

## Dual $V_{COM}$ Amplifier & Gamma Reference Buffer

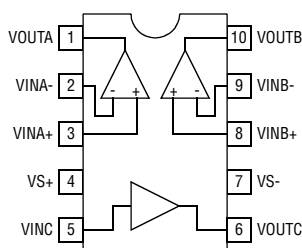
**élantec**<sup>®</sup>

The EL5128 integrates two  $V_{COM}$  amplifiers with a single gamma reference buffer. Operating on supplies ranging from 5V to 15V, while consuming only 2.0mA, the EL5128 has a bandwidth of 12MHz (-3dB) and provides common mode input ability beyond the supply rails, as well as rail-to-rail output capability. This enables this amplifier to offer maximum dynamic range at any supply voltage. The EL5128 also features fast slewing and settling times, as well as a high output drive capability of 30mA (sink and source).

The EL5128 is targeted at TFT-LCD applications, including notebook panels, monitors, and LCD-TVs. It is available in the 10-pin MSOP package and is specified for operation over the -40°C to +85°C temperature range.

## Pinout

**EL5128IY**  
**(10-PIN MSOP)**  
TOP VIEW



## Features

- Dual  $V_{COM}$  amplifier
- Single gamma reference buffer
- 12MHz -3dB bandwidth
- Supply voltage = 4.5V to 16.5V
- Low supply current = 2.0mA
- High slew rate = 10V/ $\mu$ s
- Unity-gain stable
- Beyond the rails input capability
- Rail-to-rail output swing
- Ultra-small package

## Applications

- TFT-LCD drive circuits
- Notebook displays
- LCD desktop monitors
- LCD-TVs

## Ordering Information

PART NUMBER	PACKAGE	TAPE & REEL	OUTLINE #
EL5128IY	10-Pin MSOP	-	MDP0043
EL5128IY-T7	10-Pin MSOP	7"	MDP0043
EL5128IY-T13	10-Pin MSOP	13"	MDP0043

**Absolute Maximum Ratings**

Supply Voltage between  $V_{S+}$  and  $V_{S-}$  ..... +18V  
 Input Voltage .....  $V_{S-} - 0.5V$ ,  $V_{S+} + 0.5V$   
 Maximum Continuous Output Current ..... 30mA  
 ESD Voltage ..... 2kV

**Thermal Information**

Maximum Die Temperature ..... +125°C  
 Storage Temperature ..... -65°C to +150°C  
 Power Dissipation ..... See Curves

**Operating Conditions**

Operating Temperature ..... -40°C to +85°C

**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. 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 Specifications**

$V_{S+} = +5V$ ,  $V_{S-} = -5V$ ,  $R_L = 10k\Omega$  and  $C_L = 10pF$  to 0V,  $T_A = 25^\circ C$  unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
<b>Input Characteristics</b>						
$V_{OS}$	Input Offset Voltage	$V_{CM} = 0V$		2	12	mV
$TCV_{OS}$	Average Offset Voltage Drift	<sup>a</sup>		5		$\mu V/^\circ C$
$I_B$	Input Bias Current	$V_{CM} = 0V$		2	50	nA
$R_{IN}$	Input Impedance			1		G $\Omega$
$C_{IN}$	Input Capacitance			1.35		pF
$CMIR$	Common-Mode Input Range	( $V_{COM}$ amps)	-5.5		+5.5	V
$CMRR$	Common-Mode Rejection Ratio	( $V_{COM}$ amps) for $V_{IN}$ from -5.5V to +5.5V	50	70		dB
$A_{VOL}$	Open-Loop Gain	$-4.5V \leq V_{OUT} \leq +4.5V$ ( $V_{COM}$ amps)	75	95		dB
$AV$	Voltage Gain	$-4.5V \leq V_{OUT} \leq +4.5V$	0.995		1.005	V/V
<b>Output Characteristics</b>						
$V_{OL}$	Output Swing Low	$I_L = -5mA$		-4.92	-4.85	V
$V_{OH}$	Output Swing High	$I_L = 5mA$	4.85	4.92		V
$I_{SC}$	Short Circuit Current			$\pm 120$		mA
$I_{OUT}$	Output Current			$\pm 30$		mA
<b>Power Supply Performance</b>						
$PSRR$	Power Supply Rejection Ratio	$V_S$ is moved from $\pm 2.25V$ to $\pm 7.75V$	60	80		dB
$I_S$	Supply Current (Per Amplifier)	No load		660	1000	$\mu A$
<b>Dynamic Performance</b>						
$SR$	Slew Rate <sup>b</sup>	$-4.0V \leq V_{OUT} \leq +4.0V$ , 20% to 80%		10		V/ $\mu s$
$t_S$	Settling to +0.1% ( $A_V = +1$ )	( $A_V = +1$ ), $V_O = 2V$ step		500		ns
$BW$	-3dB Bandwidth	$R_L = 10k\Omega$ , $C_L = 10pF$		12		MHz
$GBWP$	Gain-Bandwidth Product	$R_L = 10k\Omega$ , $C_L = 10pF$ ( $V_{COM}$ amps)		8		MHz
$PM$	Phase Margin	$R_L = 10k\Omega$ , $C_L = 10pF$ ( $V_{COM}$ amps)		50		°
$CS$	Channel Separation	$f = 5MHz$		75		dB

