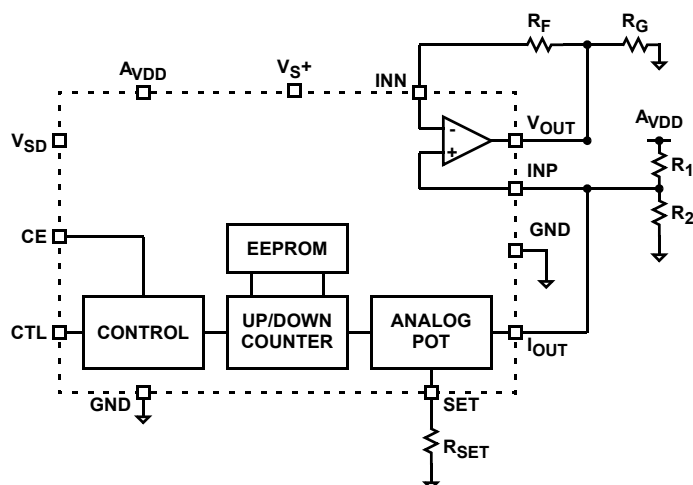


## Programmable $V_{COM}$

The EL9200, EL9201, and EL9202 represent programmable  $V_{COM}$  amplifiers for use in TFT-LCD displays. Featuring 1, 2, and 4 channels of  $V_{COM}$  amplification, respectively, each device features just a single programmable current source for adding offset to one  $V_{COM}$  output. This current source is programmable using a single wire interface to one of 128 levels. The value is stored on an internal EEPROM memory.

The EL9200 is available in the 12-pin DFN package and the EL9201 and EL9202 are available in 24-pin QFN packages. All are specified for operation over the  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range.

## Typical Block Diagram



## Features

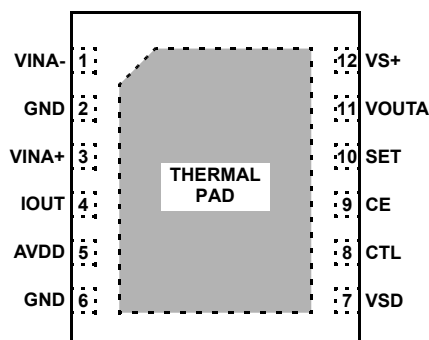
- 128 step adjustable sink current
- EEPROM memory
- 2-pin adjustment and disable
- Single, dual or quad amplifiers
  - 44MHz bandwidth
  - 80V/ $\mu\text{s}$  slew rate
  - 60mA continuous output
  - 180mA peak output
- Up to 18V operation
- 2.6V to 3.6V logic control
- Pb-free available (RoHS compliant)

## Applications

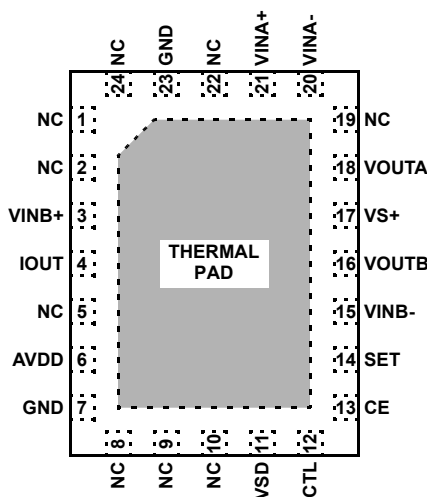
- TFT-LCD  $V_{COM}$  supplies for
  - LCD-TVs
  - LCD monitors

## Pinouts

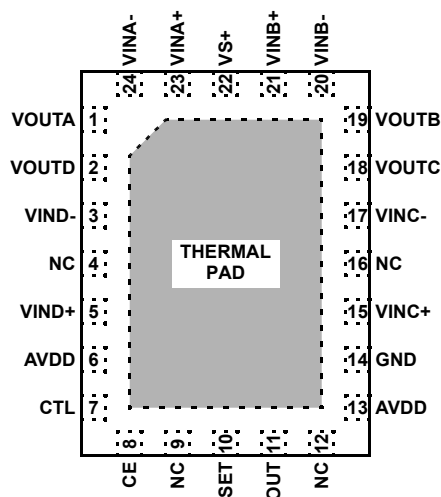
**EL9200**  
(12-PIN DFN)  
TOP VIEW



**EL9201**  
(24-PIN QFN)  
TOP VIEW



**EL9202**  
(24-PIN QFN)  
TOP VIEW



## Ordering Information

PART NUMBER	PACKAGE	TAPE & REEL	PKG. DWG. #
EL9200IL	12-Pin DFN	-	MDP0047
EL9200IL-T7	12-Pin DFN	7"	MDP0047
EL9200IL-T13	12-Pin DFN	13"	MDP0047
EL9200ILZ (See Note)	12-Pin DFN (Pb-Free)	-	MDP0047
EL9200ILZ-T7 (See Note)	12-Pin DFN (Pb-Free)	7"	MDP0047
EL9200ILZ-T13 (See Note)	12-Pin DFN (Pb-Free)	13"	MDP0047
EL9201IL	24-Pin QFN	-	MDP0046
EL9201IL-T7	24-Pin QFN	7"	MDP0046
EL9201IL-T13	24-Pin QFN	13"	MDP0046

PART NUMBER	PACKAGE	TAPE & REEL	PKG. DWG. #
EL9201ILZ (See Note)	24-Pin QFN (Pb-Free)	-	MDP0046
EL9201ILZ-T7 (See Note)	24-Pin QFN (Pb-Free)	7"	MDP0046
EL9201ILZ-T13 (See Note)	24-Pin QFN (Pb-Free)	13"	MDP0046
EL9202IL	24-Pin QFN	-	MDP0046
EL9202IL-T7	24-Pin QFN	7"	MDP0046
EL9202IL-T13	24-Pin QFN	13"	MDP0046
EL9202ILZ (See Note)	24-Pin QFN (Pb-Free)	-	MDP0046
EL9202ILZ-T7 (See Note)	24-Pin QFN (Pb-Free)	7"	MDP0046
EL9202ILZ-T13 (See Note)	24-Pin QFN (Pb-Free)	13"	MDP0046

NOTE: Intersil Pb-free products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.

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

$V_{S+}$  Supply Voltage between  $V_{S+}$  and GND .....18V  
 Supply Voltage between  $V_{SD}$  and GND .....4V  
 Maximum Continuous Output Current ..... 65mA  
 Input Voltages to GND  
     SET, CE .....-0.3V to +4V  
     CTL .....-0.3V to +16V  
 Output Voltages to GND  
     OUT .....-0.3V to +20V

$A_{VDD}$  .....-0.3V to +20V  
 ESD Rating - HBM for Device ..... 2kV  
 Ambient Operating Temperature .....-40°C to +85°C  
 Maximum Die Temperature ..... +150°C  
 Storage Temperature .....-65°C to +150°C  
 Maximum Lead Temperature (Soldering 10s) ..... +300°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. 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**  $V_{SD} = 3\text{V}$ ,  $V_{S+} = 15\text{V}$ ,  $A_{VDD} = 15\text{V}$ ,  $R_{SET} = 24.9\text{k}\Omega$ , and  $T_A = 25^\circ\text{C}$  unless otherwise specified

