

**élantec**  
HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

## EL5221C

Dual 12MHz Rail-to-Rail Input-Output Buffer

EL5221C

### Features

- 12MHz -3dB bandwidth
- Unity gain buffer
- Supply voltage = 4.5V to 16.5V
- Low supply current (per buffer) = 500 $\mu$ A
- High slew rate = 10V/ $\mu$ s
- Rail-to-rail operation

### Applications

- TFT-LCD drive circuits
- Electronics notebooks
- Electronics games
- Personal communication devices
- Personal Digital Assistants (PDA)
- Portable instrumentation
- Wireless LANs
- Office automation
- Active filters
- ADC/DAC buffer

### Ordering Information

Part No.	Package	Tape & Reel	Outline #
EL5221CW-T7	SOT23-6	7"	MDP0038
EL5221CW-T13	SOT23-6	13"	MDP0038
EL5221CY-T7	MSOP-8	7"	MDP0043
EL5221CY-T13	MSOP-8	13"	MDP0043

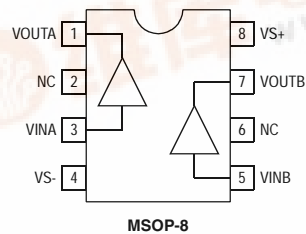
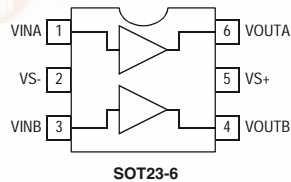
### General Description

The EL5221C is a dual, low power, high voltage rail-to-rail input-output buffer. Operating on supplies ranging from 5V to 15V, while consuming only 500 $\mu$ A per channel, the EL5221C has a bandwidth of 12MHz (-3dB). The EL5221C also provides rail-to-rail input and output ability, giving the maximum dynamic range at any supply voltage.

The EL5221C also features fast slewing and settling times, as well as a high output drive capability of 30mA (sink and source). These features make the EL5221C ideal for use as voltage reference buffers in Thin Film Transistor Liquid Crystal Displays (TFT-LCD). Other applications include battery power, portable devices, and anywhere low power consumption is important.

The EL5221C is available in space-saving SOT23-6 and MSOP-8 packages and operates over a temperature range of -40°C to +85°C.

### Connection Diagrams



Note: All information contained in this data sheet has been carefully checked and is believed to be accurate as of the date of publication; however, this data sheet cannot be a "controlled document". Current revisions, if any, to these specifications are maintained at the factory and are available upon your request. We recommend checking the revision level before finalization of your design documentation.

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November 7, 2000



# EL5221C

## Dual 12MHz Rail-to-Rail Input-Output Buffer

### Absolute Maximum Ratings (T<sub>A</sub> = 25°C)

Values beyond absolute maximum ratings can cause the device to be prematurely damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied

Supply Voltage between V <sub>S+</sub> and V <sub>S-</sub>	+18V
Input Voltage	V <sub>S-</sub> - 0.5V, V <sub>S+</sub> +0.5V
Maximum Continuous Output Current	30mA

Maximum Die Temperature	+125°C
Storage Temperature	-65°C to +150°C
Operating Temperature	-40°C to +85°C
Power Dissipation	See Curves
ESD Voltage	2kV

#### 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<sub>J</sub> = T<sub>C</sub> = T<sub>A</sub>

### Electrical Characteristics

V<sub>S+</sub> = +5V, V<sub>S-</sub> = -5V, R<sub>L</sub> = 10kΩ and C<sub>L</sub> = 10pF to 0V, T<sub>A</sub> = 25°C unless otherwise specified.