a. Measured over operating temperature range

b. Slew rate is measured on rising and falling edges

**Electrical Specifications**

$V_{S+} = 5V$ ,  $V_{S-} = 0V$ ,  $R_L = 10k\Omega$  and  $C_L = 10pF$  to 2.5V,  $T_A = 25^\circ C$  unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
<b>Input Characteristics</b>						
$V_{OS}$	Input Offset Voltage	$V_{CM} = 2.5V$		2	10	mV
$TCV_{OS}$	Average Offset Voltage Drift	<sup>a</sup>		5		$\mu V/^\circ C$
$I_B$	Input Bias Current	$V_{CM} = 2.5V$		2	50	nA
$R_{IN}$	Input Impedance			1		$G\Omega$
$C_{IN}$	Input Capacitance			1.35		pF
$CMIR$	Common-Mode Input Range		-0.5		+5.5	V
$CMRR$	Common-Mode Rejection Ratio	for $V_{IN}$ from -0.5V to +5.5V	45	66		dB
$A_{VOL}$	Open-Loop Gain	$0.5V \leq V_{OUT} \leq +4.5V$	75	95		dB
$A_V$	Voltage Gain	$0.5V \leq V_{OUT} \leq +4.5V$	0.995		1.005	V/V
<b>Output Characteristics</b>						
$V_{OL}$	Output Swing Low	$I_L = -5mA$		80	150	mV
$V_{OH}$	Output Swing High	$I_L = +5mA$	4.85	4.92		V
$I_{SC}$	Short Circuit Current			$\pm 120$		mA
$I_{OUT}$	Output Current			$\pm 30$		mA
<b>Power Supply Performance</b>						
PSRR	Power Supply Rejection Ratio	$V_S$ is moved from 4.5V to 15.5V	60	80		dB
$I_S$	Supply Current (Per Amplifier)	No load		660	1000	$\mu A$
<b>Dynamic Performance</b>						
SR	Slew Rate <sup>b</sup>	$1V \leq V_{OUT} \leq 4V$ , 20% to 80%		10		V/ $\mu s$
$t_S$	Settling to +0.1% ( $A_V = +1$ )	( $A_V = +1$ ), $V_O = 2V$ step		500		ns
BW	-3dB Bandwidth	$R_L = 10k\Omega$ , $C_L = 10pF$		12		MHz
GBWP	Gain-Bandwidth Product	$R_L = 10k\Omega$ , $C_L = 10pF$		8		MHz
PM	Phase Margin	$R_L = 10k\Omega$ , $C_L = 10pF$		50		°
CS	Channel Separation	$f = 5MHz$		75		dB

