

## LPC660 Low Power CMOS Quad Operational Amplifier

Check for Samples: [LPC660](#)

### FEATURES

- Rail-to-rail output swing
- Micropower operation: (1 mW)
- Specified for 100 kΩ and 5 kΩ loads
- High voltage gain: 120 dB
- Low input offset voltage: 3 mV
- Low offset voltage drift: 1.3 μV/°C
- Ultra low input bias current: 2 fA
- Input common-mode includes V<sup>-</sup>
- Operation range from +5V to +15V
- Low distortion: 0.01% at 1 kHz
- Slew rate: 0.11 V/μs
- Full military temp. range available

### APPLICATIONS

- High-impedance buffer
- Precision current-to-voltage converter
- Long-term integrator
- High-impedance preamplifier
- Active filter
- Sample-and-Hold circuit
- Peak detector

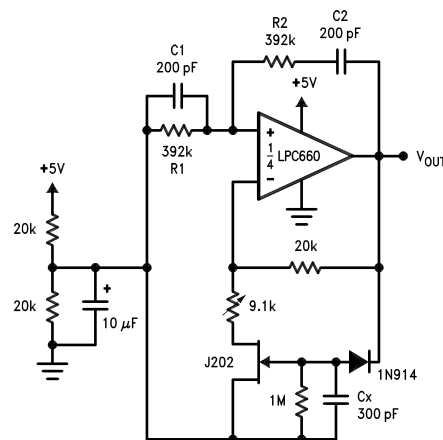
### Application Circuit

### DESCRIPTION

The LPC660 CMOS Quad operational amplifier is ideal for operation from a single supply. It features a wide range of operating voltages from +5V to +15V and features rail-to-rail output swing in addition to an input common-mode range that includes ground. Performance limitations that have plagued CMOS amplifiers in the past are not a problem with this design. Input V<sub>OS</sub>, drift, and broadband noise as well as voltage gain (into 100 kΩ and 5 kΩ) are all equal to or better than widely accepted bipolar equivalents, while the power supply requirement is typically less than 1 mW.

This chip is built with National's advanced Double-Poly Silicon-Gate CMOS process.

See the LPC662 datasheet for a Dual CMOS operational amplifier and LPC661 datasheet for a single CMOS operational amplifier with these same features.



Oscillator frequency is determined by R1, R2, C1, and C2:

$$f_{OSC} = 1/2\pi RC$$

where R = R1 = R2 and C = C1 = C2.

**Figure 1. Sine-Wave Oscillator**



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings <sup>(1)</sup>

Differential Input Voltage	±Supply Voltage
Supply Voltage ( $V^+ - V^-$ )	16V
Output Short Circuit to $V^+$	(2)
Output Short Circuit to $V^-$	(3)
Lead Temperature	
(Soldering, 10 sec.)	260°C
Storage Temp. Range	-65°C to +150°C
Junction Temperature <sup>(4)</sup>	150°C
ESD Rating	
(C = 100 pF, R = 1.5 kΩ)	1000V
Power Dissipation	(4)
Current at Input Pin	±5 mA
Current at Output Pin	±18 mA
Voltage at Input/Output Pin	( $V^+$ ) + 0.3V, ( $V^-$ ) - 0.3V
Current at Power Supply Pin	35 mA

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.
- (2) Do not connect output to  $V^+$  when  $V^+$  is greater than 13V or reliability may be adversely affected.
- (3) Applies to both single supply and split supply operation. Continuous short circuit operation at elevated ambient temperature and/or multiple Op Amp shorts can result in exceeding the maximum allowed junction temperature of 150°C. Output currents in excess of ±30 mA over long term may adversely affect reliability.
- (4) The maximum power dissipation is a function of  $T_{J(max)}$ ,  $\theta_{JA}$  and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(max)} - T_A) / \theta_{JA}$ .

## Operating Ratings <sup>(1)</sup>

Temperature Range	
LPC660AM	-55°C ≤ $T_J$ ≤ +125°C
LPC660AI	-40°C ≤ $T_J$ ≤ +85°C
LPC660I	-40°C ≤ $T_J$ ≤ +85°C
Supply Range	4.75V to 15.5V
Power Dissipation	(2)
Thermal Resistance ( $\theta_{JA}$ ), <sup>(3)</sup>	
14-Pin Ceramic DIP	90°C/W
14-Pin Molded DIP	85°C/W
14-Pin SOIC	115°C/W
14-Pin Side Brazed Ceramic DIP	90°C/W

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed.
- (2) For operating at elevated temperatures, the device must be derated based on the thermal resistance  $\theta_{JA}$  with  $P_D = (T_J - T_A) / \theta_{JA}$ .
- (3) All numbers apply for packages soldered directly into a PC board.

## DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ . **Boldface** limits apply at the temperature extremes.  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = 1.5\text{V}$ ,  $V_O = 2.5\text{V}$ , and  $R_L > 1\text{M}$  unless otherwise specified.

Parameter	Conditions	Typ	LPC660AM	LPC660AI	LPC660I	Units
			LPC660AMJ/883			
			Limit <sup>(1) (2)</sup>	Limit <sup>(1)</sup>	Limit <sup>(1)</sup>	
Input Offset Voltage		1	3	3	6	mV
			<b>3.5</b>	<b>3.3</b>	<b>6.3</b>	max
Input Offset Voltage Average Drift		1.3				$\mu\text{V}/^\circ\text{C}$
Input Bias Current		0.002	20			pA
			<b>100</b>	<b>4</b>	<b>4</b>	max
Input Offset Current		0.001	20			pA
			<b>100</b>	<b>2</b>	<b>2</b>	max
Input Resistance		$>1$				Tera $\Omega$
Common Mode Rejection Ratio	$0\text{V} \leq V_{CM} \leq 12.0\text{V}$ $V^+ = 15\text{V}$	83	70	70	63	dB
			<b>68</b>	<b>68</b>	<b>61</b>	min
Positive Power Supply Rejection Ratio	$5\text{V} \leq V^+ \leq 15\text{V}$	83	70	70	63	dB
			<b>68</b>	<b>68</b>	<b>61</b>	min
Negative Power Supply Rejection Ratio	$0\text{V} \leq V^- \leq -10\text{V}$	94	84	84	74	dB
			<b>82</b>	<b>83</b>	<b>73</b>	min
Input Common Mode Voltage Range	$V^+ = 5\text{V} \text{ \& } 15\text{V}$ For CMRR $> 50\text{ dB}$	-0.4	-0.1	-0.1	-0.1	V
			<b>0</b>	<b>0</b>	<b>0</b>	max
		$V^+ - 1.9$	$V^+ - 2.3$	$V^+ - 2.3$	$V^+ - 2.3$	V
			<b><math>V^+ - 2.6</math></b>	<b><math>V^+ - 2.5</math></b>	<b><math>V^+ - 2.5</math></b>	min
Large Signal	$R_L = 100\text{ k}\Omega$ <sup>(3)</sup>	1000	400	400	300	V/mV
Voltage Gain	Sourcing	500	<b>250</b>	<b>300</b>	<b>200</b>	min
			180	180	90	V/mV
			<b>70</b>	<b>120</b>	<b>70</b>	min
	$R_L = 5\text{ k}\Omega$ <sup>(3)</sup>	1000	200	200	100	V/mV
			<b>150</b>	<b>160</b>	<b>80</b>	min
			100	100	50	V/mV
	Sinking	250	<b>35</b>	<b>60</b>	<b>40</b>	min