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
$V_{S+}$	Supply Voltage		4.5		16.5	V
$I_{S+}$	Quiescent Current	EL9200		3.8	4.8	mA
		EL9201		7.6	9.6	mA
		EL9202		10.5	16	mA
$V_{SD}$	Logic Supply Voltage	For programming	3		3.6	V
		For operation	2.6		3.6	V
$I_{SD}$	Quiescent Logic Current	CE = 3.6V			50	$\mu\text{A}$
		CE = GND			25	$\mu\text{A}$
		Program (charge pump current) (Note 1)			23	mA
		Read (Note 1)			3	mA
$I_{ADD}$	Supply Current	Note 2			25	$\mu\text{A}$
$CTL_{IH}$	CTL High Voltage	$2.6\text{V} < V_{SD} < 3.6\text{V}$	$0.7 \cdot V_{SD}$		$0.8 \cdot V_{SD}$	V
$CTL_{IL}$	CTL Low Voltage	$2.6\text{V} < V_{SD} < 3.6\text{V}$	$0.2 \cdot V_{SD}$		$0.3 \cdot V_{SD}$	V
$CTL_{IHRPW}$	CTL High Rejected Pulse Width		20			$\mu\text{s}$
$CTL_{ILRPW}$	CTL Low Rejected Pulse Width		20			$\mu\text{s}$
$CTL_{IHMPW}$	CTL High Minimum Pulse Width		200			$\mu\text{s}$
$CTL_{ILMPW}$	CTL Low Minimum Pulse Width				200	$\mu\text{s}$
$CTL_{MTC}$	CTL Minimum Time Between Counts			10		$\mu\text{s}$
$ICTL$	CTL Input Current	CTL = GND			10	$\mu\text{A}$
		CTL = $V_{SD}$			10	$\mu\text{A}$
$CTL_{CAP}$	CTL Input Capacitance			10		pF
$CE_{IL}$	CE Input Low Voltage	$2.6\text{V} < V_{SD} < 3.6\text{V}$			0.4	V
$CE_{IH}$	CE Input High Voltage	$2.6\text{V} < V_{SD} < 3.6\text{V}$	1.6			V
$CE_{ST}$	CE Minimum Start Up Time	(Note 1)	1			ms
$CTL_{PROM}$	CTL EEPROM Program Voltage	$2.6\text{V} < V_{SD} < 3.6\text{V}$ (Note 2)	4.9		15.75	V
$CTL_{PT}$	CTL EEPROM Programming Signal Time	$> 4.9\text{V}$	200			$\mu\text{s}$
$P_T$	Programming Time			100		ms
$EE_{WC}$	EE Write Cycles	Guaranteed by design	1000			cycles
$SET_{DN}$	SET Differential Nonlinearity	Monotonic over-temperature		$\pm 1$		LSB

# EL9200, EL9201, EL9202

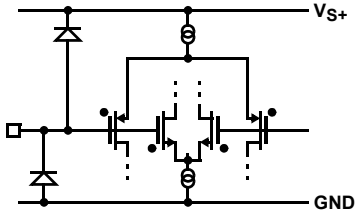
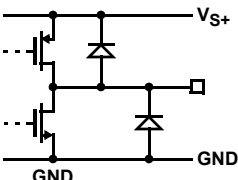
## Electrical Specifications $V_{SD} = 3V$ , $V_{S+} = 15V$ , $A_{VDD} = 15V$ , $R_{SET} = 24.9k\Omega$ , and $T_A = 25^\circ C$ unless otherwise specified

PARAMETER	DESCRIPTION	CONDITION	MIN	TYP	MAX	UNIT
SET <sub>ZSE</sub>	SET Zero-Scale Error	Note 3			±2	LSB
SET <sub>FSE</sub>	SET Full-Scale Error	Note 3			±8	LSB
I <sub>SET</sub>	SET Current	Through R <sub>SET</sub> (Note 1)			120	μA
SET <sub>ER</sub>	SET External Resistance	To GND, A <sub>VDD</sub> = 20V (Note 1)	10		200	kΩ
		To GND, A <sub>VDD</sub> = 4.5V (Note 1)	2.25		45	kΩ
A <sub>VDD</sub> to SET	A <sub>VDD</sub> to SET Voltage Attenuation			1:20		V/V
OUT <sub>ST</sub>	OUT Settling Time	To ±0.5 LSB error band (Note 1)		20		μs
V <sub>OUT</sub>	OUT Voltage Range	(Note 1)	V <sub>SET</sub> + 0.5V		13	V
OUT <sub>VD</sub>	OUT Voltage Drift	(Note 1)			10	mV
<b>AMPLIFIER CHARACTERISTICS</b>						
<b>INPUT CHARACTERISTICS</b>						
V <sub>OS</sub>	Input Offset Voltage	V <sub>CM</sub> = 0V		3	15	mV
TCV <sub>OS</sub>	Average Offset Voltage Drift (Note 1)			7		μV/°C
I <sub>B</sub>	Input Bias Current	V <sub>CM</sub> = 0V		2	60	nA
R <sub>IN</sub>	Input Impedance			1		GΩ
C <sub>IN</sub>	Input Capacitance			2		pF
CMRR	Common-Mode Rejection Ratio	For V <sub>IN</sub> from -5.5V to +5.5V	50	70		dB
A <sub>VOL</sub>	Open-Loop Gain	-4.5V ≤ V <sub>OUT</sub> ≤ +4.5V	60	70		dB
<b>OUTPUT CHARACTERISTICS</b>						
V <sub>OL</sub>	Output Swing Low	R <sub>L</sub> = 1.5kΩ to 0		0.09	0.15	V
V <sub>OH</sub>	Output Swing High		14.85	14.9		V
I <sub>SC</sub>	Short-Circuit Current		±150	±180		mA
I <sub>OUT</sub>	Output Current			±65		mA
<b>POWER SUPPLY PERFORMANCE</b>						
PSRR	Power Supply Rejection Ratio	V <sub>S+</sub> is moved from 4.5V to 15.5V	55	80		dB
<b>DYNAMIC PERFORMANCE</b>						
SR	Slew Rate (Note 4)	-4.0V ≤ V <sub>OUT</sub> ≤ 4.0V, 20% to 80%	60	80		V/μs
t <sub>S</sub>	Settling to +0.1% (A <sub>V</sub> = +1)	(A <sub>V</sub> = +1), V <sub>OUT</sub> = 2V step		80		ns
BW	-3dB Bandwidth			44		MHz
GBWP	Gain-Bandwidth Product			32		MHz
PM	Phase Margin			50		°
CS	Channel Separation	f = 5MHz (EL9201 & EL9202 only)		110		dB
d <sub>G</sub>	Differential Gain (Note 5)	R <sub>F</sub> = R <sub>G</sub> = 1kΩ and V <sub>OUT</sub> = 1.4V		0.17		%
d <sub>p</sub>	Differential Phase (Note 5)	R <sub>F</sub> = R <sub>G</sub> = 1kΩ and V <sub>OUT</sub> = 1.4V		0.24		°

### NOTES:

1. Simulated and determined via design and not directly tested
2. Tested at A<sub>VDD</sub> = 20V
3. Wafer sort only
4. NTSC signal generator used