*a. Measured over operating temperature range*

*b. Slew rate is measured on rising and falling edges*

**Electrical Specifications**

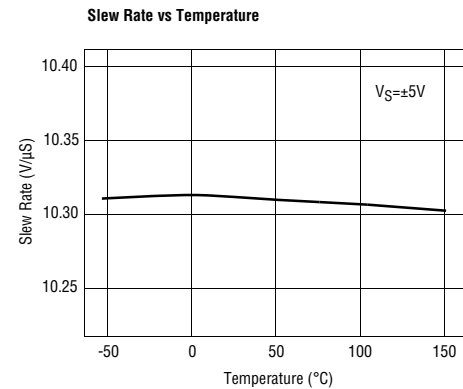
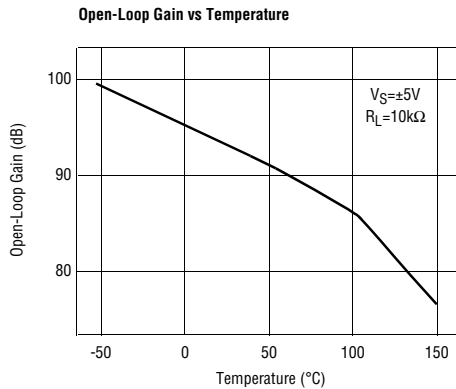
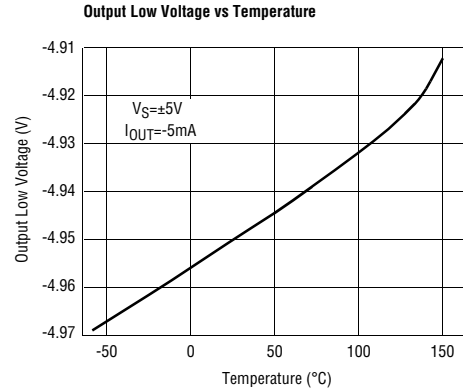
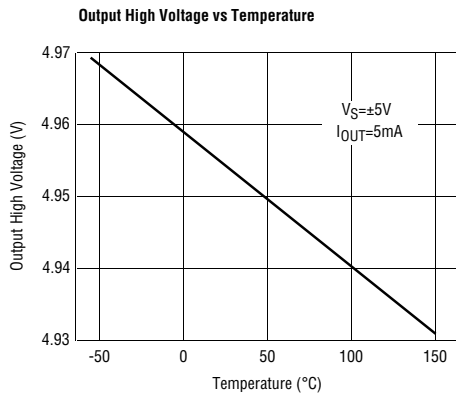
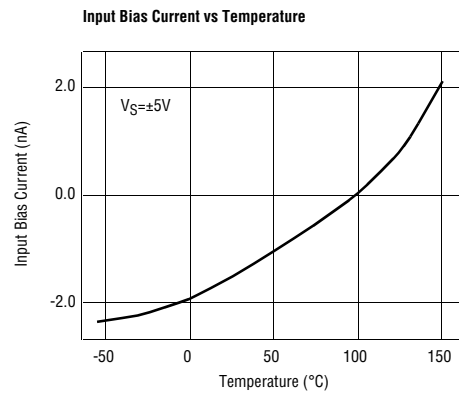
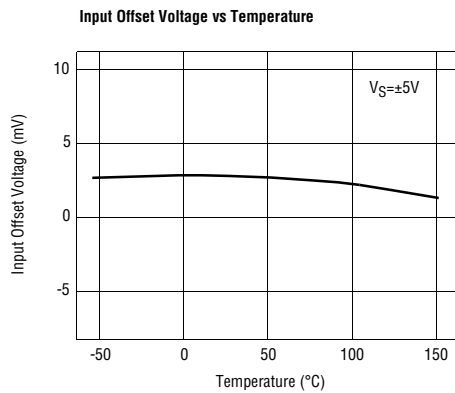
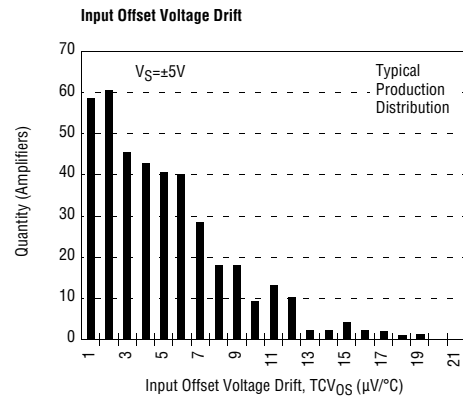
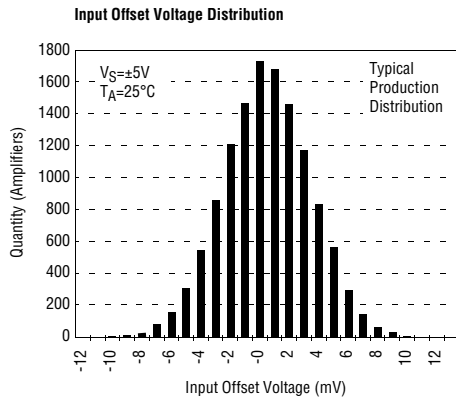
$V_{S+} = 15V$ ,  $V_{S-} = 0V$ ,  $R_L = 10k\Omega$  and  $C_L = 10pF$  to 7.5V,  $T_A = 25^\circ C$  unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
<b>Input Characteristics</b>						
$V_{OS}$	Input Offset Voltage	$V_{CM} = 7.5V$		2	14	mV
$TCV_{OS}$	Average Offset Voltage Drift	<sup>a</sup>		5		$\mu V/^\circ C$
$I_B$	Input Bias Current	$V_{CM} = 7.5V$		2	50	nA
$R_{IN}$	Input Impedance			1		$G\Omega$
$C_{IN}$	Input Capacitance			1.35		pF
$CMIR$	Common-Mode Input Range		-0.5		+15.5	V
$CMRR$	Common-Mode Rejection Ratio	for $V_{IN}$ from -0.5V to +15.5V	53	72		dB
$A_{VOL}$	Open-Loop Gain	$0.5V \leq V_{OUT} \leq 14.5V$	75	95		dB
$A_V$	Voltage Gain	$0.5V \leq V_{OUT} \leq 14.5V$	0.995		1.005	V/V
<b>Output Characteristics</b>						
$V_{OL}$	Output Swing Low	$I_L = -5mA$		80	150	mV
$V_{OH}$	Output Swing High	$I_L = +5mA$	14.85	14.92		V
$I_{SC}$	Short Circuit Current			$\pm 120$		mA
$I_{OUT}$	Output Current			$\pm 30$		mA
<b>Power Supply Performance</b>						
PSRR	Power Supply Rejection Ratio	$V_S$ is moved from 4.5V to 15.5V	60	80		dB
$I_S$	Supply Current (Per Amplifier)	No load		660	1000	$\mu A$
<b>Dynamic Performance</b>						
SR	Slew Rate <sup>b</sup>	$1V \leq V_{OUT} \leq 14V$ , 20% to 80%		10		V/ $\mu s$
$t_S$	Settling to +0.1% ( $A_V = +1$ )	( $A_V = +1$ ), $V_O = 2V$ step		500		ns
BW	-3dB Bandwidth	$R_L = 10k\Omega$ , $C_L = 10pF$		12		MHz
GBWP	Gain-Bandwidth Product	$R_L = 10k\Omega$ , $C_L = 10pF$		8		MHz
PM	Phase Margin	$R_L = 10k\Omega$ , $C_L = 10 pF$		50		°
CS	Channel Separation	$f = 5MHz$		75		dB