(1) Limits are guaranteed by testing or correlation.

(2) A military RETS electrical test specification is available on request. At the time of printing, the LPC660AMJ/883 RETS specification complied fully with the **boldface** limits in this column. The LPC660AMJ/883 may also be procured to a Standard Military Drawing specification.

(3)  $V^+ = 15\text{V}$ ,  $V_{CM} = 7.5\text{V}$  and  $R_L$  connected to  $7.5\text{V}$ . For Sourcing tests,  $7.5\text{V} \leq V_O \leq 11.5\text{V}$ . For Sinking tests,  $2.5\text{V} \leq V_O \leq 7.5\text{V}$ .

## DC Electrical Characteristics (continued)

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ . **Boldface** limits apply at the temperature extremes.  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = 1.5\text{V}$ ,  $V_O = 2.5\text{V}$ , and  $R_L > 1\text{M}$  unless otherwise specified.

Parameter	Conditions	Typ	LPC660AM	LPC660AI	LPC660I	Units
			LPC660AMJ/883			
			Limit <sup>(1)</sup> <sup>(2)</sup>			
Output Swing	$V^+ = 5\text{V}$ $R_L = 100\text{ k}\Omega$ to $V^+/2$	4.987	4.970	4.970	4.940	V
			<b>4.950</b>	<b>4.950</b>	<b>4.910</b>	min
		0.004	0.030	0.030	0.060	V
			<b>0.050</b>	<b>0.050</b>	<b>0.090</b>	max
	$V^+ = 5\text{V}$ $R_L = 5\text{ k}\Omega$ to $V^+/2$	4.940	4.850	4.850	4.750	V
			<b>4.750</b>	<b>4.750</b>	<b>4.650</b>	min
		0.040	0.150	0.150	0.250	V
			<b>0.250</b>	<b>0.250</b>	<b>0.350</b>	max
	$V^+ = 15\text{V}$ $R_L = 100\text{ k}\Omega$ to $V^+/2$	14.970	14.920	14.920	14.880	V
			<b>14.880</b>	<b>14.880</b>	<b>14.820</b>	min
		0.007	0.030	0.030	0.060	V
			<b>0.050</b>	<b>0.050</b>	<b>0.090</b>	max
Output Current $V^+ = 5\text{V}$	Sourcing, $V_O = 0\text{V}$	22	16	16	13	mA
			<b>12</b>	<b>14</b>	<b>11</b>	min
	Sinking, $V_O = 5\text{V}$	21	16	16	13	mA
			<b>12</b>	<b>14</b>	<b>11</b>	min
Output Current $V^+ = 15\text{V}$	Sourcing, $V_O = 0\text{V}$	40	19	28	23	mA
			<b>19</b>	<b>25</b>	<b>20</b>	min
	Sinking, $V_O = 13\text{V}$ <sup>(4)</sup>	39	19	28	23	mA
			<b>19</b>	<b>24</b>	<b>19</b>	min
Supply Current	All Four Amplifiers $V_O = 1.5\text{V}$	160	200	200	240	$\mu\text{A}$
			<b>250</b>	<b>230</b>	<b>270</b>	max

(4) Do not connect output to  $V^+$  when  $V^+$  is greater than 13V or reliability may be adversely affected.