## Pin Descriptions

PIN	IN/OUT	DESCRIPTION	EQUIVALENT CIRCUIT
VINX-	Input	Amplifier X inverting input, where: X = A for EL9200 X = A, B for EL9201 X = A, B, C, D for EL9202	 <p>CIRCUIT 1</p>
VINX+	Input	Amplifier X non-inverting input, where: X = A for EL9200 X = A, B for EL9201 X = A, B, C, D for EL9202	Reference Circuit 1
VS+	Supply	Op amp supply; bypass to GND with 0.1 $\mu$ F capacitor	
VOUTX	Output	Amplifier X output, where: X = A for EL9200 X = A, B for EL9201 X = A, B, C, D for EL9202	 <p>CIRCUIT 2</p>
NC	-	No connect; not internally connected	
GND	Supply	Ground connection	
IOUT	Output	Adjustable sink current output pin; the current sinks into the OUT pin is equal to the DAC setting times the maximum adjustable sink current divided by 128; see SET pin function description for the maxim adjustable sink current setting	
SET	Output	Maximum sink current adjustment point; connect a resistor from SET to GND to set the maximum adjustable sink current of the OUT pin; the maximum adjustable sink current is equal to $(A_{VDD}/20)$ divided by $R_{SET}$	
CE	Input	Counter enable pin; connect CE to $V_{DD}$ to enable counting of the internal counter; connect CE to GND to inhibit counting	
CTL	Input	Internal counter up/down control and internal EEPROM programming control input; if CE is high, a mid-to-low transition increments the 7-bit counter, raising the DAC setting, increasing the OUT sink current, and lowering the divider voltage at OUT; a mid-to-high transition decrements the 7-bit counter, lowering the DAC setting, decreasing the OUT sink current, and increasing the divider voltage at OUT; applying 4.9V and above with appropriately arranged timing will overwrite EEPROM with the contents in the 7-bit counter; see EEPROM Programming section for details	
AVDD	Supply	analog voltage supply; bypass to GND with 0.1 $\mu$ F capacitor	
VSD	Supply	System power supply input; bypass to GND with 0.1 $\mu$ F capacitor	

