

## Dual Very Low Noise Amplifier



The EL2227 is a dual, low-noise amplifier, ideally suited to line receiving applications in ADSL and

HDSLII designs. With low noise specification of just 1.9nV/√Hz and 1.2pA/√Hz, the EL2227 is perfect for the detection of very low amplitude signals.

The EL2227 features a -3dB bandwidth of 115MHz and is gain-of-2 stable. The EL2227 also affords minimal power dissipation with a supply current of just 4.8mA per amplifier. The amplifier can be powered from supplies ranging from ±2.5V to ±12V.

The EL2227 is available in a space-saving 8-pin MSOP package as well as the industry-standard 8-pin SO. It can operate over the -40°C to +85°C temperature range.

## Ordering Information

PART NUMBER	PACKAGE	TAPE & REEL	PKG. NO.
EL2227CY	8-Pin MSOP	-	MDP0043
EL2227CY-T13	8-Pin MSOP	13"	MDP0043
EL2227CY-T7	8-Pin MSOP	7"	MDP0043
EL2227CS	8-Pin SO	-	MDP0027
EL2227CS-T13	8-Pin SO	13"	MDP0027
EL2227CS-T7	8-Pin SO	7"	MDP0027

## Features

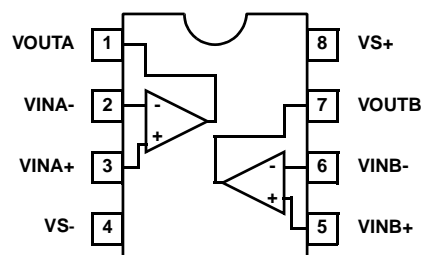
- Voltage noise of only 1.9nV/√Hz
- Current noise of only 1.2pA/√Hz
- Bandwidth (-3dB) of 115MHz @A<sub>V</sub> = +2
- Gain-of-2 stable
- Just 4.8mA per amplifier
- 8-pin MSOP package
- ±2.5V to ±12V operation

## Applications

- ADSL receivers
- HDSLII receivers
- Ultrasound input amplifiers
- Wideband instrumentation
- Communications equipment
- AGC & PLL active filters
- Wideband sensors

## Pinout

**EL2227**  
**(8-PIN SO, MSOP)**  
TOP VIEW



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

Supply Voltage between  $V_{S+}$  and  $V_{S-}$  .....28V  
 Input Voltage .....  $V_{S-} - 0.3\text{V}$ ,  $V_{S+} + 0.3\text{V}$   
 Maximum Continuous Output Current ..... 40mA  
 Maximum Die Temperature .....  $150^\circ\text{C}$

Storage Temperature .....  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Operating Temperature .....  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Power Dissipation ..... See Curves  
 ESD Voltage ..... 2kV