## AC Electrical Characteristics

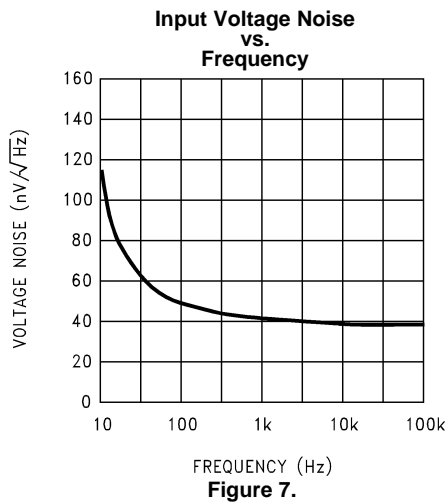
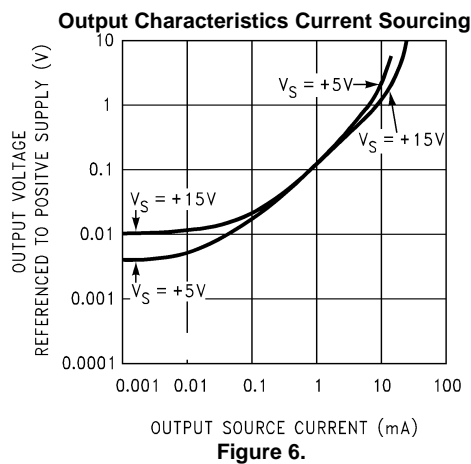
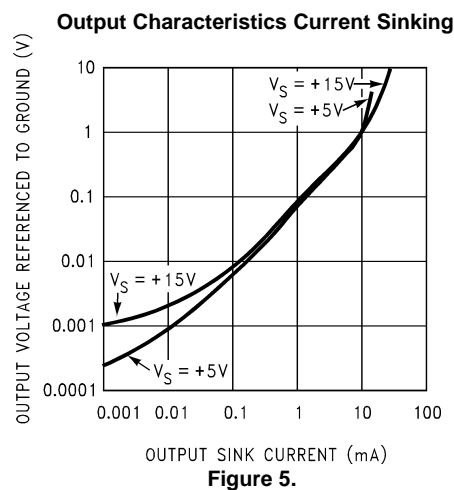
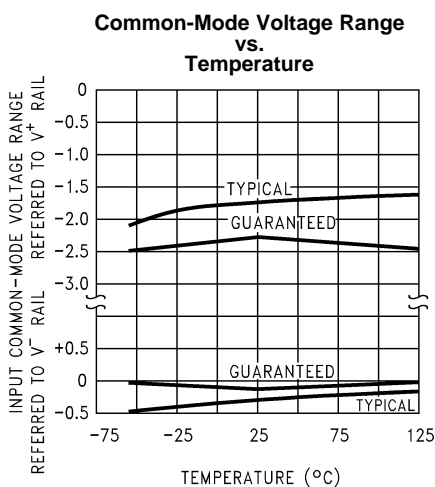
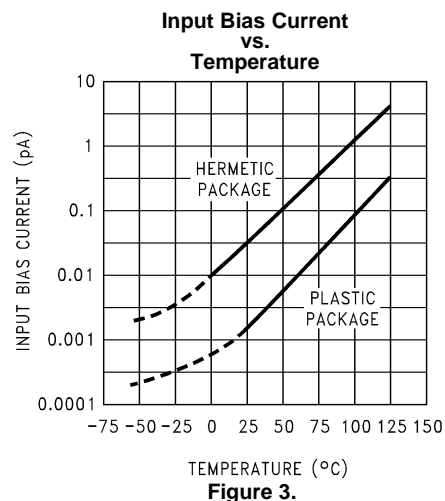
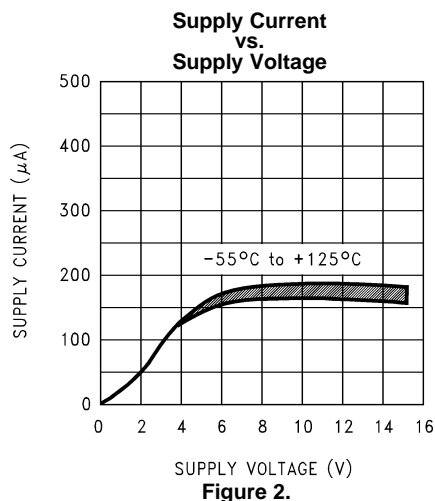
Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ . **Boldface** limits apply at the temperature extremes.  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{CM} = 1.5\text{V}$ ,  $V_O = 2.5$ , and  $R_L > 1\text{M}$  unless otherwise specified.

Parameter	Conditions	Typ	LPC660AM	LPC660AI	LPC660I	Units
			LPC660AMJ/883			
			Limit <sup>(1) (2)</sup>	Limit <sup>(1)</sup>	Limit <sup>(1)</sup>	
Slew Rate	<sup>(3)</sup>	0.11	0.07	0.07	0.05	V/ $\mu\text{s}$ min
			<b>0.04</b>	<b>0.05</b>	<b>0.03</b>	
Gain-Bandwidth Product		0.35				MHz
Phase Margin		50				Deg
Gain Margin		17				dB
Amp-to-Amp Isolation	<sup>(4)</sup>	130				dB
Input Referred Voltage Noise	F = 1 kHz	42				nV/ $\sqrt{\text{Hz}}$
Input Referred Current Noise	F = 1 kHz	0.0002				pA/ $\sqrt{\text{Hz}}$
Total Harmonic Distortion	F = 1 kHz, $A_V = -10$ $R_L = 100\text{ k}\Omega$ , $V_O = 8\text{ V}_{PP}$	0.01				%

- (1) Limits are guaranteed by testing or correlation.
- (2) A military RETS electrical test specification is available on request. At the time of printing, the LPC660AMJ/883 RETS specification complied fully with the **boldface** limits in this column. The LPC660AMJ/883 may also be procured to a Standard Military Drawing specification.
- (3)  $V^+ = 15\text{V}$ . Connected as Voltage Follower with 10V step input. Number specified is the slower of the positive and negative slew rates.
- (4) Input referred.  $V^+ = 15\text{V}$  and  $R_L = 100\text{ k}\Omega$  connected to  $V^+/2$ . Each amp excited in turn with 1 kHz to produce  $V_O = 13\text{ V}_{PP}$ .

## Typical Performance Characteristics

$V_S = \pm 7.5V$ ,  $T_A = 25^\circ C$  unless otherwise specified



## Typical Performance Characteristics (continued)

$V_S = \pm 7.5V$ ,  $T_A = 25^\circ C$  unless otherwise specified

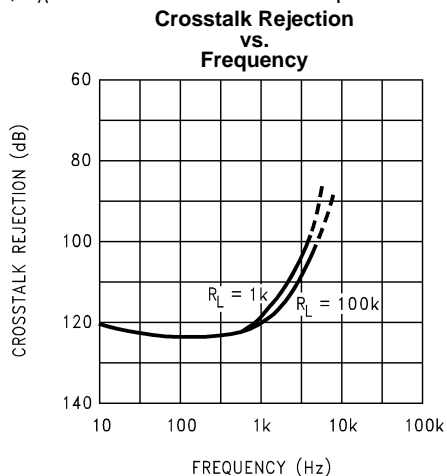


Figure 8.

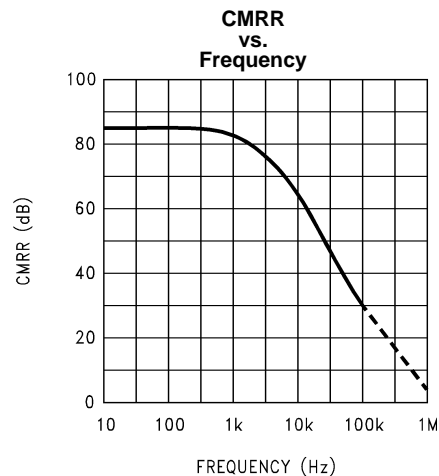


Figure 9.

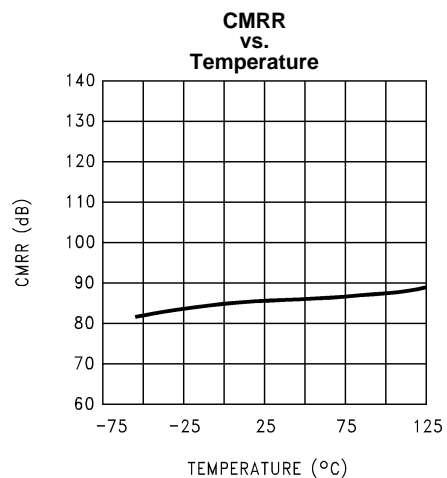


Figure 10.

