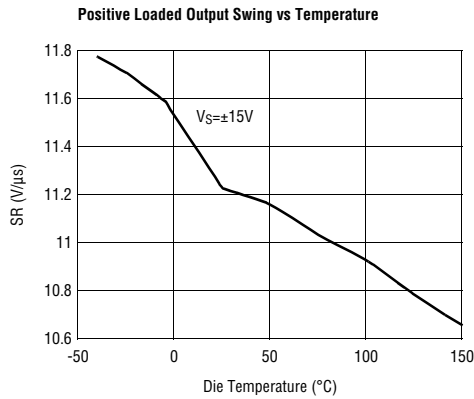
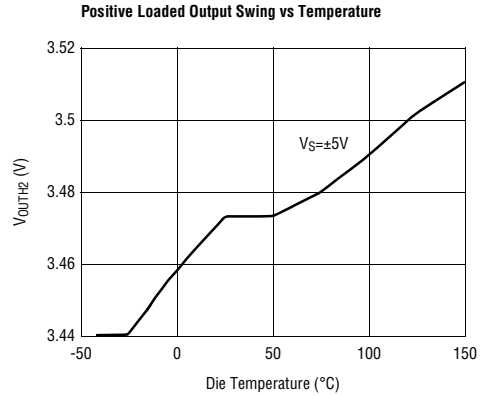
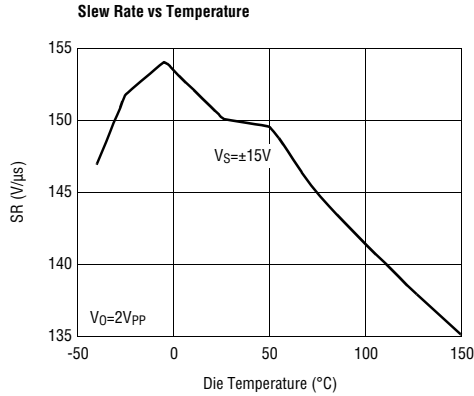
Negative Output Swing vs Temperature



Slew Rate vs Temperature



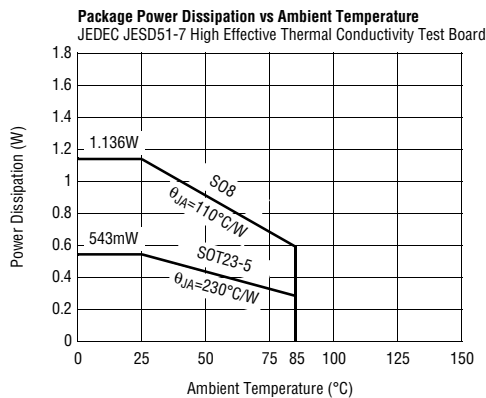
## Typical Performance Curves



# EL2126C

Ultra-Low Noise, Low Power, Wideband Amplifier

## Typical Performance Curves



EL2126CW (5-Pin SOT-23)	EL2126CS (8-Pin SO)	Pin Name	Pin Function	Equivalent Circuit
1	6	VOUT	Output	<p style="text-align: center;"><b>Circuit 1</b></p>
2	4	VS-	Supply	
3	3	VINA+	Input	<p style="text-align: center;"><b>Circuit 2</b></p>
4	2	VINA-	Input	Reference Circuit 2
5	7	VS+	Supply	

# EL2126C

*Ultra-Low Noise, Low Power, Wideband Amplifier*

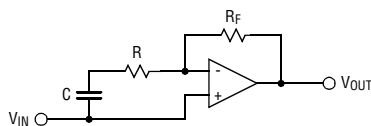
## Applications Information

### Product Description

The EL2126C is an ultra-low noise, wideband monolithic operational amplifier built on Elantec's proprietary high speed complementary bipolar process. It features 1.3nV/ $\sqrt{\text{Hz}}$  input voltage noise, 200 $\mu\text{V}$  typical offset voltage, and 73dB THD. It is intended for use in systems such as ultrasound imaging where very small signals are needed to be amplified. The EL2126C also has excellent DC specifications: 200 $\mu\text{V}$   $V_{OS}$ , 22 $\mu\text{A}$   $I_B$ , 0.4 $\mu\text{A}$   $I_{OS}$ , and 106dB CMRR. These specifications allow the EL2126C to be used in DC-sensitive applications such as difference amplifiers.