## Amplifier Typical Performance Curves

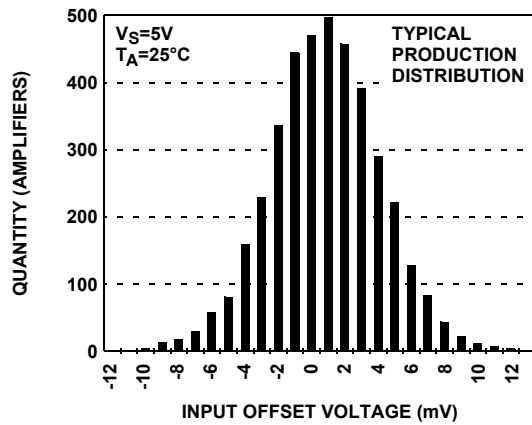


FIGURE 1. INPUT OFFSET VOLTAGE DISTRIBUTION

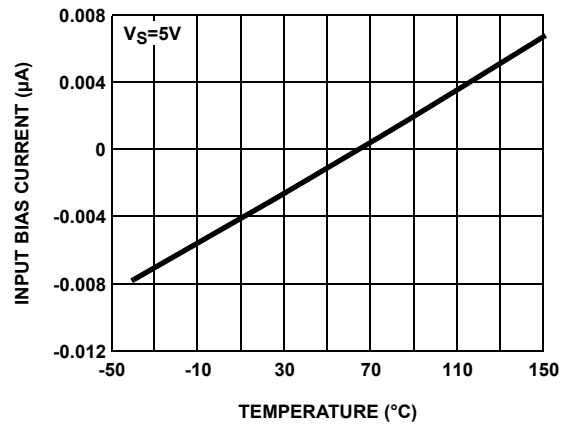


FIGURE 2. INPUT BIAS CURRENT vs TEMPERATURE

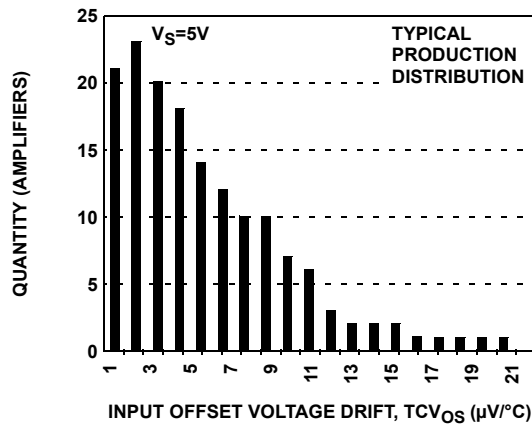


FIGURE 3. INPUT OFFSET VOLTAGE DRIFT

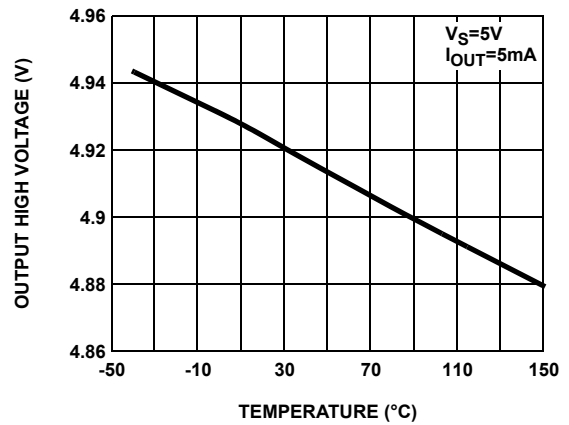


FIGURE 4. OUTPUT HIGH VOLTAGE vs TEMPERATURE

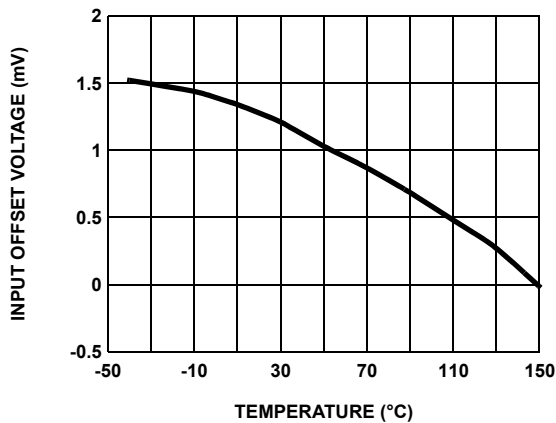


FIGURE 5. INPUT OFFSET VOLTAGE vs TEMPERATURE

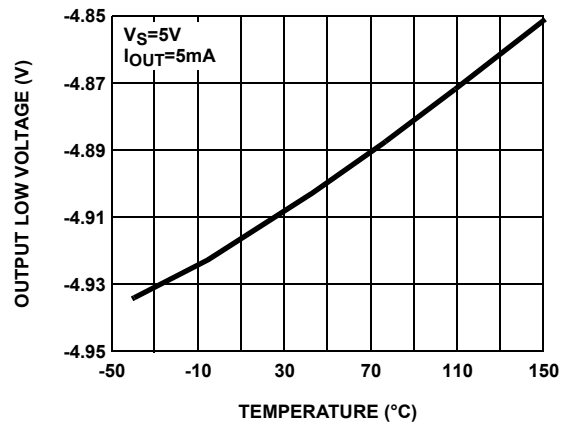


FIGURE 6. OUTPUT LOW VOLTAGE vs TEMPERATURE

## Amplifier Typical Performance Curves

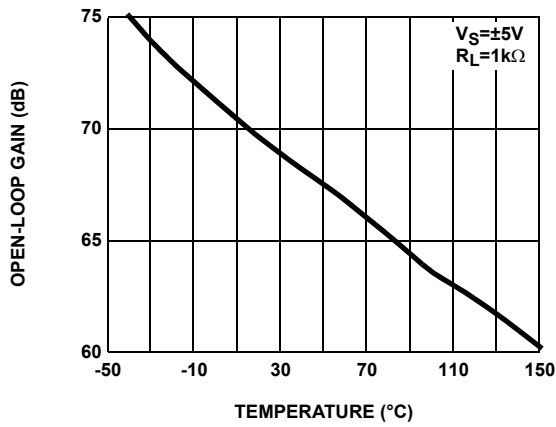


FIGURE 7. OPEN-LOOP GAIN vs TEMPERATURE

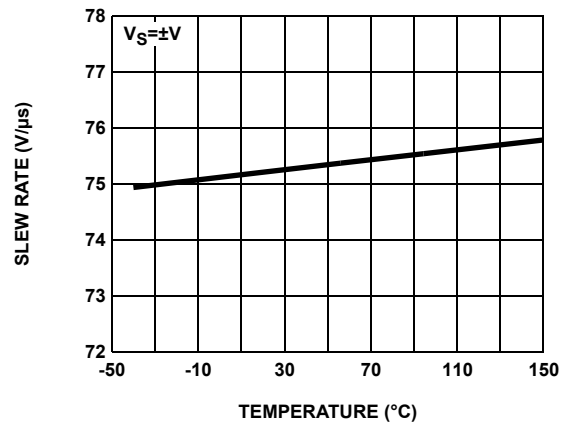


FIGURE 8. SLEW RATE vs TEMPERATURE

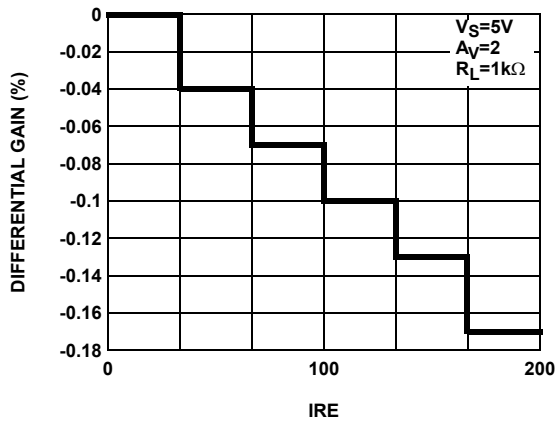


FIGURE 9. DIFFERENTIAL GAIN

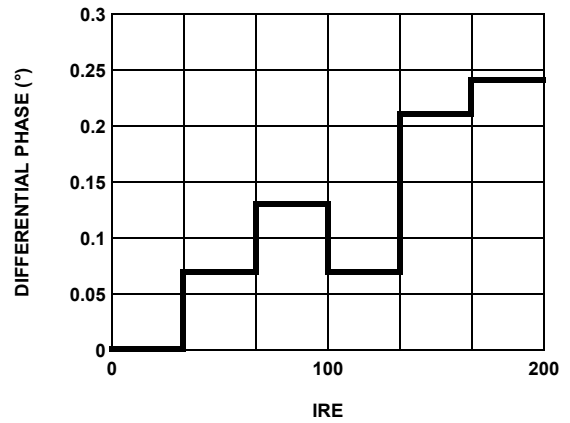


FIGURE 10. DIFFERENTIAL PHASE

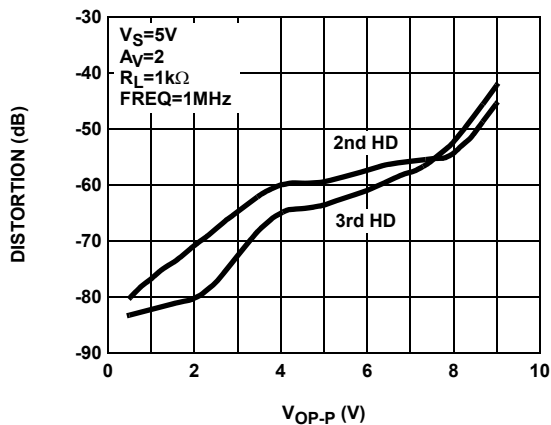


FIGURE 11. HARMONIC DISTORTION vs  $V_{OP-P}$

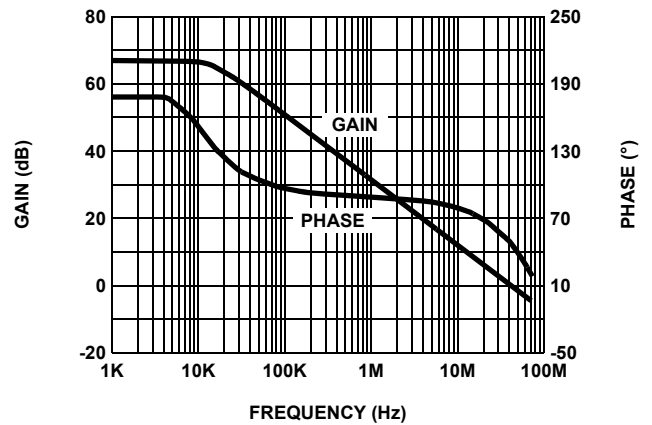


FIGURE 12. OPEN LOOP GAIN AND PHASE

## Amplifier Typical Performance Curves

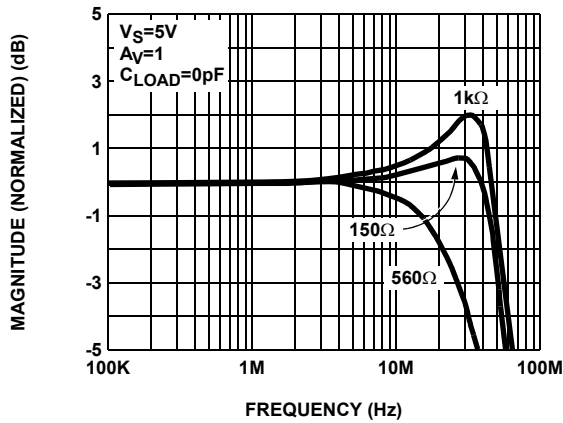


FIGURE 13. FREQUENCY RESPONSE FOR VARIOUS  $R_L$

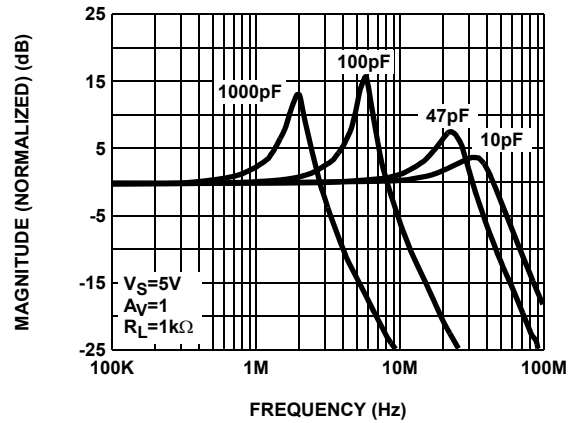


FIGURE 14. FREQUENCY RESPONSE FOR VARIOUS  $C_L$

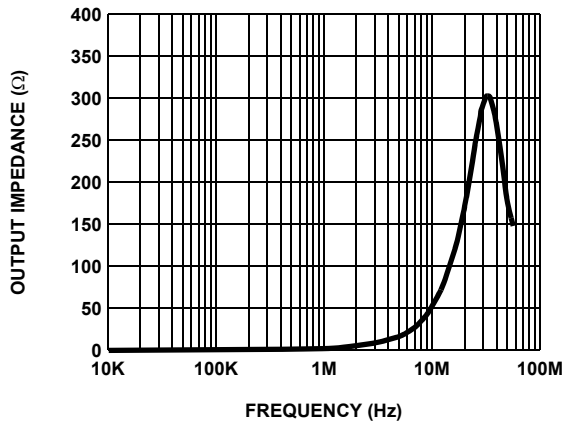


FIGURE 15. CLOSED LOOP OUTPUT IMPEDANCE

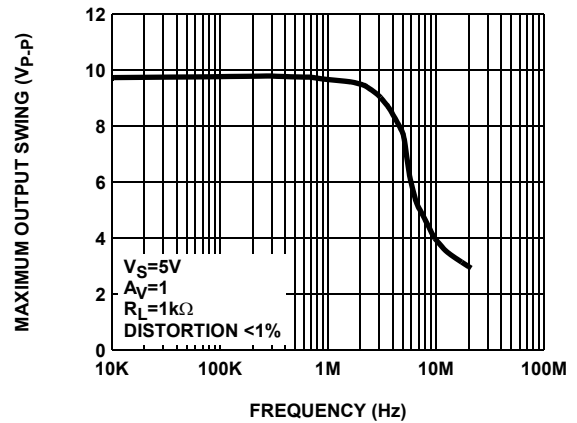


FIGURE 16. MAXIMUM OUTPUT SWING vs FREQUENCY

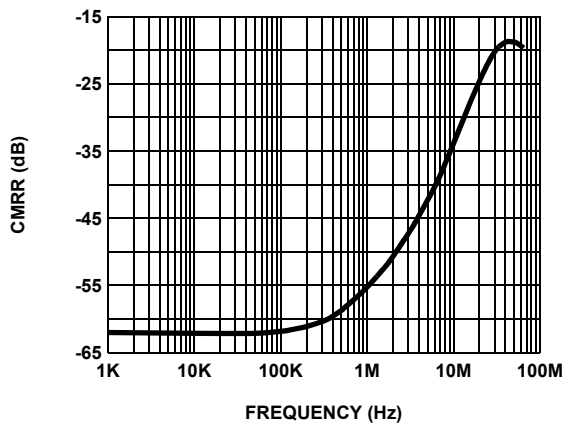


FIGURE 17. CMRR

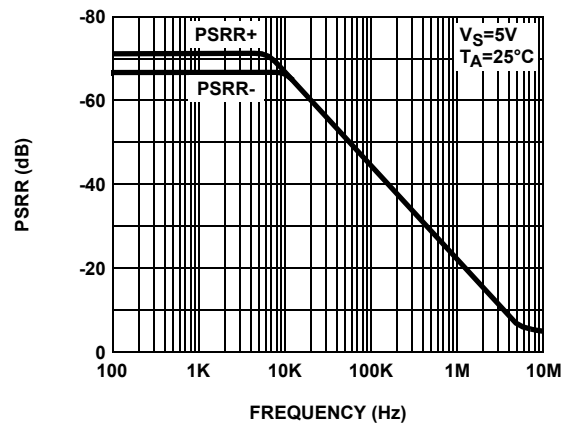


FIGURE 18. PSRR



## Amplifier Typical Performance Curves

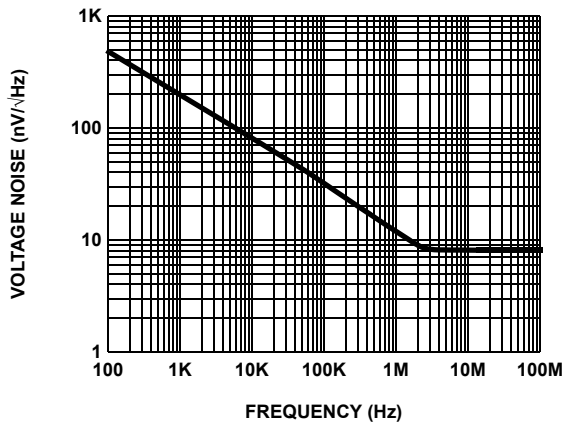


FIGURE 19. INPUT VOLTAGE NOISE SPECTRAL DENSITY

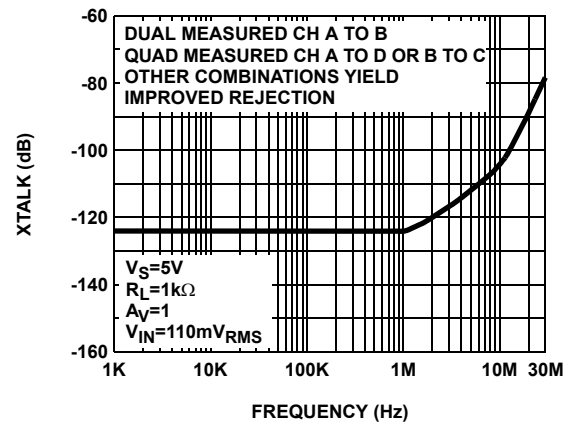


FIGURE 20. CHANNEL SEPARATION

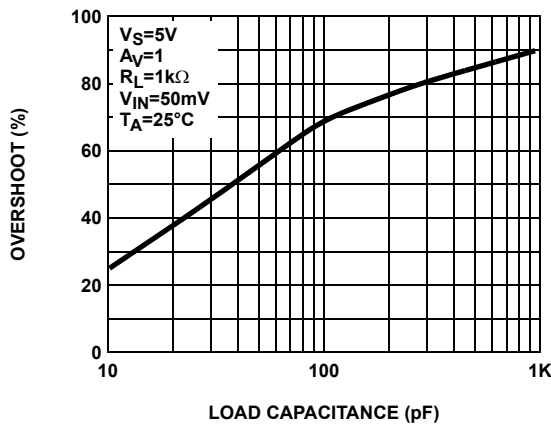


FIGURE 21. SMALL-SIGNAL OVERSHOOT vs LOAD CAPACITANCE