*a. Measured over operating temperature range*

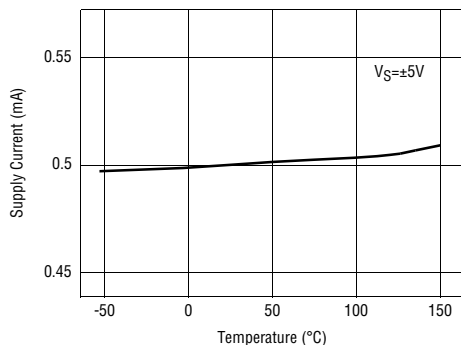
*b. Slew rate is measured on rising and falling edges*

## Typical Performance Curves

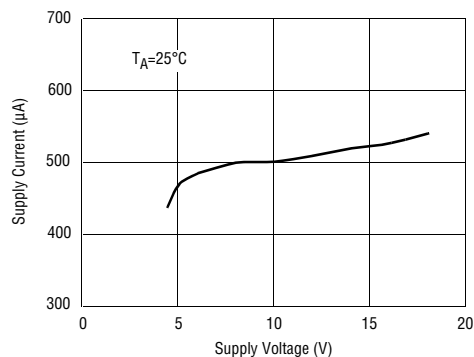


## Typical Performance Curves

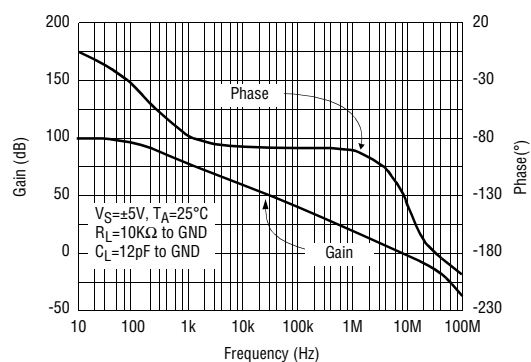
Supply Current per Amplifier vs Temperature