### Gain-Bandwidth Product

The EL2126C has a gain-bandwidth product of 650MHz at  $\pm 5\text{V}$ . For gains less than 20, higher-order poles in the amplifier's transfer function contribute to even higher closed-loop bandwidths. For example, the EL2126C has a -3dB bandwidth of 100MHz at a gain of 10 and decreases to 33MHz at gain of 20. It is important to note that the extra bandwidth at lower gain does not come at the expenses of stability. Even though the EL2126C is designed for gain  $\geq 10$ . With external compensation, the device can also operate at lower gain settings. The RC network shown in Figure 1 reduces the feedback gain at high frequency and thus maintains the amplifier stability. R values must be less than  $R_F$  divided by 9 and 1 divided by  $2\pi RC$  must be less than 200MHz.



**Figure 1.**

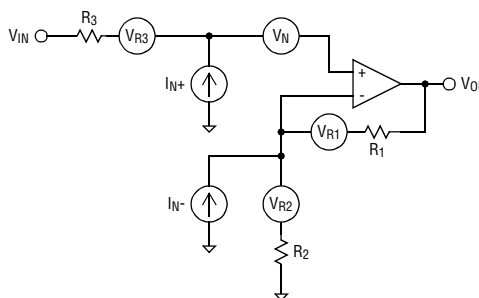
### Choice of Feedback Resistor, $R_F$

The feedback resistor forms a pole with the input capacitance. As this pole becomes larger, phase margin is reduced. This increases ringing in the time domain and peaking in the frequency domain. Therefore,  $R_F$  has some maximum value which should not be exceeded for

optimum performance. If a large value of  $R_F$  must be used, a small capacitor in the few pF range in parallel with  $R_F$  can help to reduce this ringing and peaking at the expense of reducing the bandwidth. Frequency response curves for various  $R_F$  values are shown in the typical performance curves section of this data sheet.

### Noise Calculations

The primary application for the EL2126C is to amplify very small signals. To maintain the proper signal-to-noise ratio, it is essential to minimize noise contribution from the amplifier. Figure 2 below shows all the noise sources for all the components around the amplifier.



**Figure 2.**

$V_N$  is the amplifier input voltage noise

$I_{N+}$  is the amplifier positive input current noise

$I_{N-}$  is the amplifier negative input current noise

$V_{RX}$  is the thermal noise associated with each resistor:

$$V_{RX} = \sqrt{4kTRx}$$

where:

- k is Boltzmann's constant =  $1.380658 \times 10^{-23}$
- T is temperature in degrees Kelvin (273+  $^{\circ}\text{C}$ )

The total noise due to the amplifier seen at the output of the amplifier can be calculated by using the following equation:

$$V_{ON} = \sqrt{BW} \times \sqrt{\left( V_N^2 \times \left( 1 + \frac{R_1}{R_2} \right)^2 + I_{N-}^2 \times R_1^2 + I_{N+}^2 \times R_3^2 \times \left( 1 + \frac{R_1}{R_2} \right)^2 + 4 \times K \times T \times R_1 + 4 \times K \times T \times R_2 \times \left( \frac{R_1}{R_2} \right)^2 + 4 \times K \times T \times R_3 \times \left( 1 + \frac{R_1}{R_2} \right)^2 \right)}$$

As the above equation shows, to keep noise at a minimum, small resistor values should be used. At higher amplifier gain configuration where  $R_2$  is reduced, the noise due to  $I_{N-}$ ,  $R_2$ , and  $R_1$  decreases and the noise caused by  $I_{N+}$ ,  $V_N$ , and  $R_3$  starts to dominate. Because noise is summed in a root-mean-squares method, noise sources smaller than 25% of the largest noise source can be ignored. This can greatly simplify the formula and make noise calculation much easier to calculate.

### Output Drive Capability

The EL2126C is designed to drive low impedance load. It can easily drive 6V<sub>p-p</sub> signal into a 100Ω load. This high output drive capability makes the EL2126C an ideal choice for RF, IF, and video applications. Furthermore, the EL2126C is current-limited at the output, allowing it to withstand momentary short to ground. However, the power dissipation with output-shortened cannot exceed the power dissipation capability of the package.

### Driving Cables and Capacitive Loads

Although the EL2126C is designed to drive low impedance load, capacitive loads will decrease the amplifier's phase margin. As shown in the performance curves, capacitive load can result in peaking, overshoot and possible oscillation. For optimum AC performance, capacitive loads should be reduced as much as possible or isolated with a series resistor between 5Ω to 20Ω. When driving coaxial cables, double termination is always recommended for reflection-free performance. When properly terminated, the capacitance of the coaxial cable will not add to the capacitive load seen by the amplifier.

### Power Supply Bypassing And Printed Circuit Board Layout

As with any high frequency devices, good printed circuit board layout is essential for optimum performance.