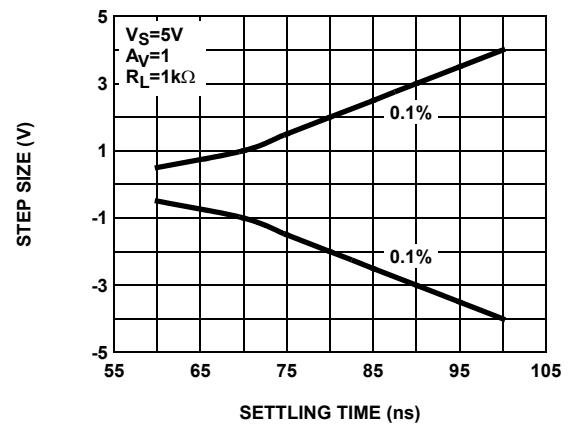


FIGURE 22. SETTLING TIME vs STEP SIZE

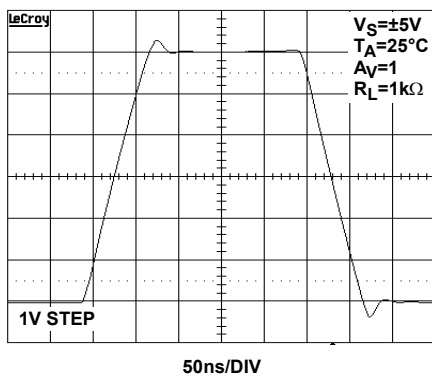


FIGURE 23. LARGE SIGNAL TRANSIENT RESPONSE

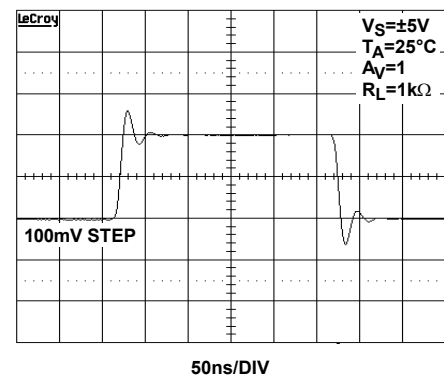


FIGURE 24. SMALL SIGNAL TRANSIENT RESPONSE

## Amplifier Typical Performance Curves

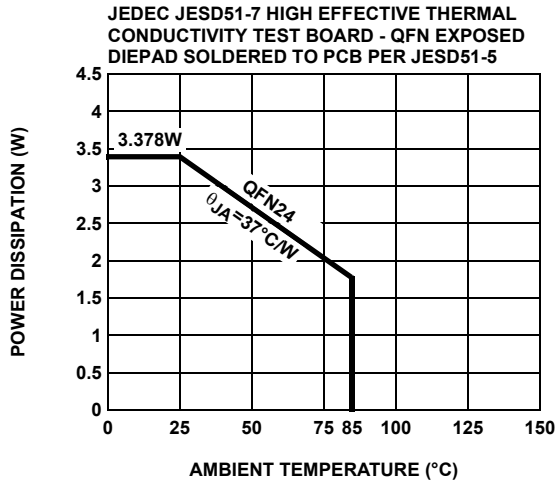


FIGURE 25. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

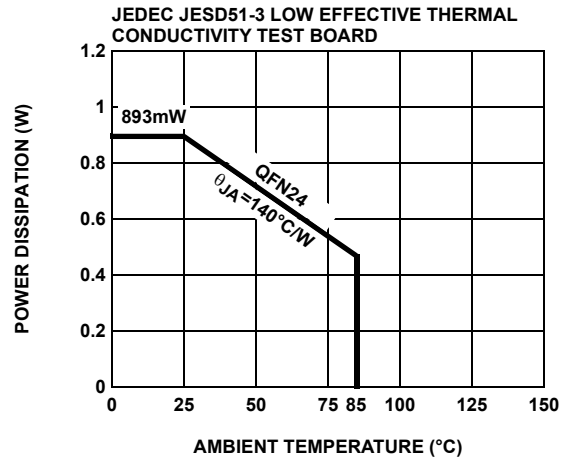


FIGURE 26. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

## Application Information

This device provides the ability to reduce the flicker of an LCD panel by adjustment of the  $V_{COM}$  voltage during production test and alignment. A 128-step resolution is provided under digital control which adjusts the sink current of the output. The output is connected to an external voltage divider, so that the device will have the capability to reduce the voltage on the output by increasing the output sink current.

The adjustment of the output and the programming of the non-volatile memory are provided on one pin while the counter enable (CE) is provided on a separate pin. The output is adjusted via the CTL pin either by counting up with a mid to low transition or by counting down with a mid to high transition. Once the minimum or maximum value is reached on the 128 steps, the device will not overflow or underflow beyond that minimum or maximum value. An increment of the counter will increase the output sink current which will lower the voltage on the external voltage divider. A decrement of the counter will decrease the output sink current, which will raise the voltage on the external voltage divider.

Once the desired output level is obtained, the part can store it's setting using the non-volatile memory in the device. See the non-volatile programming section for detailed information.