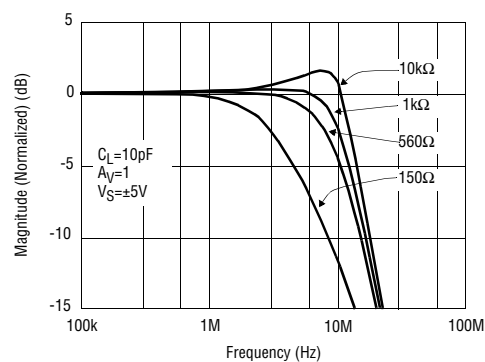
Supply Current per Amplifier vs Supply Voltage



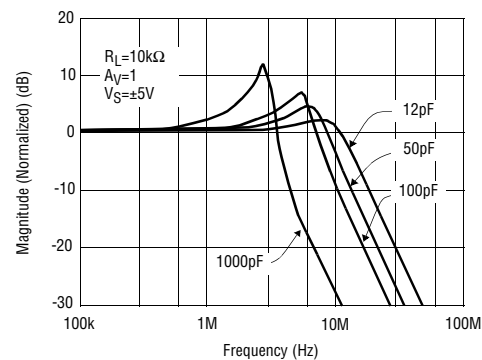
Open Loop Gain and Phase vs Frequency



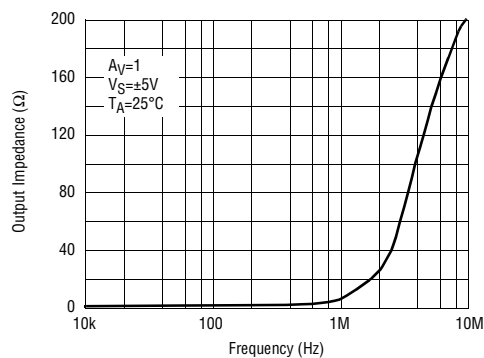
Frequency Response for Various  $R_L$



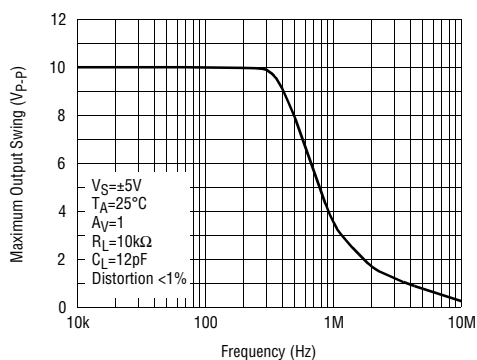
Frequency Response for Various  $C_L$



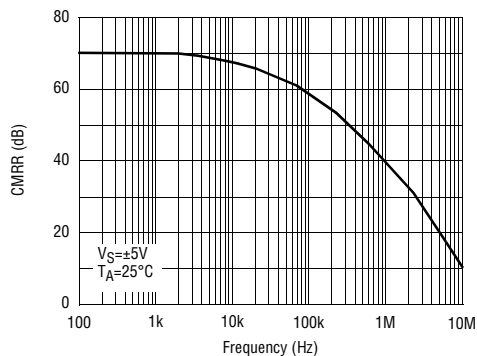
Closed Loop Output Impedance vs Frequency