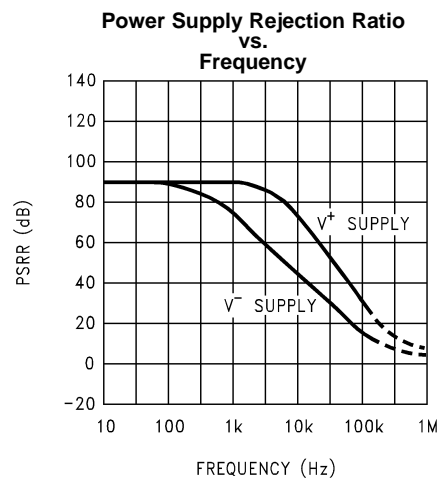


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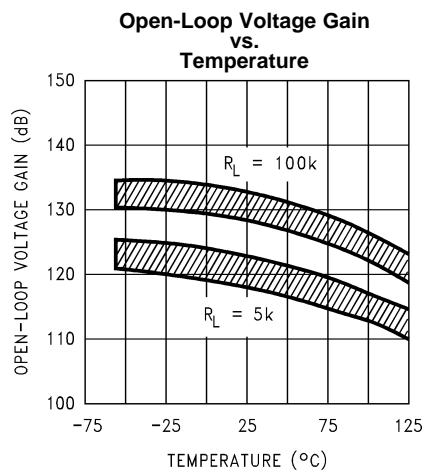


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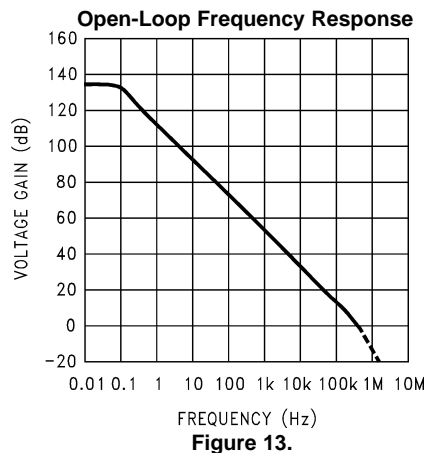


Figure 13.

## Typical Performance Characteristics (continued)

$V_S = \pm 7.5V$ ,  $T_A = 25^\circ C$  unless otherwise specified

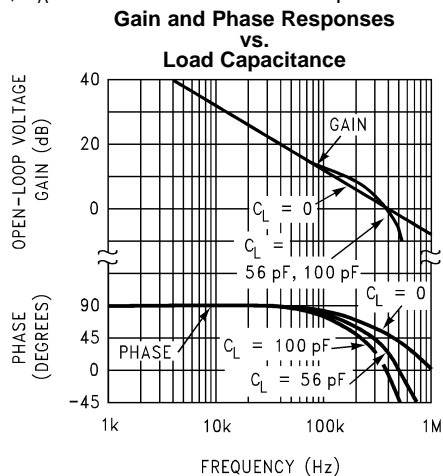


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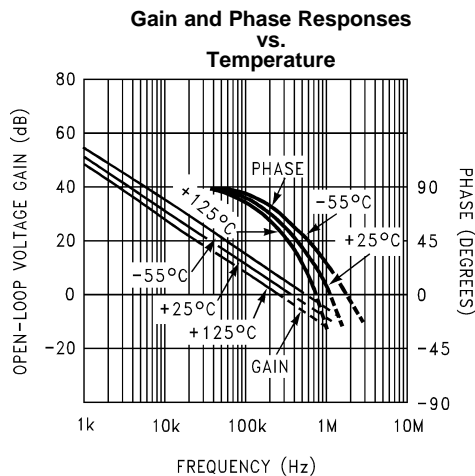


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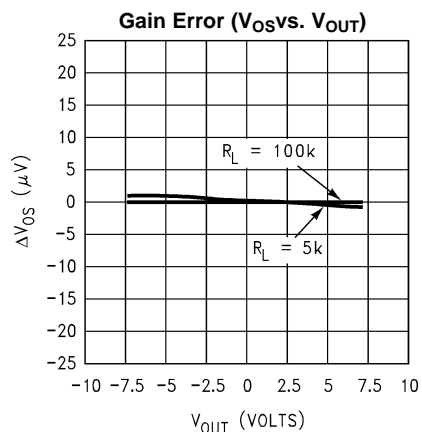


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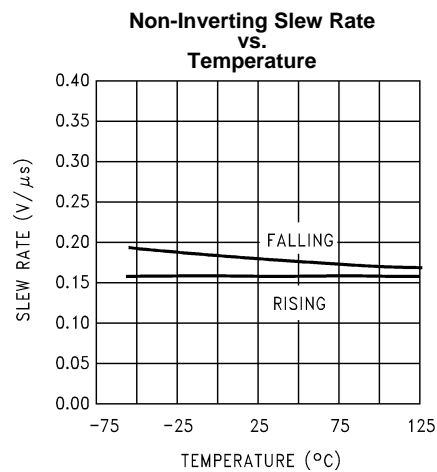


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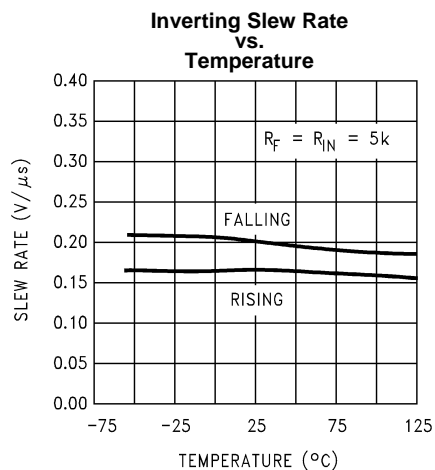


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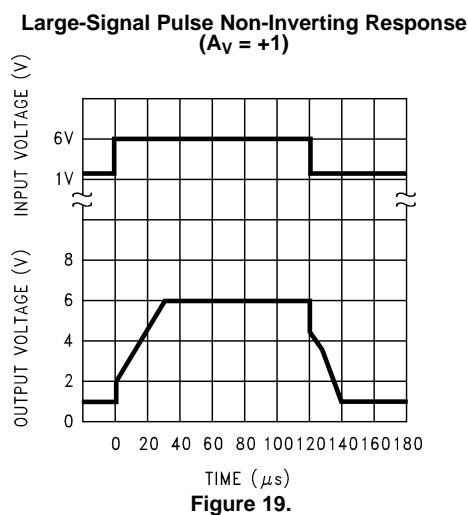


Figure 19.