NOTE: Once the desired output level is stored in the EEPROM, the CE pin must go low to preserve the stored value.

## Adjustable Sink Current Output

The device provides an output sink current which lowers the voltage on the external voltage divider. The equations that control the output are given below:

$$I_{OUT} = \frac{\text{Setting}}{128} \times \frac{A_{VDD}}{20(R_{SET})}$$

$$V_{OUT} = \left( \frac{R_2}{R_1 + R_2} \right) V_{AVDD} \left( 1 - \frac{\text{Setting}}{128} \times \frac{R_1}{20(R_{SET})} \right)$$

NOTE: Where setting is an integer between 1 and 128.

## 7-Bit Up/Down Counter

The counter sets the level to the digital potentiometer and is connected to the non-volatile memory. When the part is programmed, the counter setting is loaded into the non-volatile memory. This value will be loaded from the non-volatile memory into the counter during power-on. The counter will not exceed its maximum level and will hold that value during subsequent increment requests on the CTL pin. The counter will not exceed its minimum level and will hold that value during subsequent decrement requests on the CTL pin.

## CTL Pin

CTL should have a noise filter to reduce bouncing or noise on the input that could cause unwanted counting when the CE pin is high. The board should have an additional ESD protection circuit, with a series 1kΩ resistor and a shunt 0.01μF capacitor connected on the CTL pin.

In order to increment the setting, pulse CTL low for more than 200μs. The output sink current increases and lowers the  $V_{COM}$  lever by one least-significant bit (LSB). On the other hand, to decrement the setting, pulse CTL high for

more than 200 $\mu$ s. The output sink current will decrease and the  $V_{COM}$  level will increase by one LSB.

To avoid unintentional adjustment, the EL9200, EL9201, and EL9202 guarantees to reject CTL pulses shorter than 20 $\mu$ s.