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

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

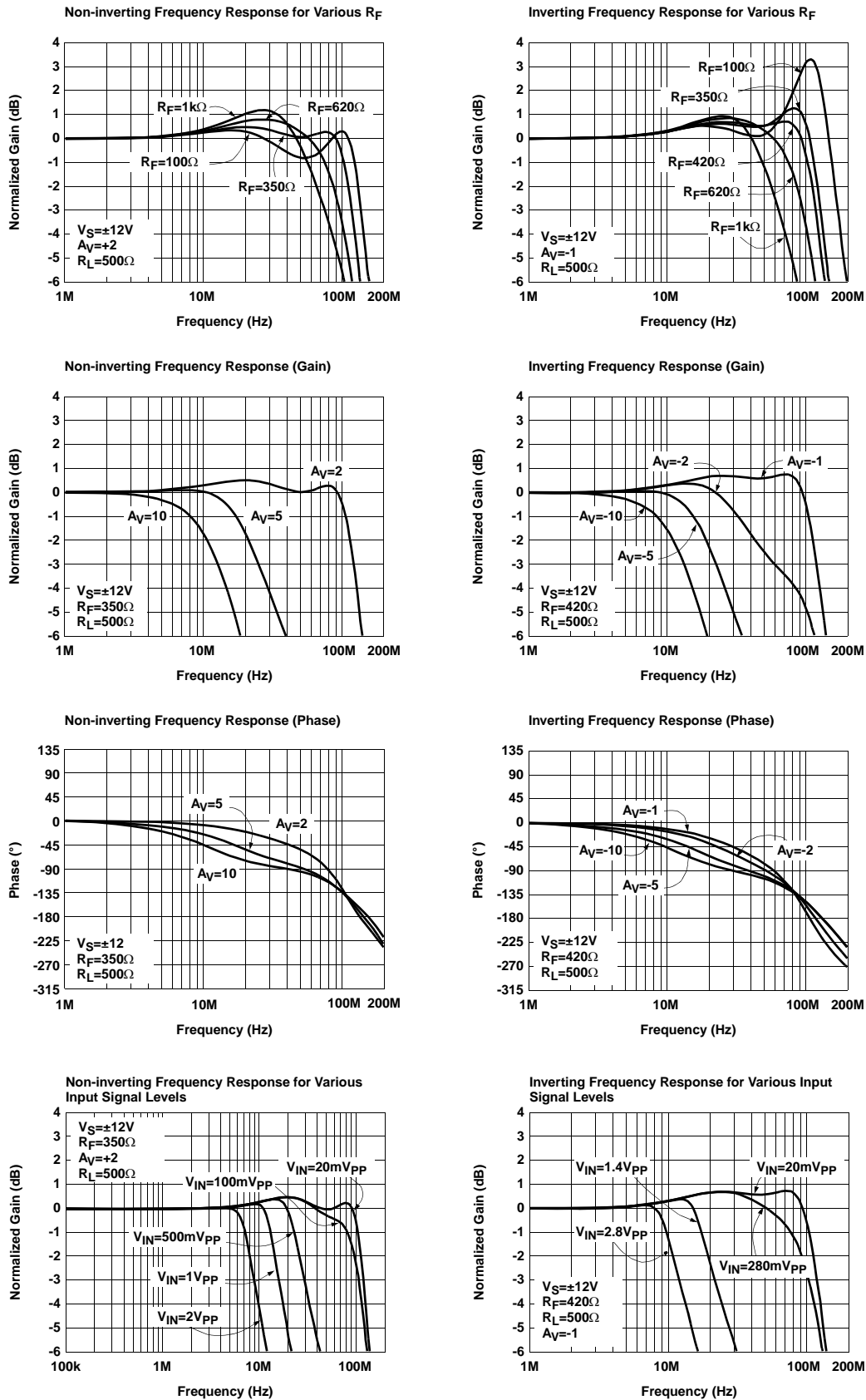
**Electrical Specifications**  $V_{S+} = +12\text{V}$ ,  $V_{S-} = -12\text{V}$ ,  $R_L = 500\Omega$  and  $C_L = 3\text{pF}$  to  $0\text{V}$ ,  $R_F = R_G = 620\Omega$ , and  $T_A = 25^\circ\text{C}$  unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
<b>INPUT CHARACTERISTICS</b>						
$V_{OS}$	Input Offset Voltage	$V_{CM} = 0\text{V}$		-0.2	3	mV
$TCV_{OS}$	Average Offset Voltage Drift			-0.6		$\mu\text{V}/^\circ\text{C}$
$I_B$	Input Bias Current	$V_{CM} = 0\text{V}$	-9	-3.4		$\mu\text{A}$
$R_{IN}$	Input Impedance			7.3		$\text{M}\Omega$
$C_{IN}$	Input Capacitance			1.6		pF
CMIR	Common-Mode Input Range		-11.8		+10.4	V
CMRR	Common-Mode Rejection Ratio	for $V_{IN}$ from -11.8V to 10.4V	60	94		dB
$A_{VOL}$	Open-Loop Gain	$-5\text{V} \leq V_{OUT} \leq 5\text{V}$	70	87		dB
$e_N$	Voltage Noise	$f = 100\text{kHz}$		1.9		$\text{nV}/\sqrt{\text{Hz}}$
$i_N$	Current Noise	$f = 100\text{kHz}$		1.2		$\text{pA}/\sqrt{\text{Hz}}$
<b>OUTPUT CHARACTERISTICS</b>						
$V_{OL}$	Output Swing Low	$R_L = 500\Omega$		-10.4	-10	V
		$R_L = 250\Omega$		-9.8	-9	V
$V_{OH}$	Output Swing High	$R_L = 500\Omega$	10	10.4		V
		$R_L = 250\Omega$	9.5	10		V
$I_{SC}$	Short Circuit Current	$R_L = 10\Omega$	140	180		mA
<b>POWER SUPPLY PERFORMANCE</b>						
PSRR	Power Supply Rejection Ratio	$V_S$ is moved from $\pm 2.25\text{V}$ to $\pm 12\text{V}$	65	95		dB
$I_S$	Supply Current (Per Amplifier)	No Load		4.8	6.5	mA
$V_S$	Operating Range		$\pm 2.5$		$\pm 12$	V
<b>DYNAMIC PERFORMANCE</b>						
SR	Slew Rate (Note 2)	$\pm 2.5\text{V}$ square wave, measured 25%-75%	40	50		$\text{V}/\mu\text{S}$
$t_S$	Settling to 0.1% ( $A_V = +2$ )	( $A_V = +2$ ), $V_O = \pm 1\text{V}$		65		ns
BW	-3dB Bandwidth	$R_F = 358\Omega$		115		MHz
HD2	2nd Harmonic Distortion	$f = 1\text{MHz}$ , $V_O = 2V_{P-P}$ , $R_L = 500\Omega$ , $R_F = 358\Omega$		93		dBc
		$f = 1\text{MHz}$ , $V_O = 2V_{P-P}$ , $R_L = 150\Omega$ , $R_F = 358\Omega$		83		dBc
HD3	3rd Harmonic Distortion	$f = 1\text{MHz}$ , $V_O = 2V_{P-P}$ , $R_L = 500\Omega$ , $R_F = 358\Omega$		94		dBc
		$f = 1\text{MHz}$ , $V_O = 2V_{P-P}$ , $R_L = 150\Omega$ , $R_F = 358\Omega$		76		dBc