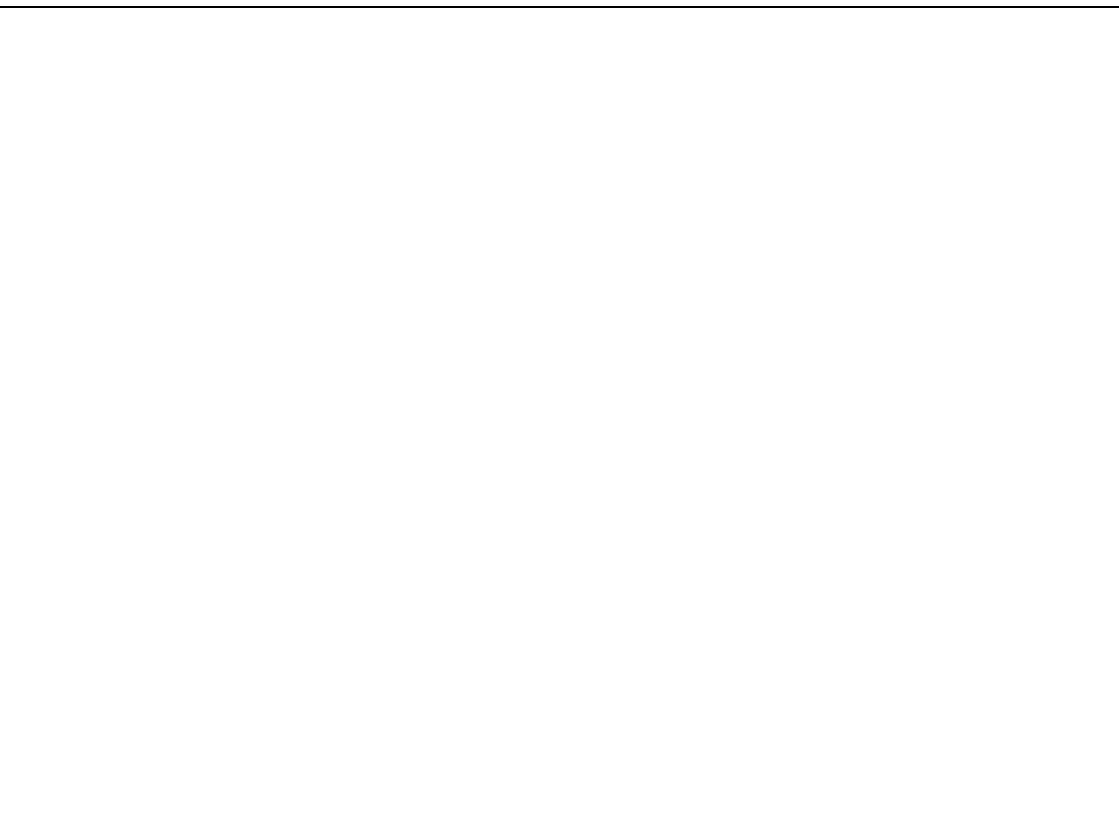
Ground plane construction is highly recommended. Lead lengths should be kept as short as possible. The power supply pins must be closely bypassed to reduce the risk of oscillation. The combination of a 4.7μF tantalum capacitor in parallel with 0.1μF ceramic capacitor has been proven to work well when placed at each supply pin. For single supply operation, where pin 4 ( $V_S$ -) is connected to the ground plane, a single 4.7μF tantalum capacitor in parallel with a 0.1μF ceramic capacitor across pins 7 ( $V_S$ +) and pin 4 ( $V_S$ -) will suffice.

For good AC performance, parasitic capacitance should be kept to a minimum. Ground plane construction again should be used. Small chip resistors are recommended to minimize series inductance. Use of sockets should be avoided since they add parasitic inductance and capacitance which will result in additional peaking and overshoot.

### Supply Voltage Range and Single Supply Operation

The EL2126C has been designed to operate with supply voltage range of ±2.5V to ±15V. With a single supply, the EL2126C will operate from +5V to +30V. Pins 4 and 7 are the power supply pins. The positive power supply is connected to pin 7. When used in single supply mode, pin 4 is connected to ground. When used in dual supply mode, the negative power supply is connected to pin 4.

As the power supply voltage decreases from +30V to +5V, it becomes necessary to pay special attention to the input voltage range. The EL2126C has an input voltage range of 0.4V from the negative supply to 1.2V from the positive supply. So, for example, on a single +5V supply, the EL2126C has an input voltage range which spans from 0.4V to 3.8V. The output range of the EL2126C is also quite large, on a +5V supply, it swings from 0.4V to 3.8V.

**EL2126C****Ultra-Low Noise, Low Power, Wideband Amplifier**

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