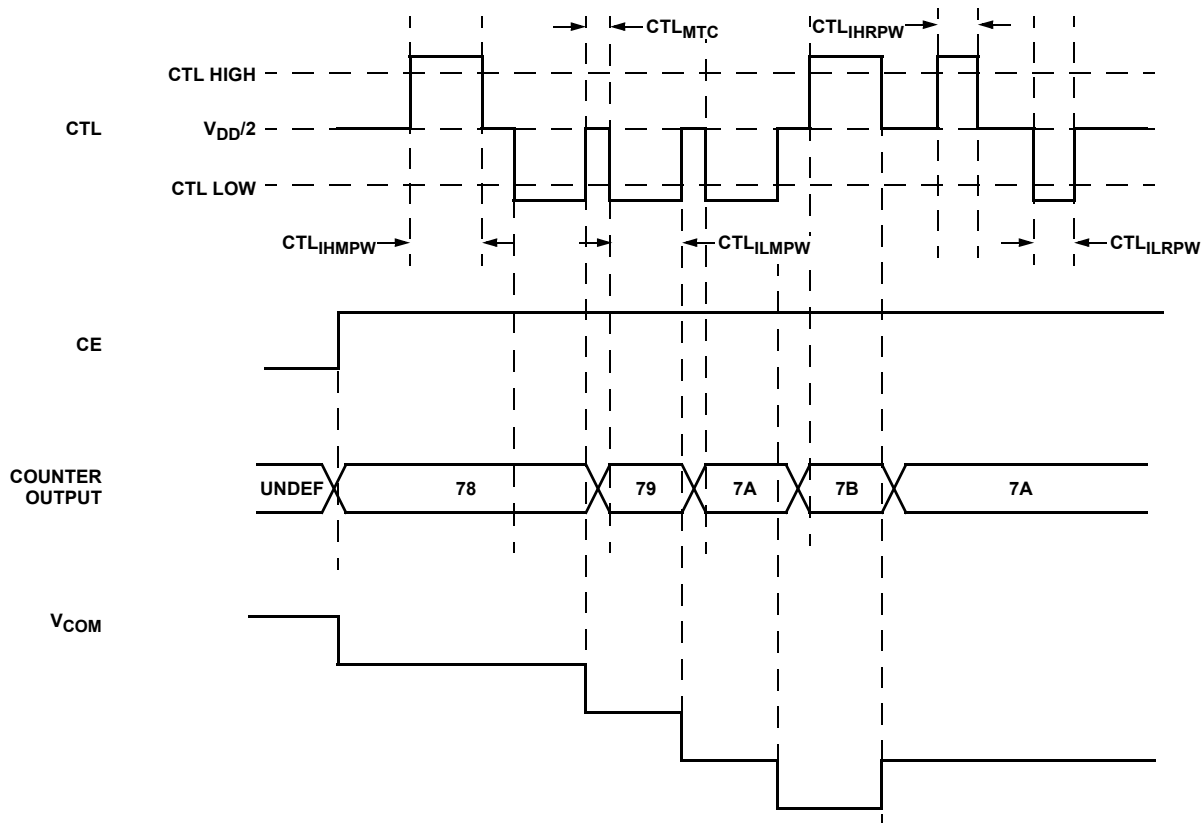
Since the internal comparators come up in an unknown state, the very first CTL pulse is ignored to avoid the possibility of a false pulse.

See Figure 27 for the timing information.

**TABLE 1. TRUTH TABLE**

INPUT			OUTPUT		
CTL	CE	$V_{DD}$	SET	$I_{CC}$	MEMORY
Mid to Hi	Hi	$V_{DD}$	Decrement	Normal	X
Mid to Lo	Hi	$V_{DD}$	Increment	Normal	X
X	Lo	$V_{DD}$	No Change	Lower	X
> 4.9V	X	$V_{DD}$	No Change	Increased	Program
X	X	0 to $V_{DD}$	Read	Increased	Read

NOTE: CE should be disabled (pulled low) before powering down the device to assure that the glitches and transients will not cause unwanted EEPROM overwriting.



**FIGURE 27.  $V_{COM}$  ADJUSTMENT**

## Non-Volatile Memory (EEPROM) Programming

When the CTL pin exceeds 4.9V, the non-volatile programming cycle will be activated. The CTL signal needs to remain above 4.9V for more than 200 $\mu$ s. The level and timing needed to program the non-volatile memory is given below. It then takes a maximum of 100ms for the programming to be completed inside the device (see  $P_T$  specification in Electrical Specification Table).

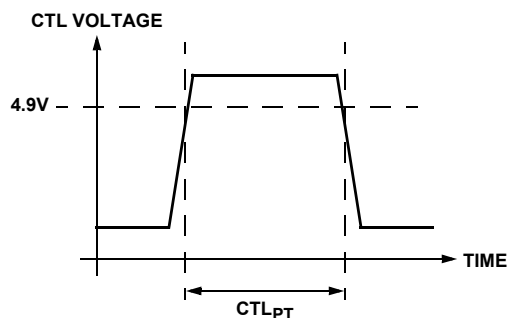


FIGURE 28. EEPROM PROGRAMMING

## Amplifiers' Operating Voltage, Input, and Output

The amplifiers are 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 amplifier specifications are stable over both the full supply range and operating temperatures of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . 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 those typically extend to within 100mV 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 27 shows the input and output waveforms for the device in the unity-gain configuration. Operation is from 5V supply with a 1k $\Omega$  load connected to GND. The input is a 10V<sub>P-P</sub> sinusoid. The output voltage is approximately 9.8V<sub>P-P</sub>.

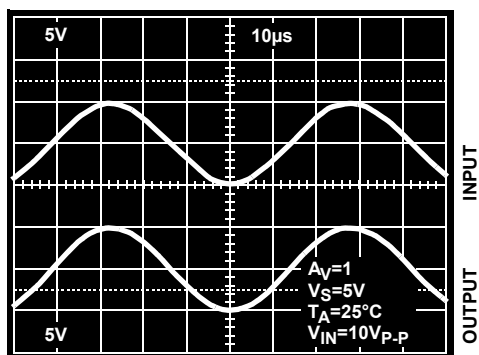


FIGURE 29. OPERATION WITH RAIL-TO-RAIL INPUT AND OUTPUT

## Short-Circuit Current Limit

The amplifiers will limit the short circuit current to  $\pm 180\text{mA}$  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  $\pm 65\text{mA}$ . This limit is set by the design of the internal metal interconnects.

## Output Phase Reversal

The amplifiers are immune to phase reversal as long as the input voltage is limited from  $V_S - 0.5\text{V}$  to  $V_S + 0.5\text{V}$ . Figure 28 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.

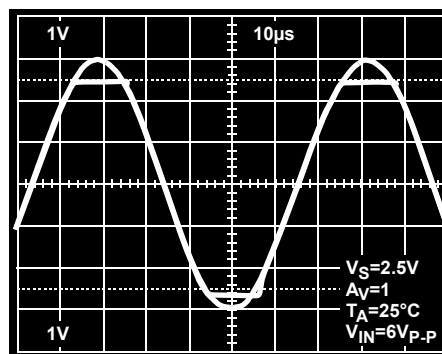


FIGURE 30. OPERATION WITH BEYOND-THE-RAILS INPUT

## Unused Amplifiers

It is recommended that any unused amplifiers in a dual and a quad package be configured as a unity gain follower. The inverting input should be directly connected to the output and the non-inverting input tied to the ground plane.

## Power Supply Bypassing and Printed Circuit Board Layout

The amplifiers 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 operation a 0.1 $\mu\text{F}$  ceramic capacitor should be placed from  $V_S$  to pin to GND. A 4.7 $\mu\text{F}$  tantalum capacitor should then be connected in parallel, placed in the region of the amplifier.

## Replacing Existing Mechanical Potentiometer Circuits

Figures 29 and 30 show the common adjustment mechanical circuits and equivalent replacement with the EL920X.