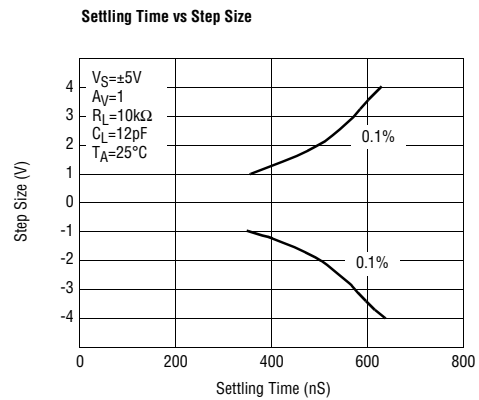
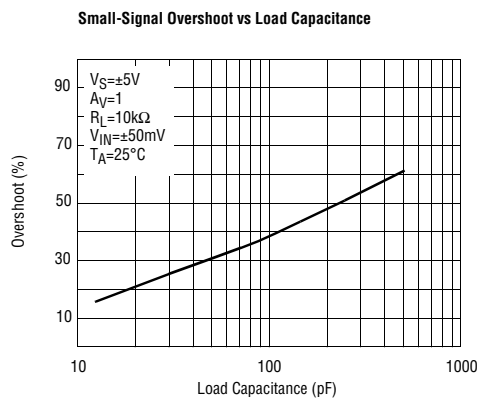
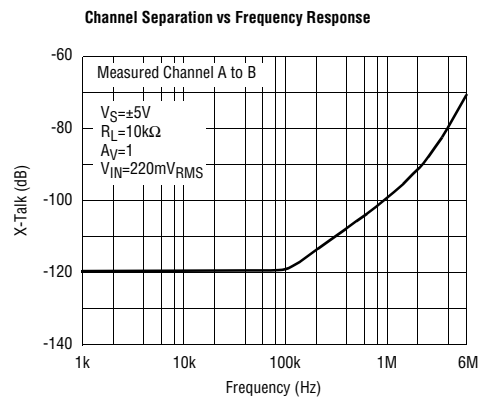
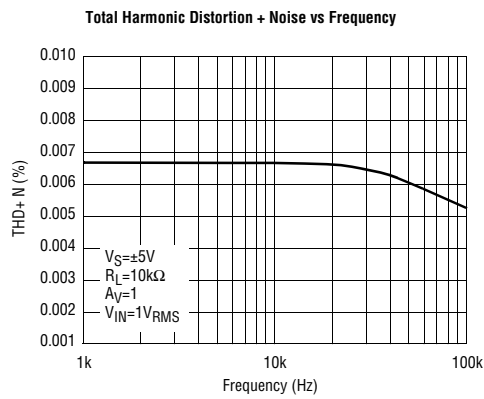
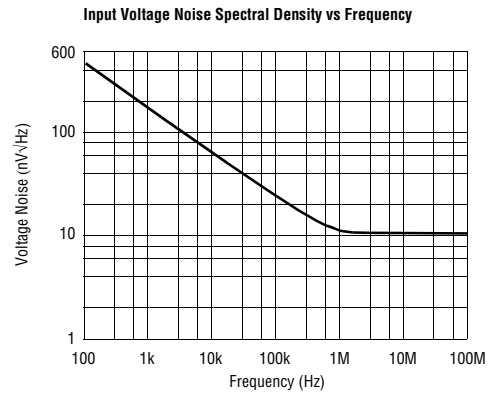
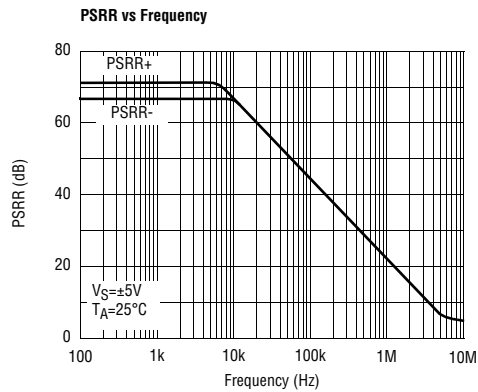
Maximum Output Swing vs Frequency



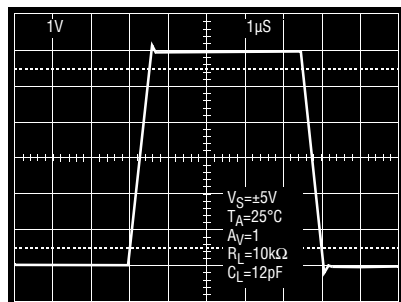
CMRR vs Frequency



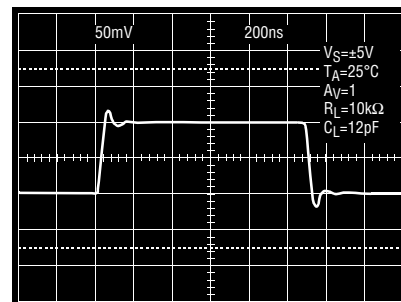
## Typical Performance Curves



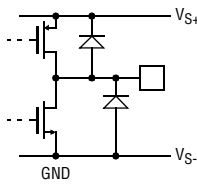
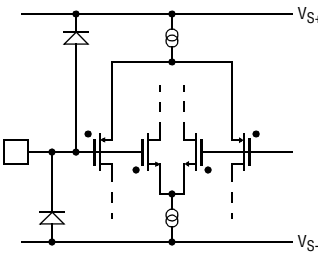
**Large Signal Transient Response**