Parameter	Description	Condition	Min	Typ	Max	Unit
<b>Input Characteristics</b>						
V <sub>OS</sub>	Input Offset Voltage	V <sub>CM</sub> = 0V		2	12	mV
TCV <sub>OS</sub>	Average Offset Voltage Drift	[1]		5		μV/°C
I <sub>B</sub>	Input Bias Current	V <sub>CM</sub> = 0V		2	50	nA
R <sub>IN</sub>	Input Impedance			1		GΩ
C <sub>IN</sub>	Input Capacitance			1.35		pF
A <sub>V</sub>	Voltage Gain	-4.5V ≤ V <sub>OUT</sub> ≤ 4.5V	0.995		1.005	V/V
<b>Output Characteristics</b>						
V <sub>OL</sub>	Output Swing Low	I <sub>L</sub> = -5mA		-4.92	-4.85	V
V <sub>OH</sub>	Output Swing High	I <sub>L</sub> = 5mA	4.85	4.92		V
I <sub>SC</sub>	Short Circuit Current	Short to GND		±120		mA
<b>Power Supply Performance</b>						
PSRR	Power Supply Rejection Ratio	V <sub>S</sub> is moved from ±2.25V to ±7.75V	60	80		dB
I <sub>S</sub>	Supply Current (Per Buffer)	No Load		500	750	μA
<b>Dynamic Performance</b>						
SR	Slew Rate [2]	-4.0V ≤ V <sub>OUT</sub> ≤ 4.0V, 20% to 80%	7	10		V/μs
t <sub>S</sub>	Settling to +0.1%	V <sub>O</sub> =2V Step		500		ns
BW	-3dB Bandwidth	R <sub>L</sub> = 10kΩ, C <sub>L</sub> = 10pF		12		MHz
CS	Channel Separation	f = 5MHz		75		dB

1. Measured over the operating temperature range
2. Slew rate is measured on rising and falling edges

# EL5221C

## Dual 12MHz Rail-to-Rail Input-Output Buffer

EL5221C

### Electrical Characteristics

$V_{S+} = +5V$ ,  $V_{S-} = 0V$ ,  $R_L = 10k\Omega$  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>[1]</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
$A_V$	Voltage Gain	$0.5 \leq V_{OUT} \leq 4.5V$	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	Short to GND		$\pm 120$		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 Buffer)	No Load		500	750	$\mu A$
<b>Dynamic Performance</b>						
SR	Slew Rate <sup>[2]</sup>	$1V \leq V_{OUT} \leq 4V$ , 20% to 80%	7	10		V/ $\mu s$
$t_S$	Settling to +0.1%	$V_O = 2V$ Step		500		ns
BW	-3dB Bandwidth	$R_L = 10k\Omega$ , $C_L = 10pF$		12		MHz
CS	Channel Separation	$f = 5MHz$		75		dB

1. Measured over the operating temperature range
2. Slew rate is measured on rising and falling edges

# EL5221C

## Dual 12MHz Rail-to-Rail Input-Output Buffer

### Electrical Characteristics

$V_{S+} = +15V$ ,  $V_{S-} = 0V$ ,  $R_L = 10k\Omega$  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	[1]		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
$A_V$	Voltage Gain	$0.5 \leq V_{OUT} \leq 14.5V$	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	Short to GND		$\pm 120$		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 Buffer)	No Load		500	750	$\mu A$
<b>Dynamic Performance</b>						
SR	Slew Rate [2]	$1V \leq V_{OUT} \leq 14V$ , 20% to 80%	7	10		V/ $\mu s$
$t_S$	Settling to +0.1%	$V_O = 2V$ Step		500		ns
BW	-3dB Bandwidth	$R_L = 10k\Omega$ , $C_L = 10pF$		12		MHz
CS	Channel Separation	$f = 5MHz$		75		dB