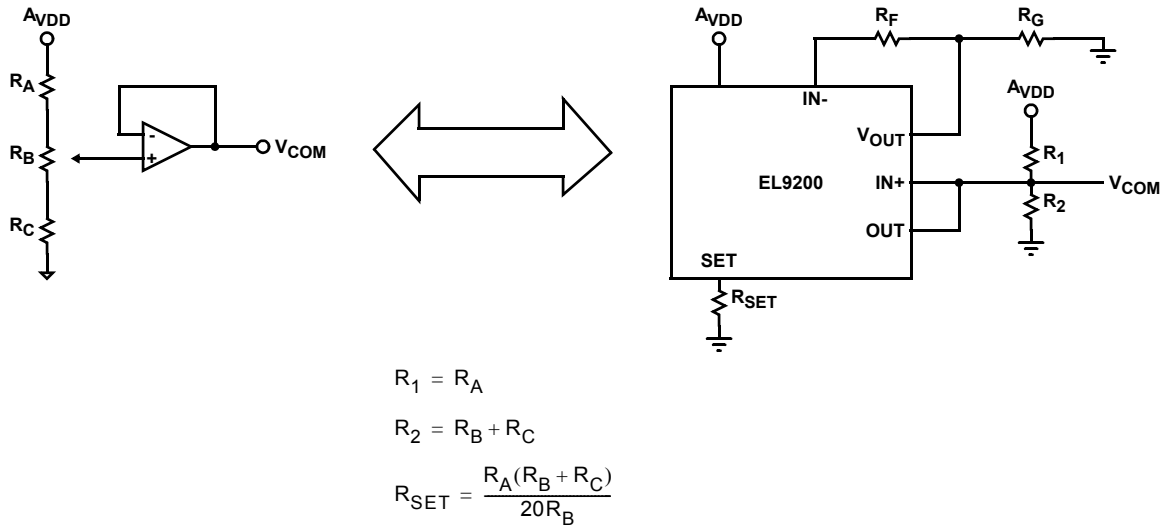


FIGURE 31. EXAMPLE OF THE REPLACEMENT FOR THE MECHANICAL POTENTIOMETER CIRCUIT USING EL9200

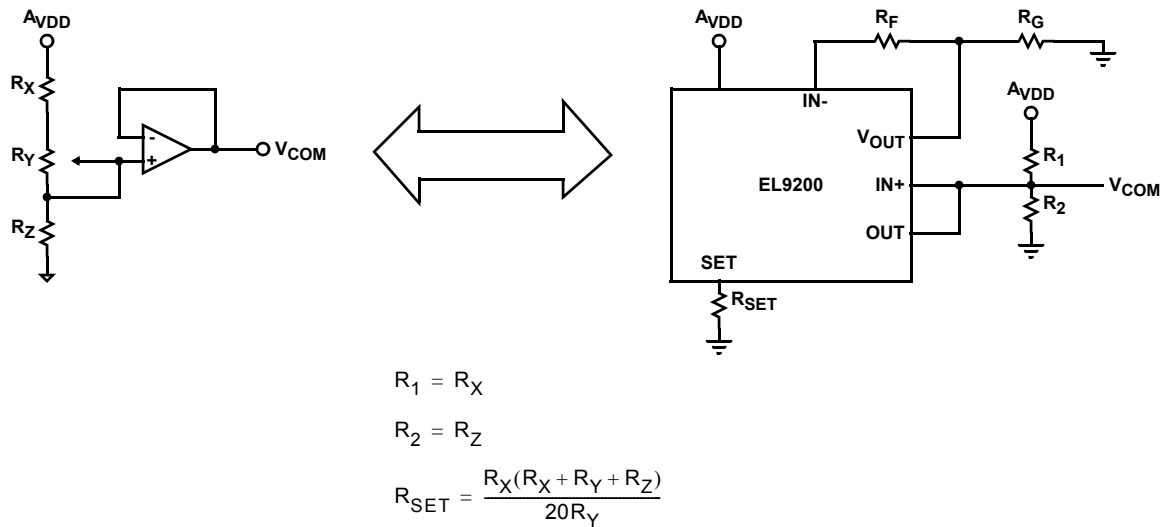
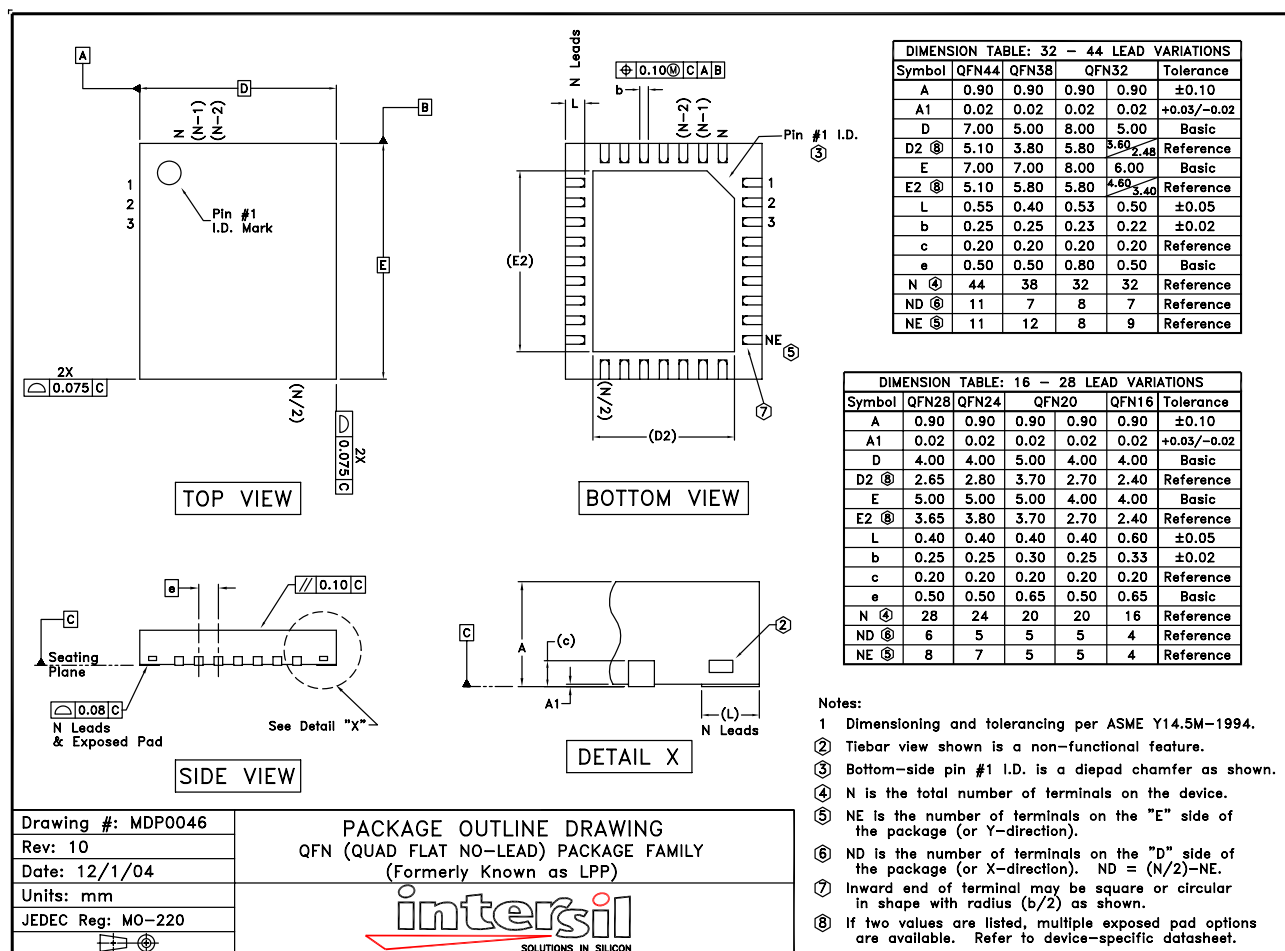


FIGURE 32. EXAMPLE OF THE REPLACEMENT FOR THE MECHANICAL POTENTIOMETER CIRCUIT USING THE EL9200

## QFN Package Outline Drawing



NOTE: The package drawing shown here may not be the latest version. To check the latest revision, please refer to the Intersil website at <http://www.intersil.com/design/packages/index.asp>

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