**Small Signal Transient Response**



**Pin Descriptions**

PIN NUMBER	PIN NAME	PIN FUNCTION	EQUIVALENT CIRCUIT
1	VOUTA	Amplifier A Output	 <p>Circuit 1</p>
2	VINA-	Amplifier A Inverting Input	 <p>Circuit 2</p>
3	VINA+	Amplifier A Non-Inverting Input	(Reference Circuit 2)
4	VS+	Positive Power Supply	
5	VINC	Amplifier C	(Reference Circuit 2)
6	VOUTC	Amplifier C Output	(Reference Circuit 2)
7	VS-	Negative Power Supply	
8	VINB+	Amplifier B Non-Inverting Input	(Reference Circuit 2)
9	VINB-	Amplifier B Inverting Input	(Reference Circuit 2)
10	VOUTB	Amplifier B Output	(Reference Circuit 1)



## Applications Information

### Product Description

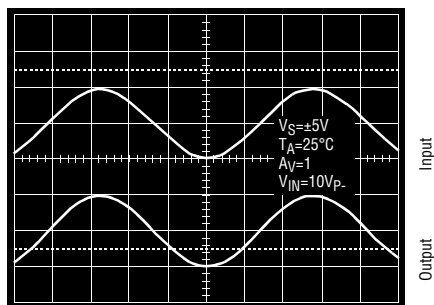
The EL5128 voltage feedback amplifier/buffer combination is fabricated using a high voltage CMOS process. It exhibits rail-to-rail input and output capability, it is unity gain stable, and has low power consumption (500μA per amplifier). These features make the EL5128 ideal for a wide range of general-purpose applications. Connected in voltage follower mode and driving a load of 10kΩ and 12pF, the EL5128 has a -3dB bandwidth of 12MHz while maintaining a 10V/μs slew rate.

### Operating Voltage, Input, and Output

The EL5128 is specified with a single nominal supply voltage from 5V to 15V or a split supply with its total range from 5V to 15V. Correct operation is guaranteed for a supply range of 4.5V to 16.5V. Most EL5128 specifications are stable over both the full supply range and operating temperatures of -40°C to +85°C. Parameter variations with operating voltage and/or temperature are shown in the typical performance curves.

The input common-mode voltage range of the amplifiers extends 500mV beyond the supply rails. The output swings of the EL5128 typically extend to within 80mV of positive and negative supply rails with load currents of 5mA. Decreasing load currents will extend the output voltage range even closer to the supply rails. Figure 1 shows the input and output waveforms for the device in the unity-gain configuration. Operation is from ±5V supply with a 10kΩ load connected to GND. The input is a 10V<sub>P-P</sub> sinusoid. The output voltage is approximately 9.985V<sub>P-P</sub>.

FIGURE 1. Operation with Rail-to-Rail Input and Output



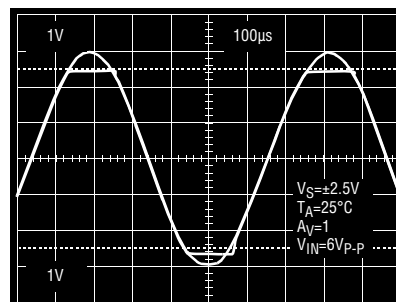
### Short Circuit Current Limit

The EL5128 will limit the short circuit current to ±120mA if the output is directly shorted to the positive or the negative supply. If an output is shorted indefinitely, the power dissipation could easily increase such that the device may be damaged. Maximum reliability is maintained if the output continuous current never exceeds ±30mA. This limit is set by the design of the internal metal interconnects.

### Output Phase Reversal

The EL5128 is immune to phase reversal as long as the input voltage is limited from (V<sub>S-</sub>) -0.5V to (V<sub>S+</sub>) +0.5V. Figure 2 shows a photo of the output of the device with the input voltage driven beyond the supply rails. Although the device's output will not change phase, the input's over-voltage should be avoided. If an input voltage exceeds supply voltage by more than 0.6V, electrostatic protection diodes placed in the input stage of the device begin to conduct and over-voltage damage could occur.

FIGURE 2. Operation with Beyond-the-Rails Input



### Power Dissipation

With the high-output drive capability of the EL5128 amplifier, it is possible to exceed the 125°C “absolute-maximum junction temperature” under certain load current conditions. Therefore, it is important to calculate the maximum junction temperature for the application to determine if load conditions need to be modified for the amplifier to remain in the safe operating area.