## Typical Performance Characteristics (continued)

$V_S = \pm 7.5V$ ,  $T_A = 25^\circ C$  unless otherwise specified

### Non-Inverting Small-Signal Pulse Response ( $A_V = +1$ )

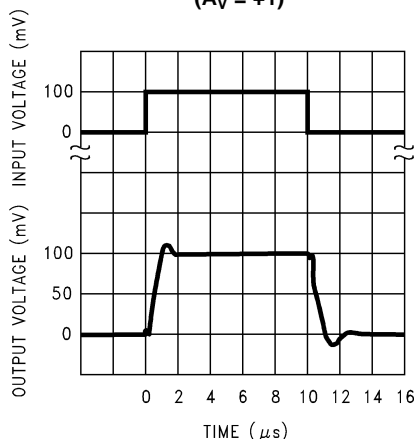


Figure 20.

### Inverting Large-Signal Pulse Response

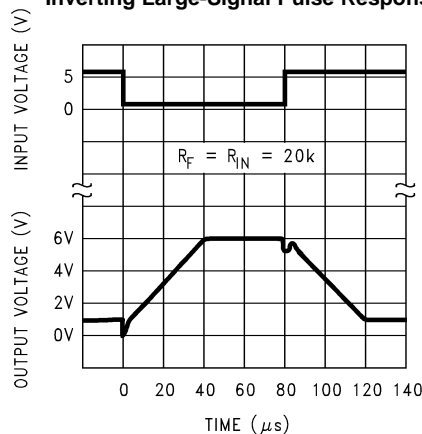


Figure 21.

### Inverting Small-Signal Pulse Response

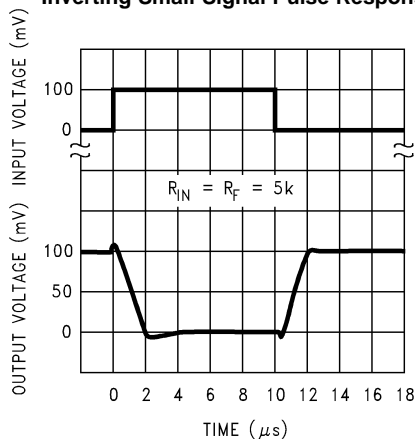
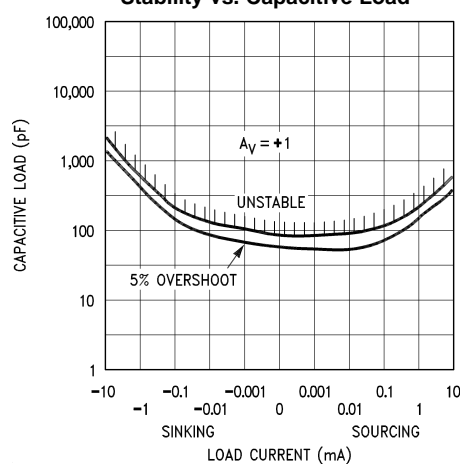


Figure 22.

### Stability vs. Capacitive Load



**Note:** Avoid resistive loads of less than  $500\Omega$ , as they may cause instability.

Figure 23.

### Stability vs. Capacitive Load

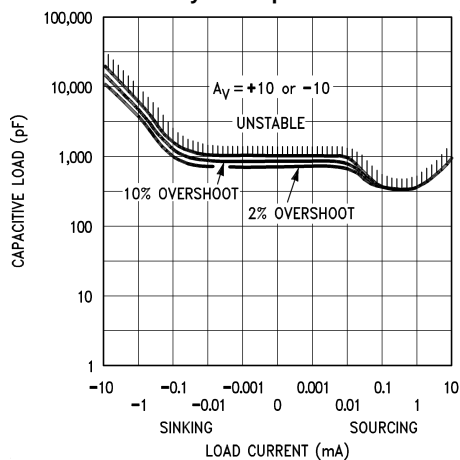


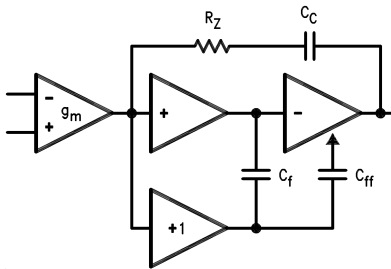
Figure 24.

## Application Hints

### AMPLIFIER TOPOLOGY

The topology chosen for the LPC660 is unconventional (compared to general-purpose op amps) in that the traditional unity-gain buffer output stage is not used; instead, the output is taken directly from the output of the integrator, to allow rail-to-rail output swing. Since the buffer traditionally delivers the power to the load, while maintaining high op amp gain and stability, and must withstand shorts to either rail, these tasks now fall to the integrator.

As a result of these demands, the integrator is a compound affair with an embedded gain stage that is doubly fed forward (via  $C_f$  and  $C_{ff}$ ) by a dedicated unity-gain compensation driver. In addition, the output portion of the integrator is a push-pull configuration for delivering heavy loads. While sinking current the whole amplifier path consists of three gain stages with one stage fed forward, whereas while sourcing the path contains four gain stages with two fed forward.



**Figure 25. LPC660 Circuit Topology (Each Amplifier)**

The large signal voltage gain while sourcing is comparable to traditional bipolar op amps, for load resistance of at least 5 k $\Omega$ . The gain while sinking is higher than most CMOS op amps, due to the additional gain stage; however, when driving load resistance of 5 k $\Omega$  or less, the gain will be reduced as indicated in the Electrical Characteristics. The op amp can drive load resistance as low as 500 $\Omega$  without instability.

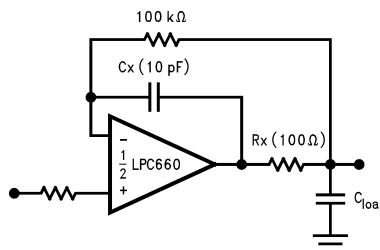
### COMPENSATING INPUT CAPACITANCE

Refer to the LMC660 or LMC662 datasheets to determine whether or not a feedback capacitor will be necessary for compensation and what the value of that capacitor would be.

### CAPACITIVE LOAD TOLERANCE

Like many other op amps, the LPC660 may oscillate when its applied load appears capacitive. The threshold of oscillation varies both with load and circuit gain. The configuration most sensitive to oscillation is a unity-gain follower. See the Typical Performance Characteristics.