1. Measured over the operating temperature range
2. Slew rate is measured on rising and falling edges

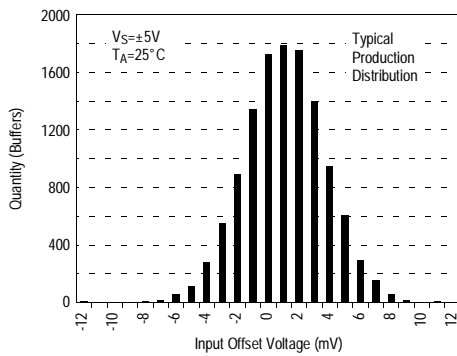
# EL5221C

## Dual 12MHz Rail-to-Rail Input-Output Buffer

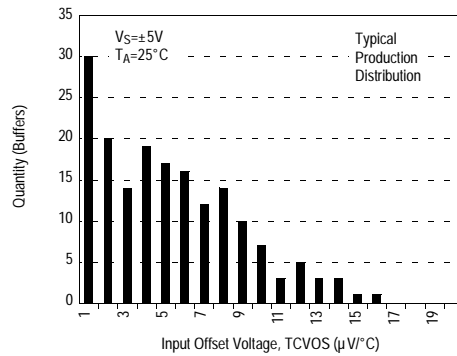
EL5221C

### Typical Performance Curves

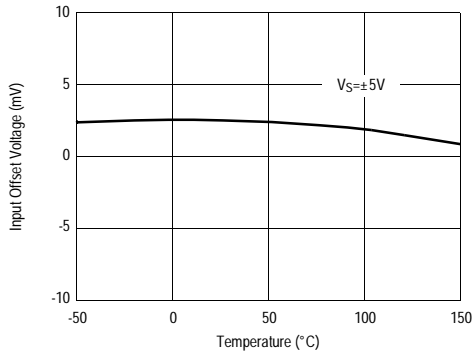
**Input Offset Voltage Distribution**



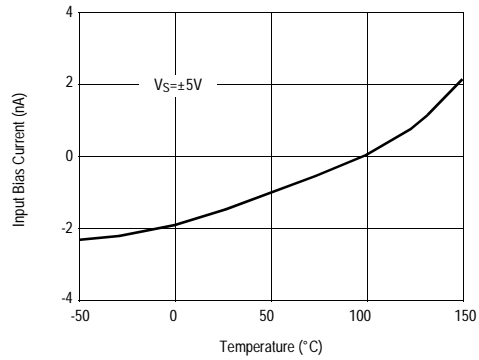
**Input Offset Voltage Drift**



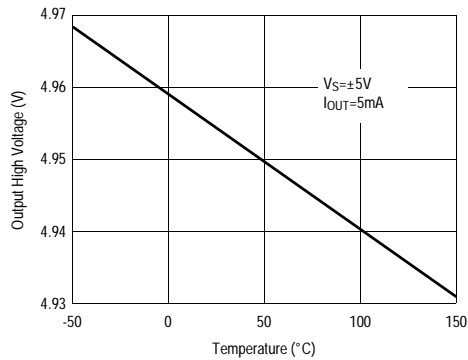