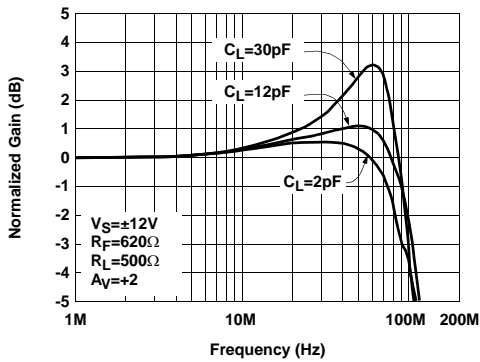
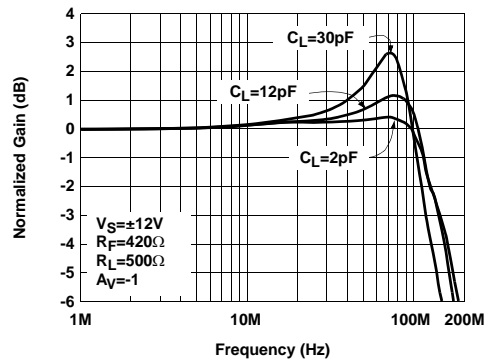
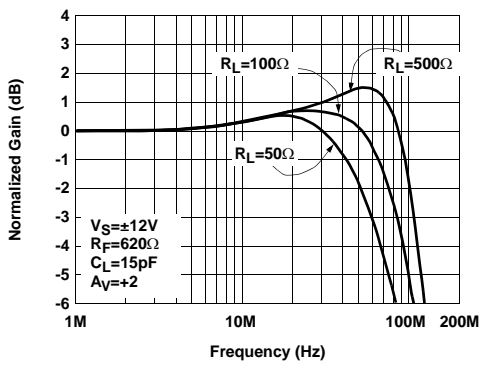
**Electrical Specifications**  $V_{S+} = +12V$ ,  $V_{S-} = -12V$ ,  $R_L = 500\Omega$  and  $C_L = 3pF$  to 0V,  $R_F = R_G = 620\Omega$ , and  $T_A = 25^\circ C$  unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
<b>INPUT CHARACTERISTICS</b>						
$V_{OS}$	Input Offset Voltage	$V_{CM} = 0V$		0.2	3	mV
$TCV_{OS}$	Average Offset Voltage Drift			-0.6		$\mu V/^\circ C$
$I_B$	Input Bias Current	$V_{CM} = 0V$	-9	-3.7		$\mu A$
$R_{IN}$	Input Impedance			7.3		$M\Omega$
$C_{IN}$	Input Capacitance			1.6		pF
CMIR	Common-Mode Input Range		-4.8		3.4	V
CMRR	Common-Mode Rejection Ratio	for $V_{IN}$ from -4.8V to 3.4V	60	97		dB
$A_{VOL}$	Open-Loop Gain	$-5V \leq V_{OUT} \leq 5V$	70	84		dB
$e_N$	Voltage Noise	$f = 100kHz$		1.9		$nV/\sqrt{Hz}$
$i_N$	Current Noise	$f = 100kHz$		1.2		$pA/\sqrt{Hz}$
<b>OUTPUT CHARACTERISTICS</b>						
$V_{OL}$	Output Swing Low	$R_L = 500\Omega$		-3.8	-3.5	V
		$R_L = 250\Omega$		-3.7	-3.5	V
$V_{OH}$	Output Swing High	$R_L = 500\Omega$	3.5	3.7		V
		$R_L = 250\Omega$	3.5	3.6		V
$I_{SC}$	Short Circuit Current	$R_L = 10\Omega$	60	100		mA
<b>POWER SUPPLY PERFORMANCE</b>						
PSRR	Power Supply Rejection Ratio	$V_S$ is moved from $\pm 2.25V$ to $\pm 12V$	65	95		dB
$I_S$	Supply Current (Per Amplifier)	No Load		4.5	5.5	mA
$V_S$	Operating Range		$\pm 2.5$		$\pm 12$	V
<b>DYNAMIC PERFORMANCE</b>						
SR	Slew Rate	$\pm 2.5V$ square wave, measured 25%-75%	35	45		$V/\mu S$
$t_S$	Settling to 0.1% ( $A_V = +2$ )	( $A_V = +2$ ), $V_O = \pm 1V$		77		ns
BW	-3dB Bandwidth	$R_F = 358\Omega$		90		MHz
HD2	2nd Harmonic Distortion	$f = 1MHz$ , $V_O = 2V_{P-P}$ , $R_L = 500\Omega$ , $R_F = 358\Omega$		98		dBc
		$f = 1MHz$ , $V_O = 2V_{P-P}$ , $R_L = 150\Omega$ , $R_F = 358\Omega$		90		dBc
HD3	3rd Harmonic Distortion	$f = 1MHz$ , $V_O = 2V_{P-P}$ , $R_L = 500\Omega$ , $R_F = 358\Omega$		94		dBc
		$f = 1MHz$ , $V_O = 2V_{P-P}$ , $R_L = 150\Omega$ , $R_F = 358\Omega$		79		dBc