The load capacitance interacts with the op amp's output resistance to create an additional pole. If this pole frequency is sufficiently low, it will degrade the op amp's phase margin so that the amplifier is no longer stable at low gains. The addition of a small resistor (50 $\Omega$  to 100 $\Omega$ ) in series with the op amp's output, and a capacitor (5 pF to 10 pF) from inverting input to output pins, returns the phase margin to a safe value without interfering with lower-frequency circuit operation. Thus, larger values of capacitance can be tolerated without oscillation. Note that in all cases, the output will ring heavily when the load capacitance is near the threshold for oscillation.



**Figure 26. Rx, Cx Improve Capacitive Load Tolerance**

Capacitive load driving capability is enhanced by using a pull up resistor to  $V^+$  (Figure 27). Typically a pull up resistor conducting 50  $\mu\text{A}$  or more will significantly improve capacitive load responses. The value of the pull up resistor must be determined based on the current sinking capability of the amplifier with respect to the desired output swing. Open loop gain of the amplifier can also be affected by the pull up resistor (see Electrical Characteristics).

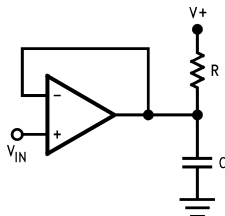


Figure 27. Compensating for Large Capacitive Loads with A Pull Up Resistor

### PRINTED-CIRCUIT-BOARD LAYOUT FOR HIGH-IMPEDANCE WORK

It is generally recognized that any circuit which must operate with less than 1000 pA of leakage current requires special layout of the PC board. When one wishes to take advantage of the ultra-low bias current of the LPC660, typically less than 0.04 pA, it is essential to have an excellent layout. Fortunately, the techniques for obtaining low leakages are quite simple. First, the user must not ignore the surface leakage of the PC board, even though it may sometimes appear acceptably low, because under conditions of high humidity or dust or contamination, the surface leakage will be appreciable.

To minimize the effect of any surface leakage, lay out a ring of foil completely surrounding the LPC660's inputs and the terminals of capacitors, diodes, conductors, resistors, relay terminals, etc. connected to the op-amp's inputs. See Figure 28. To have a significant effect, guard rings should be placed on both the top and bottom of the PC board. This PC foil must then be connected to a voltage which is at the same voltage as the amplifier inputs, since no leakage current can flow between two points at the same potential. For example, a PC board trace-to-pad resistance of  $10^{12}$  ohms, which is normally considered a very large resistance, could leak 5 pA if the trace were a 5V bus adjacent to the pad of an input. This would cause a 100 times degradation from the LPC660's actual performance. However, if a guard ring is held within 5 mV of the inputs, then even a resistance of  $10^{11}$  ohms would cause only 0.05 pA of leakage current, or perhaps a minor (2:1) degradation of the amplifier's performance. See Figure 29a, Figure 30b, Figure 31c for typical connections of guard rings for standard op-amp configurations. If both inputs are active and at high impedance, the guard can be tied to ground and still provide some protection; see Figure 32d.

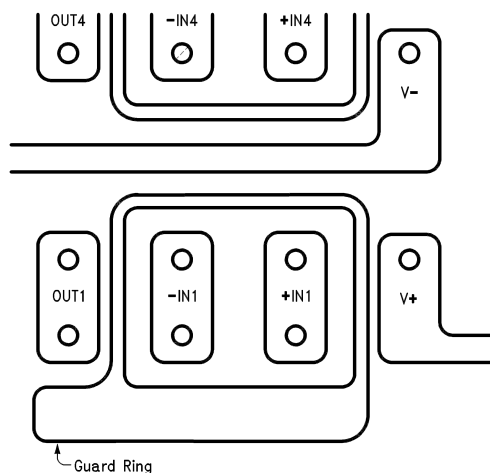
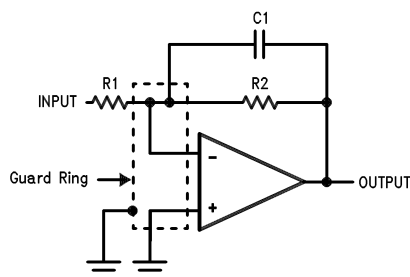
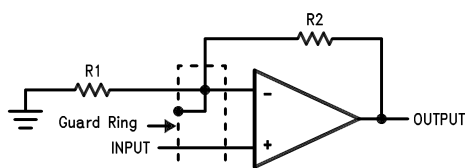
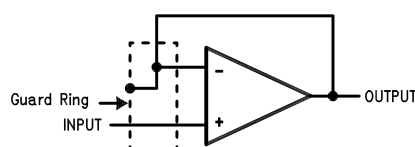
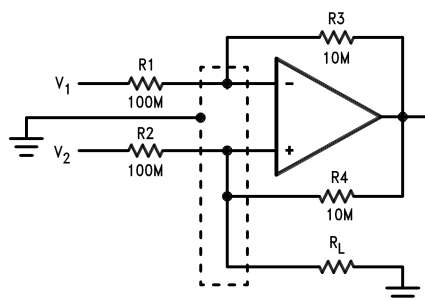
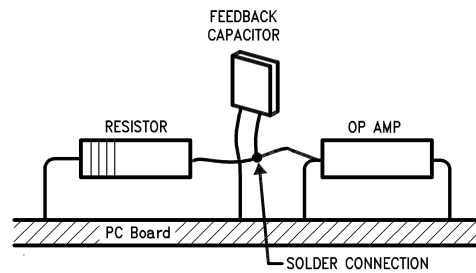


Figure 28. Example of Guard Ring in P.C. Board Layout using the LPC660

**Figure 29. (a) Inverting Amplifier****Figure 30. (b) Non-Inverting Amplifier****Figure 31. (c) Follower****Figure 32. (d) Howland Current Pump**

The designer should be aware that when it is inappropriate to lay out a PC board for the sake of just a few circuits, there is another technique which is even better than a guard ring on a PC board: Don't insert the amplifier's input pin into the board at all, but bend it up in the air and use only air as an insulator. Air is an excellent insulator. In this case you may have to forego some of the advantages of PC board construction, but the advantages are sometimes well worth the effort of using point-to-point up-in-the-air wiring. See [Figure 33](#).



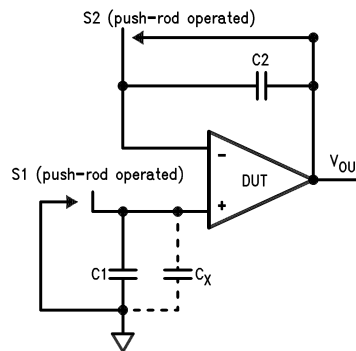
(Input pins are lifted out of PC board and soldered directly to components. All other pins connected to PC board.)