**Input Offset Voltage vs Temperature**



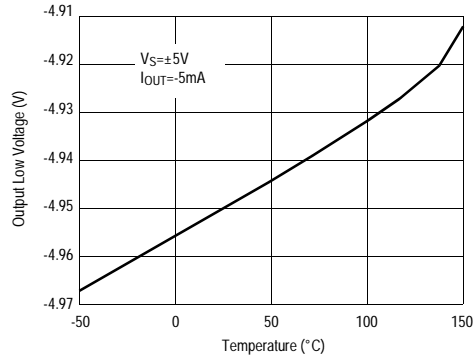
**Input Bias Current vs Temperature**



**Output High Voltage vs Temperature**



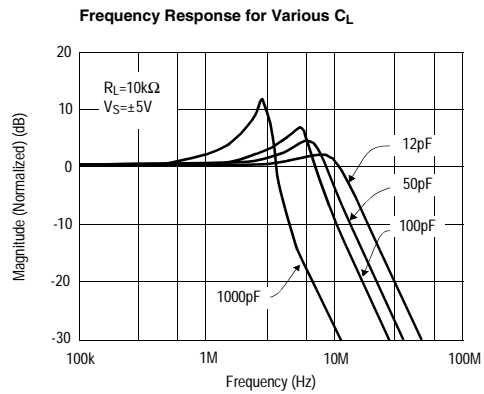
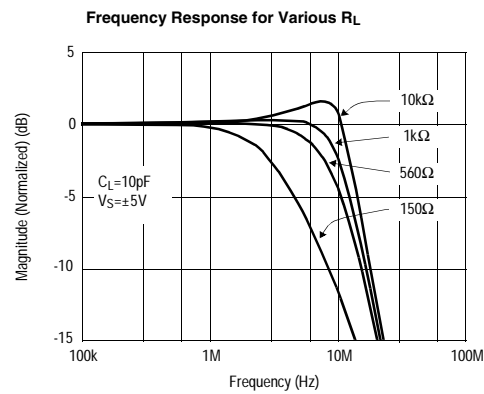
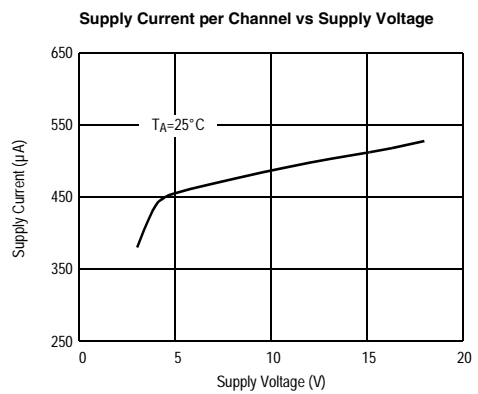
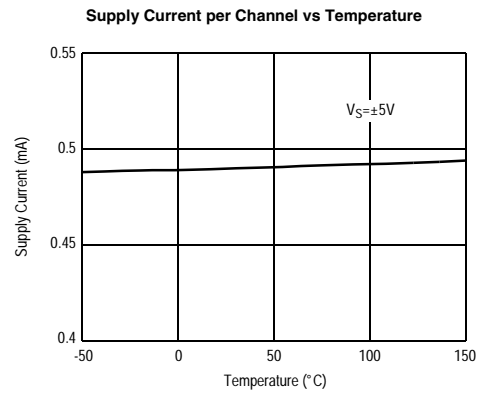
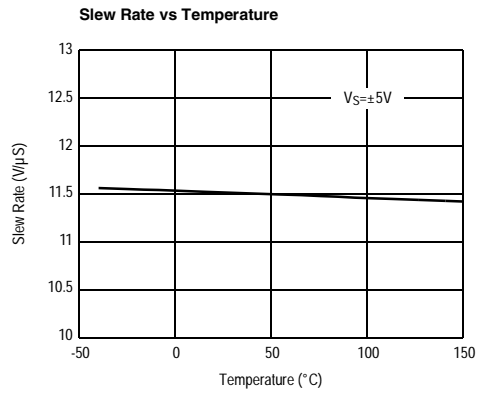
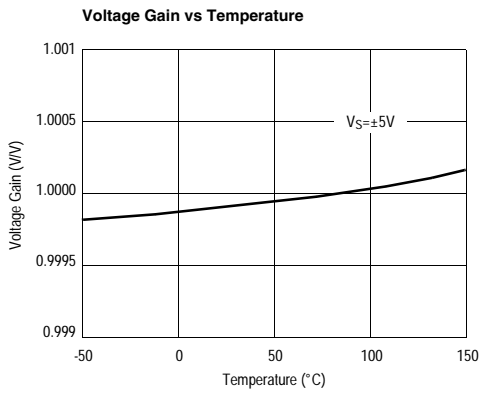
**Output Low Voltage vs Temperature**