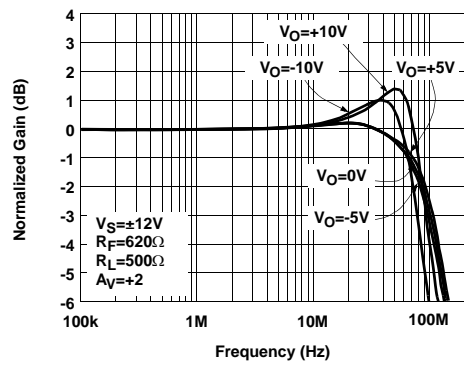
## Typical Performance Curves



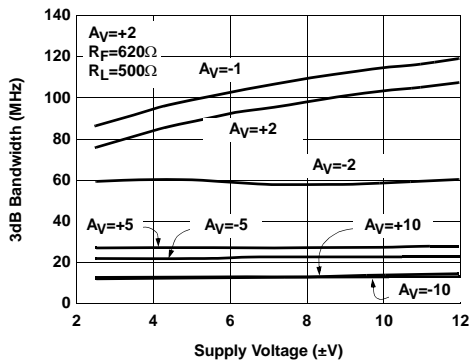
# Typical Performance Curves (Continued)

Non-inverting Frequency Response for Various  $C_L$ Inverting Frequency Response for Various  $C_L$ Non-inverting Frequency Response for Various  $R_L$ 

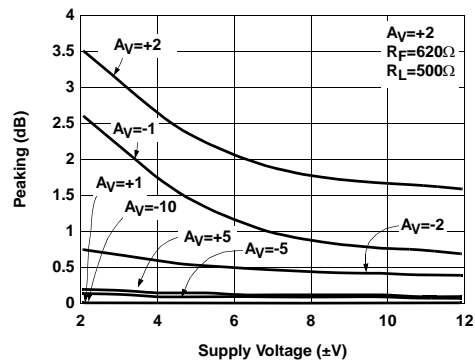
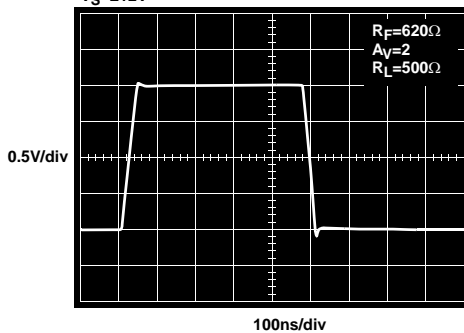
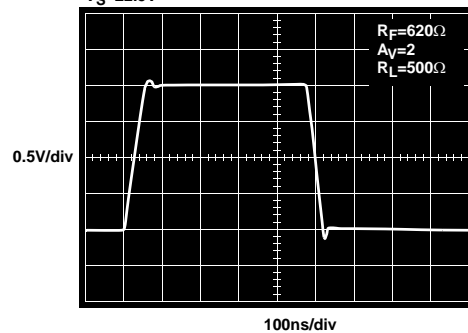
Frequency Response for Various Output DC Levels