**Figure 33. Air Wiring**

## BIAS CURRENT TESTING

The test method of Figure 34 is appropriate for bench-testing bias current with reasonable accuracy. To understand its operation, first close switch S2 momentarily. When S2 is opened, then

$$I^- = \frac{dV_{OUT}}{dt} \times C2. \quad (1)$$



**Figure 34. Simple Input Bias Current Test Circuit**

A suitable capacitor for C2 would be a 5 pF or 10 pF silver mica, NPO ceramic, or air-dielectric. When determining the magnitude of  $I^-$ , the leakage of the capacitor and socket must be taken into account. Switch S2 should be left shorted most of the time, or else the dielectric absorption of the capacitor C2 could cause errors.

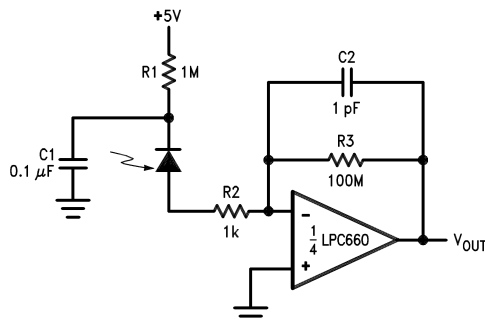
Similarly, if S1 is shorted momentarily (while leaving S2 shorted)

$$I^+ = \frac{dV_{OUT}}{dt} \times (C1 + Cx) \quad (2)$$

where  $C_x$  is the stray capacitance at the + input.

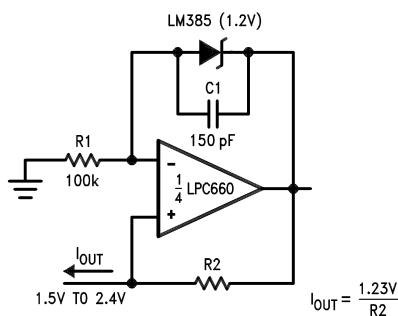
## Typical Single-Supply Applications — ( $V^+ = 5.0\text{ V}_{\text{DC}}$ )

**Figure 35. Photodiode Current-to-Voltage Converter**



**Note:** A 5V bias on the photodiode can cut its capacitance by a factor of 2 or 3, leading to improved response and lower noise. However, this bias on the photodiode will cause photodiode leakage (also known as its dark current).

**Figure 36. Micropower Current Source**



**Note:** (Upper limit of output range dictated by input common-mode range; lower limit dictated by minimum current requirement of LM385.)

**Figure 37. Low-Leakage Sample-and-Hold**

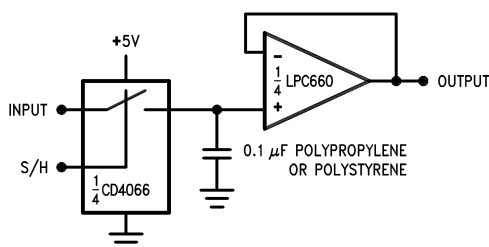
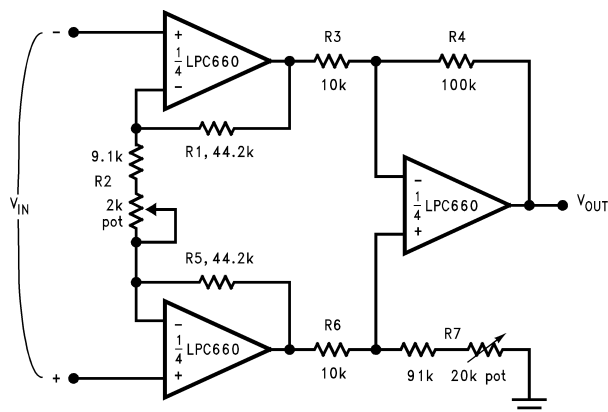


Figure 38. Instrumentation Amplifier



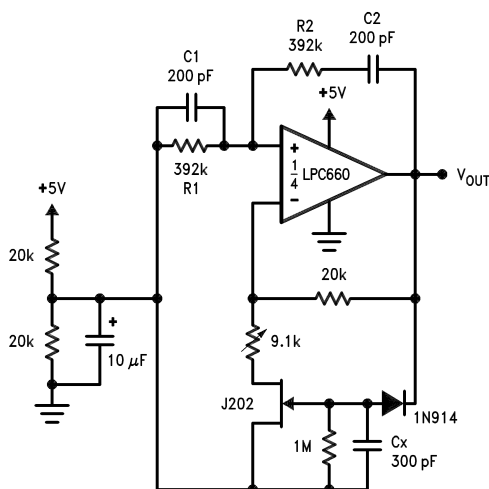
If  $R1 = R5$ ,  $R3 = R6$ , and  $R4 = R7$ ;

$$\text{then } \frac{V_{OUT}}{V_{IN}} = \frac{R2 + 2R1}{R1} \times \frac{R4}{R3}$$

$\therefore A_V \approx 100$  for circuits shown.

For good CMRR over temperature, low drift resistors should be used. Matching of  $R3$  to  $R6$  and  $R4$  to  $R7$  affects CMRR. Gain may be adjusted through  $R2$ . CMRR may be adjusted through  $R7$ .

Figure 39. Sine-Wave Oscillator

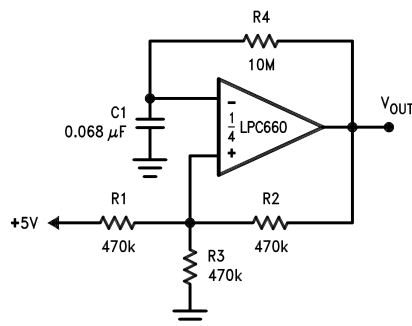


Oscillator frequency is determined by  $R1$ ,  $R2$ ,  $C1$ , and  $C2$ :

$$f_{OSC} = 1/2\pi RC$$

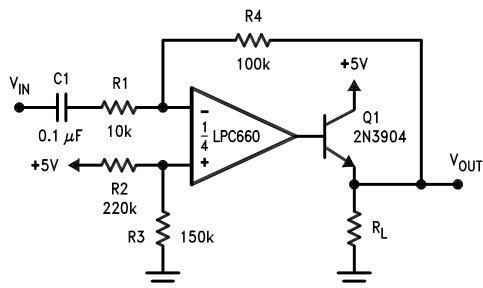
where  $R = R1 = R2$  and  $C = C1 = C2$ .