The maximum power dissipation allowed in a package is determined according to:

$$P_{DMAX} = \frac{T_{JMAX} - T_{AMAX}}{\theta_{JA}}$$

where:

- $T_{JMAX}$  = Maximum junction temperature
- $T_{AMAX}$  = Maximum ambient temperature
- $\theta_{JA}$  = Thermal resistance of the package
- $P_{DMAX}$  = Maximum power dissipation in the package

The maximum power dissipation actually produced by an IC is the total quiescent supply current times the total power supply voltage, plus the power in the IC due to the loads, or:

$$P_{DMAX} = \sum i \times [V_S \times I_{SMAX} + (V_S - V_{OUTi}) \times I_{LOADi}]$$

when sourcing, and:

$$P_{DMAX} = \sum i \times [V_S \times I_{SMAX} + (V_{OUTi} - V_{S-}) \times I_{LOADi}]$$

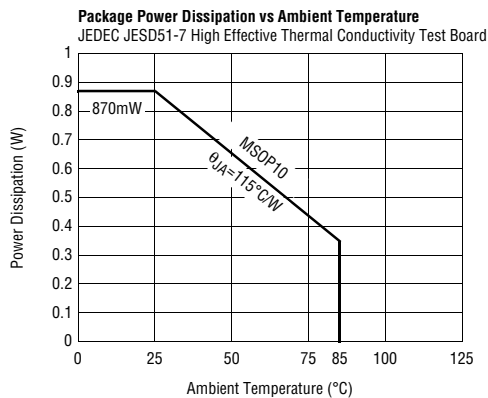
when sinking.

where:

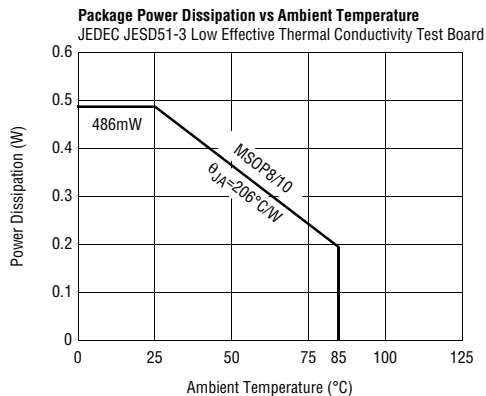
- $V_S$  = Total supply voltage
- $I_{S_{MAX}}$  = Maximum supply current per amplifier
- $V_{OUTi}$  = Maximum output voltage of the application
- $I_{LOADi}$  = Load current

If we set the two  $P_{D_{MAX}}$  equations equal to each other, we can solve for  $R_{LOADi}$  to avoid device overheat. Figures 3 and 4 provide a convenient way to see if the device will overheat. The maximum safe power dissipation can be found graphically, based on the package type and the ambient temperature. By using the previous equation, it is a simple matter to see if  $P_{D_{MAX}}$  exceeds the device's power derating curves. To ensure proper operation, it is important to observe the recommended derating curves in Figures 3 and 4.

**FIGURE 3. Package Power Dissipation vs Ambient Temperature**



**FIGURE 4. Package Power Dissipation vs Ambient Temperature**



### Driving Capacitive Loads

The EL5128 can drive a wide range of capacitive loads. As load capacitance increases, however, the -3dB bandwidth of the device will decrease and the peaking increase. The amplifiers drive 10pF loads in parallel with 10kΩ with just 1.5dB of peaking, and 100pF with 6.4dB of peaking. If less peaking is desired in these applications, a small series resistor (usually between 5Ω and 50Ω) can be placed in series with the output. However, this will obviously reduce the gain slightly. Another method of reducing peaking is to add a “snubber” circuit at the output. A snubber is a shunt load consisting of a resistor in series with a capacitor. Values of 150Ω and 10nF are typical. The advantage of a snubber is that it does not draw any DC load current or reduce the gain

### Power Supply Bypassing and Printed Circuit Board Layout

The EL5128 can provide gain at high frequency. As with any high-frequency device, good printed circuit board layout is necessary for optimum performance. Ground plane construction is highly recommended, lead lengths should be as short as possible and the power supply pins must be well bypassed to reduce the risk of oscillation. For normal single supply operation, where the  $V_{S-}$  pin is connected to ground, a 0.1μF ceramic capacitor should be placed from  $V_{S+}$  to pin to  $V_{S-}$  pin. A 4.7μF tantalum capacitor should then be connected in parallel, placed in the region of the amplifier. One 4.7μF capacitor may be used for multiple devices. This same capacitor combination should be placed at each supply pin to ground if split supplies are to be used.

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