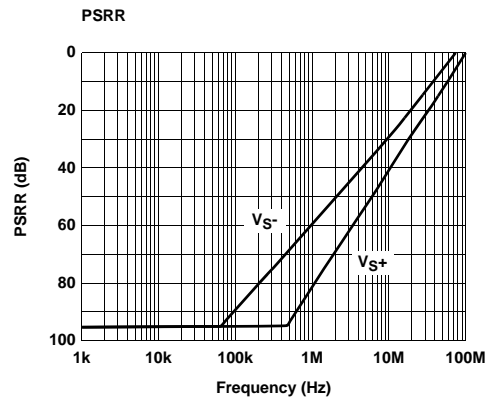
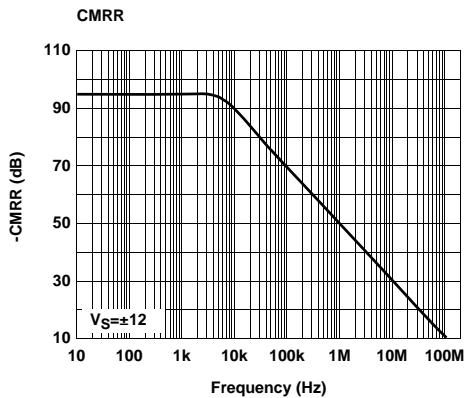
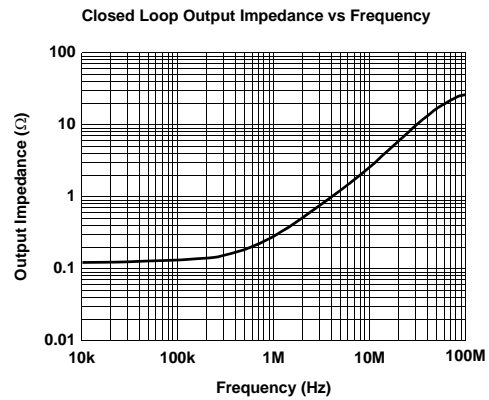
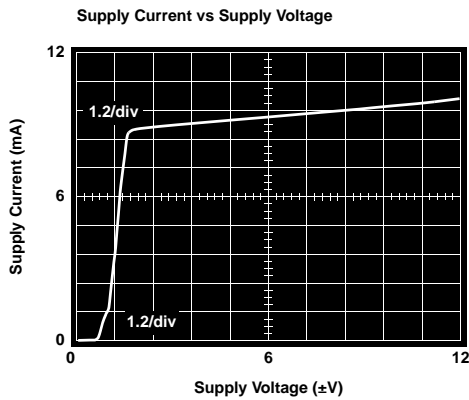
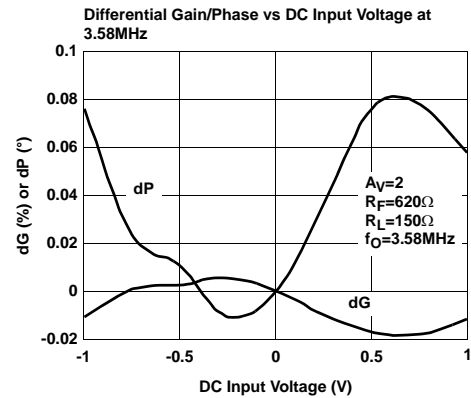
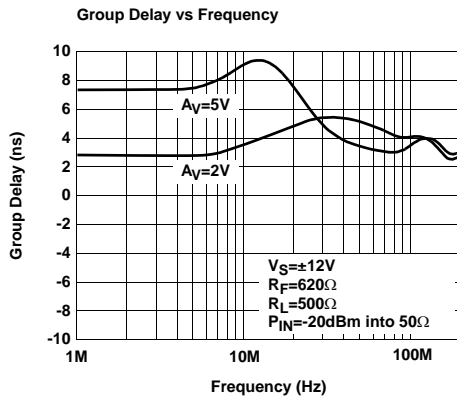
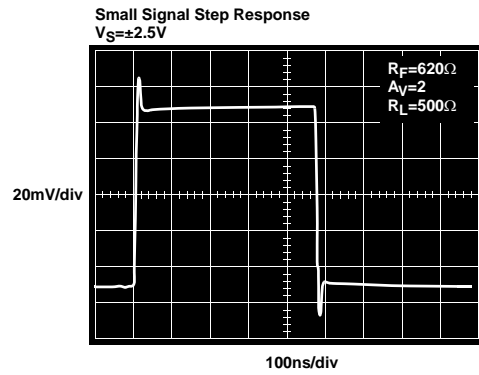
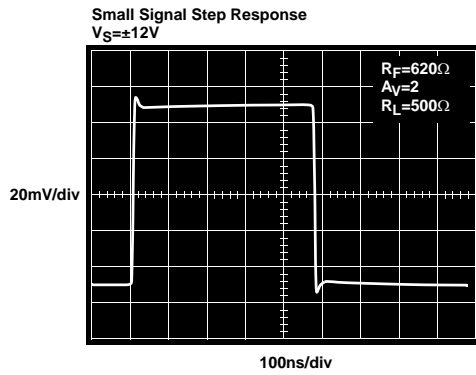
3dB Bandwidth vs Supply Voltage