Figure 40. 1 Hz Square-Wave Oscillator

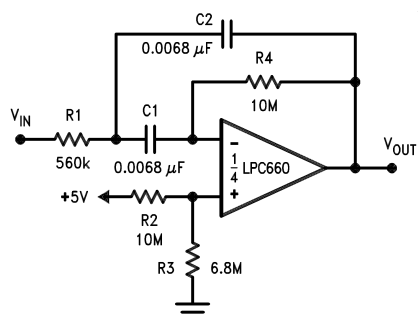


This circuit, as shown, oscillates at 2.0 kHz with a peak-to-peak output swing of 4.5V

**Figure 41. Power Amplifier**

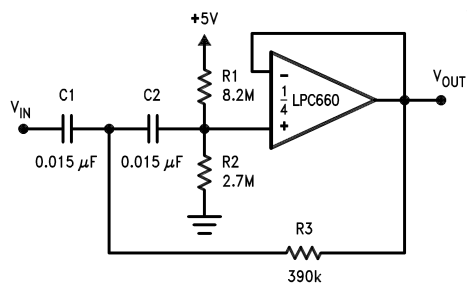


**Figure 42. 10 Hz Bandpass Filter**



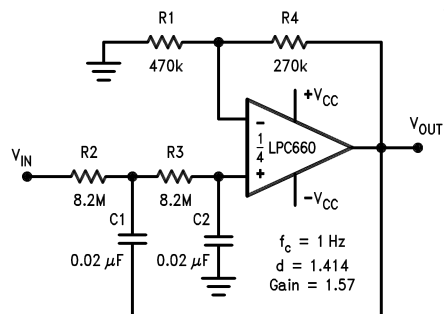
$f_0 = 10 \text{ Hz}$   
 $Q = 2.1$   
 Gain = -8.8

**Figure 43. 10 Hz High-Pass Filter (2 dB Dip)**



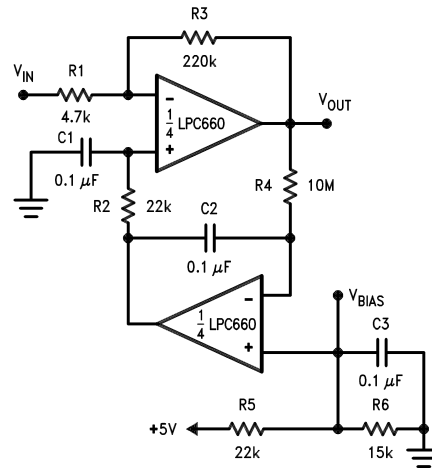
$f_c = 10 \text{ Hz}$   
 $d = 0.895$   
 Gain = 1

**Figure 44. 1 Hz Low-Pass Filter (Maximally Flat, Dual Supply Only)**





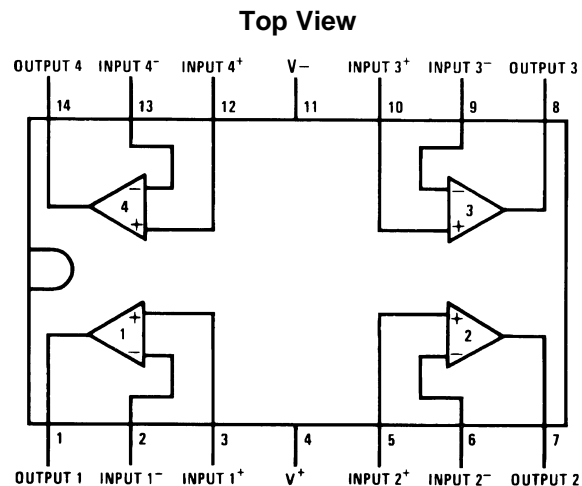
**Figure 45. High Gain Amplifier with Offset Voltage Reduction**



Gain = -46.8

Output offset voltage reduced to the level of the input offset voltage of the bottom amplifier (typically 1 mV), referred to  $V_{BIAS}$ .

## Connection Diagram



**Figure 46. 14-Pin SOIC Package**  
See Package Number D0014A

## REVISION HISTORY

Changes from Revision C (March 2013) to Revision D	Page
• Changed layout of National Data Sheet to TI format .....	<a href="#">17</a>

## PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">LPC660AIM/NOPB</a>	Active	Production	SOIC (D)   14	55   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660AIM
LPC660AIM/NOPB.A	Active	Production	SOIC (D)   14	55   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660AIM
LPC660AIM/NOPB.B	Active	Production	SOIC (D)   14	55   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660AIM
<a href="#">LPC660AIMX/NOPB</a>	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660AIM
LPC660AIMX/NOPB.A	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660AIM
LPC660AIMX/NOPB.B	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660AIM
<a href="#">LPC660IM/NOPB</a>	Active	Production	SOIC (D)   14	55   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660IM
LPC660IM/NOPB.A	Active	Production	SOIC (D)   14	55   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660IM
LPC660IM/NOPB.B	Active	Production	SOIC (D)   14	55   TUBE	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660IM
<a href="#">LPC660IMX/NOPB</a>	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660IM
LPC660IMX/NOPB.A	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660IM
LPC660IMX/NOPB.B	Active	Production	SOIC (D)   14	2500   LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 85	LPC660IM

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## TAPE AND REEL INFORMATION



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LPC660AIMX/NOPB	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1
LPC660IMX/NOPB	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

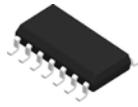
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LPC660AIMX/NOPB	SOIC	D	14	2500	356.0	356.0	35.0
LPC660IMX/NOPB	SOIC	D	14	2500	367.0	367.0	35.0

## TUBE



\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
LPC660AIM/NOPB	D	SOIC	14	55	495	8	4064	3.05
LPC660AIM/NOPB.A	D	SOIC	14	55	495	8	4064	3.05
LPC660AIM/NOPB.B	D	SOIC	14	55	495	8	4064	3.05
LPC660IM/NOPB	D	SOIC	14	55	495	8	4064	3.05
LPC660IM/NOPB.A	D	SOIC	14	55	495	8	4064	3.05
LPC660IM/NOPB.B	D	SOIC	14	55	495	8	4064	3.05

**D0014A****PACKAGE OUTLINE****SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4220718/A 09/2016

**NOTES:**

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.43 mm, per side.
5. Reference JEDEC registration MS-012, variation AB.



# EXAMPLE BOARD LAYOUT

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
SCALE:8X



SOLDER MASK DETAILS

4220718/A 09/2016

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0014A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:8X

4220718/A 09/2016

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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