# EL5221C

Dual 12MHz Rail-to-Rail Input-Output Buffer

## Typical Performance Curves

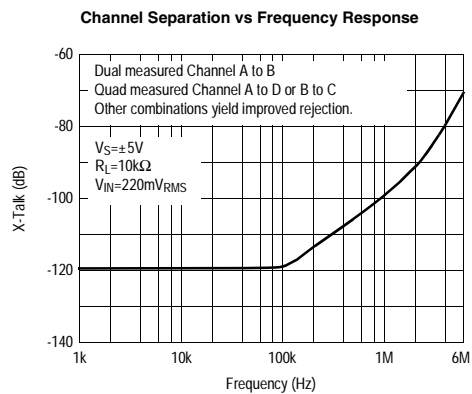
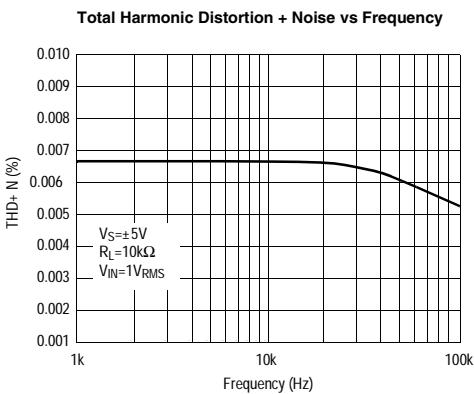
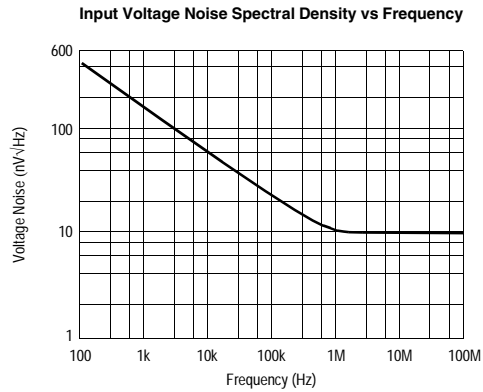
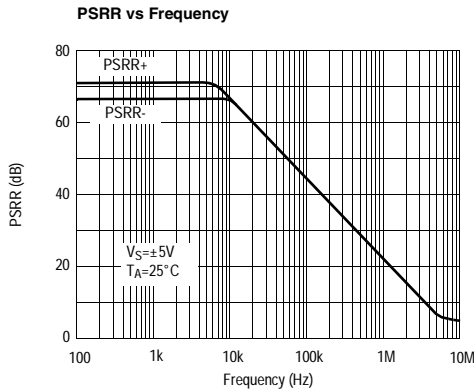
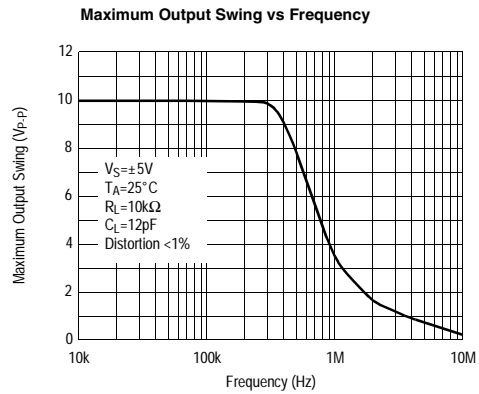
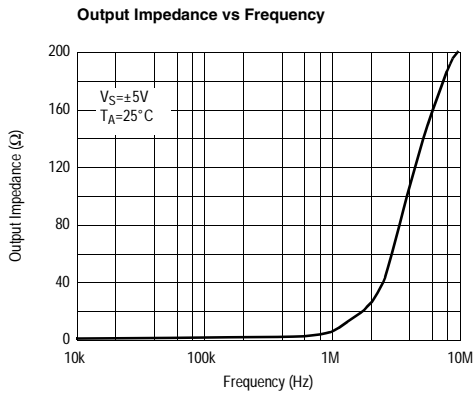


# EL5221C

## Dual 12MHz Rail-to-Rail Input-Output Buffer

EL5221C

### Typical Performance Curves

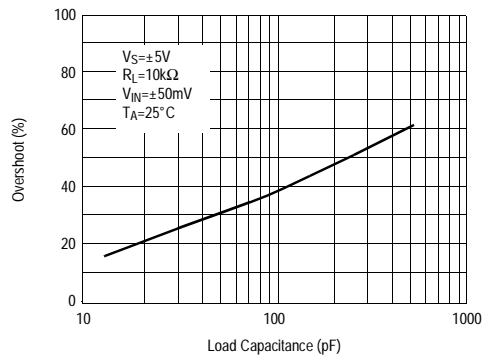


# EL5221C

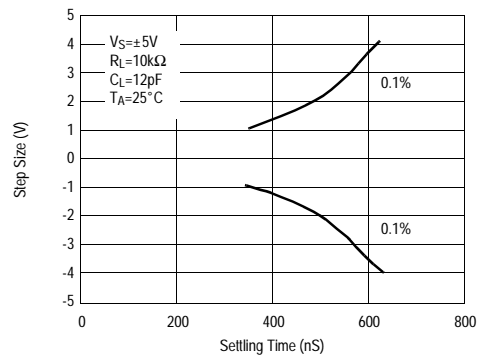
Dual 12MHz Rail-to-Rail Input-Output Buffer