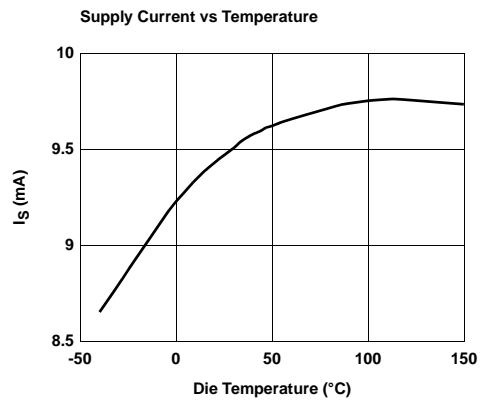
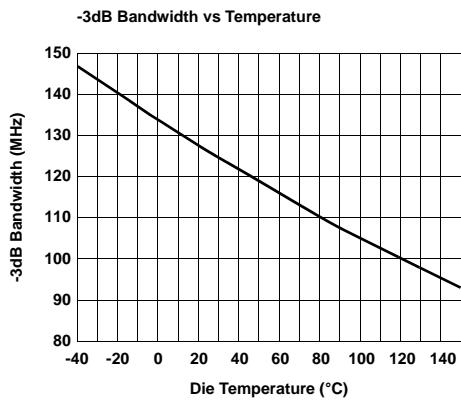
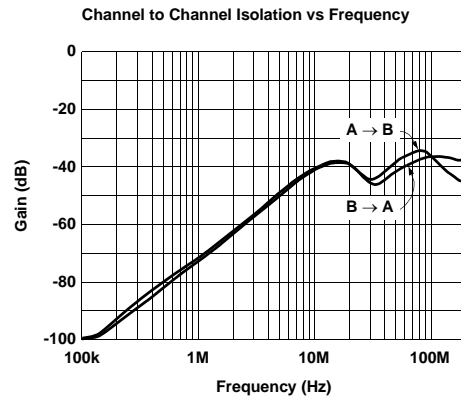
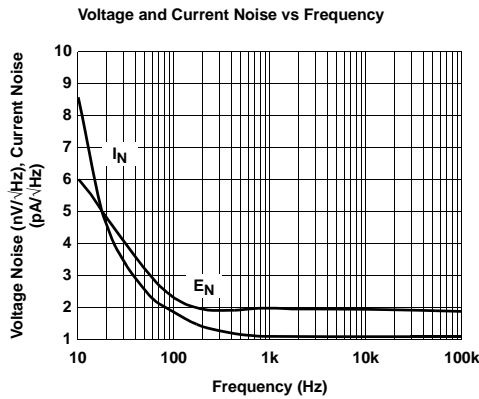
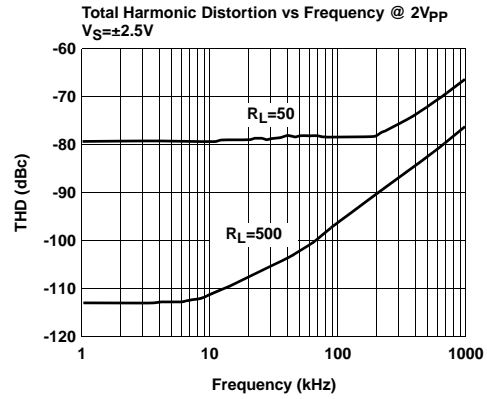
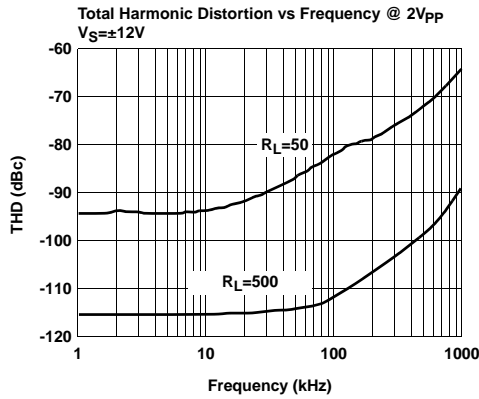
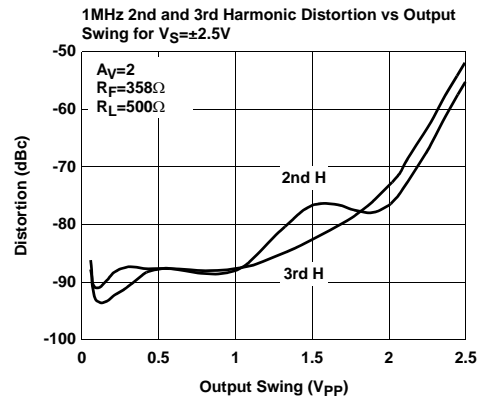
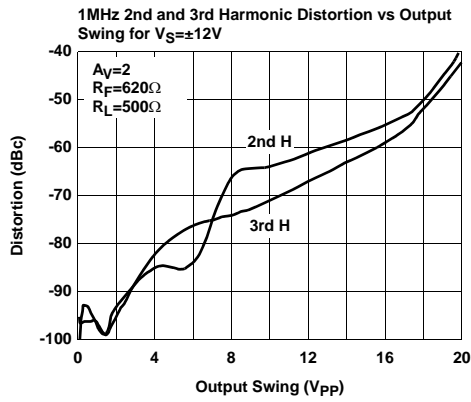
Peaking vs Supply Voltage

Large Signal Step Response  
 $V_S = \pm 12\text{V}$ Large Signal Step Response  
 $V_S = \pm 2.5\text{V}$ 

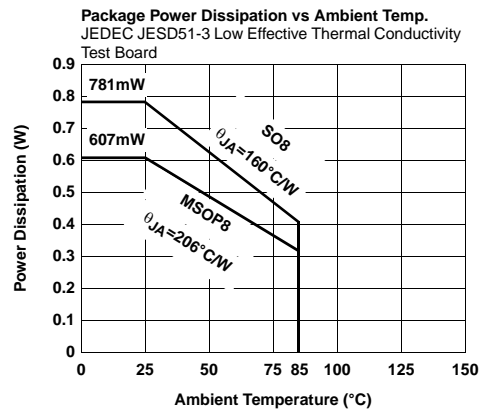
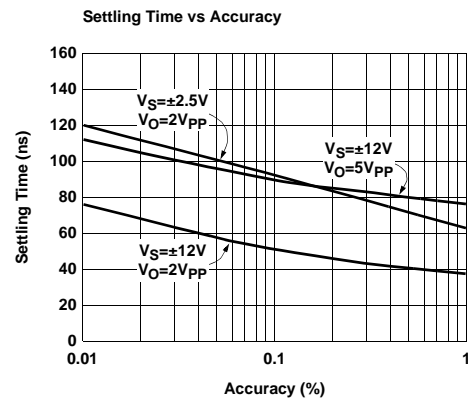
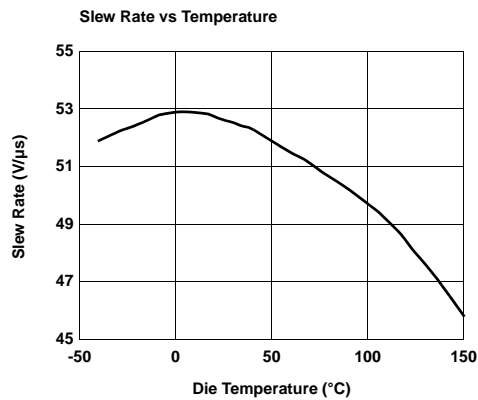
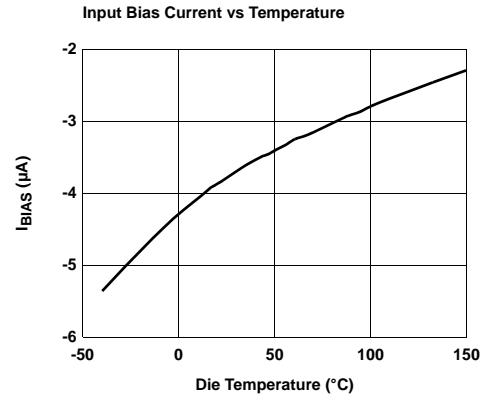
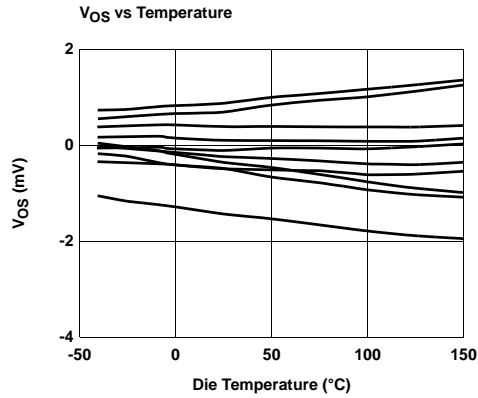
# Typical Performance Curves (Continued)



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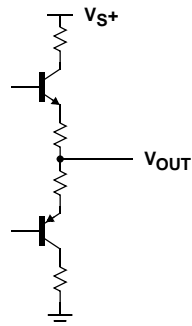
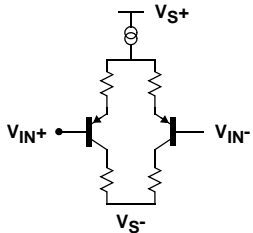


## Typical Performance Curves (Continued)





## Pin Descriptions

EL2227CY 8-PIN MSOP	EL2227CS 8-PIN SO	PIN NAME	PIN FUNCTION	EQUIVALENT CIRCUIT
1	1	VOUTA	Output	 <p>Circuit 1</p>
2	2	VINA-	Input	 <p>Circuit 2</p>
3	3	VINA+	Input	Reference Circuit 2
4	4	VS-	Supply	
5	5	VINB+	Input	
6	6	VINB-	Input	Reference Circuit 2
7	7	VOUTB	Output	Reference Circuit 1
8	8	VS+	Supply	

## Applications Information

### Product Description

The EL2227 is a dual voltage feedback operational amplifier designed especially for DMT ADSL and other applications requiring very low voltage and current noise. It also features low distortion while drawing moderately low supply current and is built on Elantec's proprietary high-speed complementary bipolar process. The EL2227 use a classical voltage-feedback topology which allows them to be used in a variety of applications where current-feedback amplifiers are not appropriate because of restrictions placed upon the feedback element used with the amplifier. The conventional topology of the EL2227 allows, for example, a capacitor to be placed in the feedback path, making it an excellent choice for applications such as active filters, sample-and-holds, or integrators.

### ADSL CPE Applications

The low noise EL2227 amplifier is specifically designed for the dual differential receiver amplifier function with ADSL

transceiver hybrids as well as other low-noise amplifier applications. A typical ADSL CPE line interface circuit is shown in Figure 1. The EL2227 is used in receiving DMT down stream signal. With careful transceiver hybrid design and the EL2227 1.9nV/ $\sqrt{\text{Hz}}$  voltage noise and 1.2pA/ $\sqrt{\text{Hz}}$  current noise performance, -140dBm/Hz system background noise performance can be easily achieved.

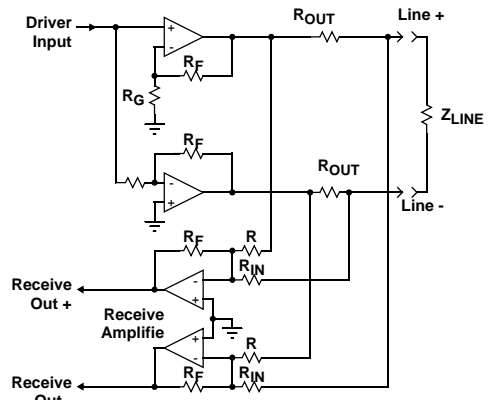


FIGURE 1. TYPICAL LINE INTERFACE CONNECTION

### Disable Function

The EL2227 is in the standard dual amplifier package without the enable/disable function. A simple way to implement the enable/disable function is depicted below. When disabled, both the positive and negative supply voltages are disconnected (see Figure 2 below.)