## Typical Performance Curves

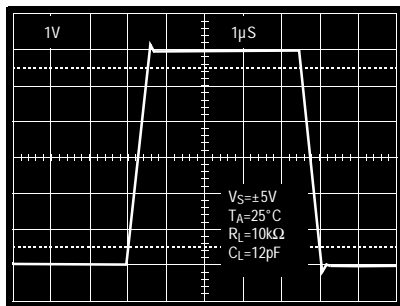
Small-Signal Overshoot vs Load Capacitance



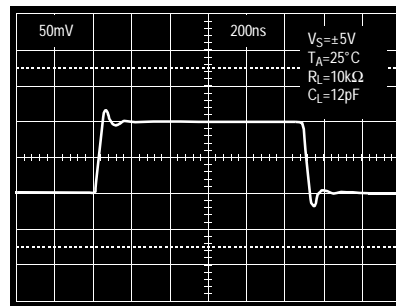
Settling Time vs Step Size



Large Signal Transient Response



Small Signal Transient Response





**EL5221C**  
Dual 12MHz Rail-to-Rail Input-Output Buffer

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**Pin Descriptions**

SOT23-6	MSOP-8	Pin Name	Function	Equivalent Circuit
1	3	V <sub>INA</sub>	Buffer A Input	<p style="text-align: center;"><b>Circuit 1</b></p>
2	4	V <sub>S-</sub>	Negative Supply Voltage	
3	5	V <sub>INB</sub>	Buffer B Input	(Reference Circuit 1)
4	7	V <sub>OUTB</sub>	Buffer B Output	<p style="text-align: center;"><b>Circuit 2</b></p>
5	8	V <sub>S+</sub>	Positive Supply Voltage	
6	1	V <sub>OUTA</sub>	Buffer A Output	(Reference Circuit 2)

# EL5221C

Dual 12MHz Rail-to-Rail Input-Output Buffer

## Applications Information

### Product Description

The EL5221C unity gain buffer is fabricated using a high voltage CMOS process. It exhibits rail-to-rail input and output capability and has low power consumption (500 $\mu$ A per buffer). These features make the EL5221C ideal for a wide range of general-purpose applications. When driving a load of 10k $\Omega$  and 12pF, the EL5221C has a -3dB bandwidth of 12MHz and exhibits 10V/ $\mu$ S slew rate.

### Operating Voltage, Input, and Output

The EL5221C 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 EL5221C specifications are stable over both the full supply range and operating temperatures of -40 $^{\circ}$ C to +85 $^{\circ}$ C. Parameter variations with operating voltage and/or temperature are shown in the typical performance curves.

The output swings of the EL5221C 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. Operation is from  $\pm$ 5V supply with a 10k $\Omega$  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>.

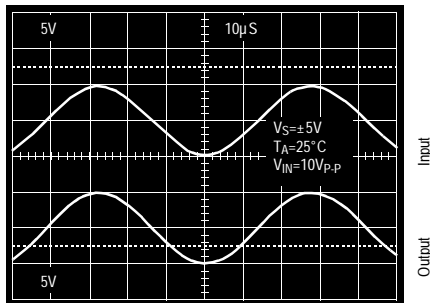


Figure 1. Operation with Rail-to-Rail Input and Output

### Short Circuit Current Limit

The EL5221C will limit the short circuit current to  $\pm$ 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  $\pm$ 30mA. This limit is set by the design of the internal metal interconnects.