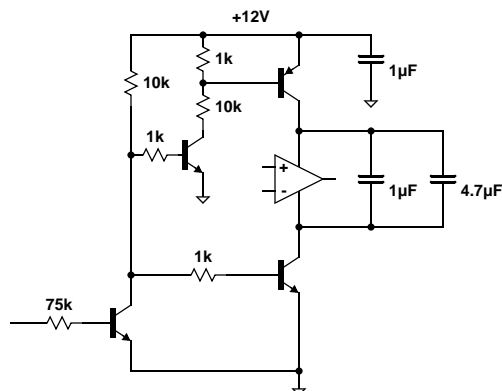


FIGURE 2.

### Power Dissipation

With the wide power supply range and large output drive capability of the EL2227, it is possible to exceed the 150°C maximum junction temperatures under certain load and power-supply conditions. It is therefore important to calculate the maximum junction temperature ( $T_{JMAX}$ ) for all applications to determine if power supply voltages, load conditions, or package type need to be modified for the EL2227 to remain in the safe operating area. These parameters are related as follows:

$$T_{JMAX} = T_{MAX} + (\theta_{JA} \times PD_{MAXTOTAL})$$

where:

$PD_{MAXTOTAL}$  is the sum of the maximum power dissipation of each amplifier in the package ( $PD_{MAX}$ )

$PD_{MAX}$  for each amplifier can be calculated as follows:

$$PD_{MAX} = 2 \times V_S \times I_{SMAX} + (V_S - V_{OUTMAX}) \times \frac{V_{OUTMAX}}{R_L}$$

where:

$T_{MAX}$  = Maximum Ambient Temperature

$\theta_{JA}$  = Thermal Resistance of the Package

$PD_{MAX}$  = Maximum Power Dissipation of 1 Amplifier

$V_S$  = Supply Voltage

$I_{MAX}$  = Maximum Supply Current of 1 Amplifier

$V_{OUTMAX}$  = Maximum Output Voltage Swing of the Application

$R_L$  = Load Resistance

To serve as a guide for the user, we can calculate maximum allowable supply voltages for the example of the video cable-driver below since we know that  $T_{JMAX} = 150^\circ\text{C}$ ,  $T_{MAX} = 75^\circ\text{C}$ ,  $I_{SMAX} = 9.5\text{mA}$ , and the package  $\theta_{JA}$ s are shown in Table 1. If we assume (for this example) that we are driving a back-terminated video cable, then the maximum average value (over duty-cycle) of  $V_{OUTMAX}$  is 1.4V, and  $R_L = 150\Omega$ , giving the results seen in Table 1.

TABLE 1.

PART	PACKAGE	$\theta_{JA}$	MAX $PD_{ISS}$ @ $T_{MAX}$	MAX $V_S$
EL2227CS	SO8	160°C/W	0.406W @ 85°C	
EL2227CY	MSOP8	206°C/W	0.315W @ 85°C	

### Single-Supply Operation

The EL2227 have been designed to have a wide input and output voltage range. This design also makes the EL2227 an excellent choice for single-supply operation. Using a single positive supply, the lower input voltage range is within 200mV of ground ( $R_L = 500\Omega$ ), and the lower output voltage range is within 875mV of ground. Upper input voltage range reaches 3.6V, and output voltage range reaches 3.8V with a 5V supply and  $R_L = 500\Omega$ . This results in a 2.625V output swing on a single 5V supply. This wide output voltage range also allows single-supply operation with a supply voltage as high as 28V.

### Gain-Bandwidth Product and the -3dB Bandwidth

The EL2227 have a gain-bandwidth product of 137MHz while using only 5mA of supply current per amplifier. For gains greater than 2, their closed-loop -3dB bandwidth is approximately equal to the gain-bandwidth product divided by the noise gain of the circuit. For gains less than 2, higher-order poles in the amplifiers' transfer function contribute to even higher closed loop bandwidths. For example, the EL2227 have a -3dB bandwidth of 115MHz at a gain of +2, dropping to 28MHz at a gain of +5. It is important to note that the EL2227 have been designed so that this "extra" bandwidth in low-gain applications does not come at the expense of stability. As seen in the typical performance curves, the EL2227 in a gain of +2 only exhibit 0.5dB of peaking with a 1000Ω load.

### Output Drive Capability

The EL2227 have been designed to drive low impedance loads. They can easily drive 6V<sub>pp</sub> into a 500Ω load. This high output drive capability makes the EL2227 an ideal choice for RF, IF and video applications.

### Printed-Circuit Layout

The EL2227 are well behaved, and easy to apply in most applications. However, a few simple techniques will help assure rapid, high quality results. As with any high-frequency device, good PCB layout is necessary for optimum performance. Ground-plane construction is highly

recommended, as is good power supply bypassing. A 0.1 $\mu$ F ceramic capacitor is recommended for bypassing both supplies. Lead lengths should be as short as possible, and bypass capacitors should be as close to the device pins as possible. For good AC performance, parasitic capacitances should be kept to a minimum at both inputs and at the output. Resistor values should be kept under 5k $\Omega$  because of the RC time constants associated with the parasitic capacitance. Metal-film and carbon resistors are both acceptable, use of wire-wound resistors is not recommended because of their parasitic inductance. Similarly, capacitors should be low-inductance for best performance.

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