### Output Phase Reversal

The EL5221C is immune to phase reversal as long as the input voltage is limited from  $V_{S-} - 0.5V$  to  $V_{S+} + 0.5V$ . 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 overvoltage 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 overvoltage damage could occur.

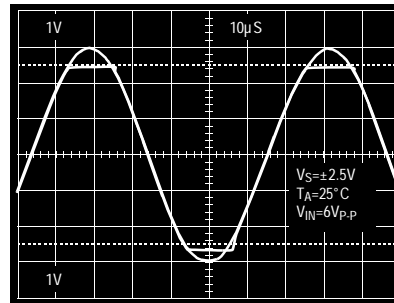


Figure 2. Operation with Beyond-the-Rails Input

### Power Dissipation

With the high-output drive capability of the EL5221C buffer, it is possible to exceed the 125 $^{\circ}$ 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 buffer 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:

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

when sourcing, and

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

when sinking.

where:

$i = 1$  to 2 for Dual Buffer

$V_S$  = Total Supply Voltage

$I_{SMAX}$  = Maximum Supply Current Per Channel

$V_{OUTi}$  = Maximum Output Voltage of the Application

$I_{LOADi}$  = Load Current

If we set the two  $P_{DMAX}$  equations equal to each other, we can solve for  $R_{LOADi}$  to avoid device overheating. Figure 3 and Figure 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  $P_{DMAX}$  exceeds

the device's power derating curves. To ensure proper operation, it is important to observe the recommended derating curves shown in Figure 3 and Figure 4.

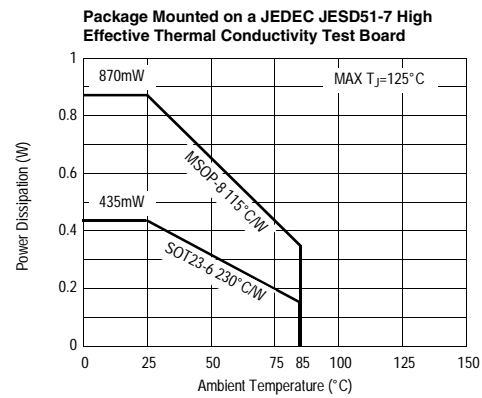


Figure 3. Package Power Dissipation vs Ambient Temperature

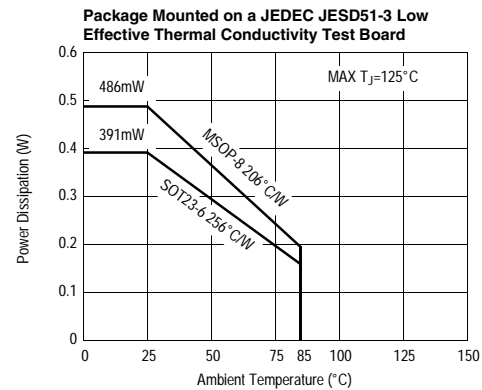


Figure 4. Package Power Dissipation vs Ambient Temperature

### Unused Buffers

It is recommended that any unused buffer have the input tied to the ground plane.

## **EL5221C**

### *Dual 12MHz Rail-to-Rail Input-Output Buffer*

#### **Driving Capacitive Loads**

The EL5221C 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 buffers drive 10pF loads in parallel with 10k $\Omega$  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 5 $\Omega$  and 50 $\Omega$ ) 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 150 $\Omega$  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 EL5221C 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<sub>S-</sub> pin is connected to ground, a 0.1 $\mu$ F ceramic capacitor should be placed from V<sub>S+</sub> to pin to V<sub>S-</sub> pin. A 4.7 $\mu$ F tantalum capacitor should then be connected in parallel, placed in the region of the buffer. One 4.7 $\mu$ F 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.

# EL5221C

Dual 12MHz Rail-to-Rail Input-Output Buffer

## General Disclaimer

Specifications contained in this data sheet are in effect as of the publication date shown. Elantec, Inc. reserves the right to make changes in the circuitry or specifications contained herein at any time without notice. Elantec, Inc. assumes no responsibility for the use of any circuits described herein and makes no representations that they are free from patent infringement.

**élantec**

HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

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