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## LMC6084

### Precision CMOS Quad Operational Amplifier

#### General Description

The LMC6084 is a precision quad low offset voltage operational amplifier, capable of single supply operation. Performance characteristics include ultra low input bias current, high voltage gain, rail-to-rail output swing, and an input common mode voltage range that includes ground. These features, plus its low offset voltage, make the LMC6084 ideally suited for precision circuit applications.

Other applications using the LMC6084 include precision full-wave rectifiers, integrators, references, and sample-and-hold circuits.

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

For designs with more critical power demands, see the LMC6064 precision quad micropower operational amplifier.

For a single or dual operational amplifier with similar features, see the LMC6081 or LMC6082 respectively.

**PATENT PENDING**

#### Features

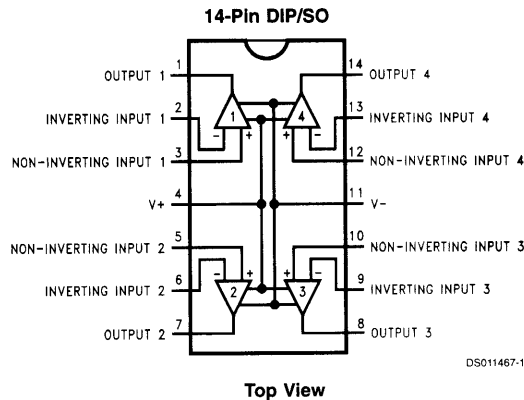
(Typical unless otherwise stated)

- Low offset voltage: 150  $\mu$ V
- Operates from 4.5V to 15V single supply
- Ultra low input bias current: 10 fA
- Output swing to within 20 mV of supply rail, 100k load
- Input common-mode range includes  $V^-$
- High voltage gain: 130 dB
- Improved latchup immunity

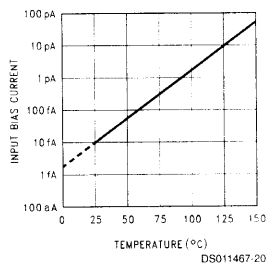
#### Applications

- Instrumentation amplifier
- Photodiode and infrared detector preamplifier
- Transducer amplifiers
- Medical instrumentation
- D/A converter
- Charge amplifier for piezoelectric transducers

#### Connection Diagram



#### Input Bias Current vs Temperature



## Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Differential Input Voltage	±Supply Voltage
Voltage at Input/Output Pin	(V <sup>+</sup> ) +0.3V, (V <sup>-</sup> ) -0.3V
Supply Voltage (V <sup>+</sup> - V <sup>-</sup> )	16V
Output Short Circuit to V <sup>+</sup>	(Note 11)
Output Short Circuit to V <sup>-</sup>	(Note 2)
Lead Temperature (Soldering, 10 Sec.)	260°C
Storage Temp. Range	-65°C to +150°C
Junction Temperature	150°C
ESD Tolerance (Note 4)	2 kV

Current at Input Pin	±10 mA
Current at Output Pin	±30 mA
Current at Power Supply Pin	40 mA
Power Dissipation	(Note 3)

## Operating Ratings (Note 1)

Temperature Range	
LMC6084AM	-55°C ≤ T <sub>J</sub> ≤ +125°C
LMC6084AI, LMC6084I	-40°C ≤ T <sub>J</sub> ≤ +85°C
Supply Voltage	4.5V ≤ V <sup>+</sup> ≤ 15.5V
Thermal Resistance (θ <sub>JA</sub> ) (Note 12)	
14-Pin Molded DIP	81°C/W
14-Pin SO	126°C/W
Power Dissipation	(Note 10)

## DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T<sub>J</sub> = 25°C. **Boldface** limits apply at the temperature extremes. V<sup>+</sup> = 5V, V<sup>-</sup> = 0V, V<sub>CM</sub> = 1.5V, V<sub>O</sub> = 2.5V and R<sub>L</sub> > 1M unless otherwise specified.

Symbol	Parameter	Conditions	Typ (Note 5)	LMC6084AM Limit (Note 6)	LMC6084AI Limit (Note 6)	LMC6084I Limit (Note 6)	Units	
V <sub>OS</sub>	Input Offset Voltage		150	350 <b>1000</b>	350 <b>800</b>	800 <b>1300</b>	μV Max	
TCV <sub>OS</sub>	Input Offset Voltage Average Drift		1.0				μV/°C	
I <sub>B</sub>	Input Bias Current		0.010	<b>100</b>	<b>4</b>	<b>4</b>	pA Max	
I <sub>OS</sub>	Input Offset Current		0.005	<b>100</b>	<b>2</b>	<b>2</b>	pA Max	
R <sub>IN</sub>	Input Resistance		>10				Tera Ω	
CMRR	Common Mode Rejection Ratio	0V ≤ V <sub>CM</sub> ≤ 12.0V V <sup>+</sup> = 15V	85	75 <b>72</b>	75 <b>72</b>	66 <b>63</b>	dB Min	
+PSRR	Positive Power Supply Rejection Ratio	5V ≤ V <sup>+</sup> ≤ 15V V <sub>O</sub> = 2.5V	85	75 <b>72</b>	75 <b>72</b>	66 <b>63</b>	dB Min	
-PSRR	Negative Power Supply Rejection Ratio	0V ≤ V <sup>-</sup> ≤ -10V	94	84 <b>81</b>	84 <b>81</b>	74 <b>71</b>	dB Min	
V <sub>CM</sub>	Input Common-Mode Voltage Range	V <sup>+</sup> = 5V and 15V for CMRR ≥ 60 dB	-0.4	-0.1 <b>0</b>	-0.1 <b>0</b>	-0.1 <b>0</b>	V Max	
			V <sup>+</sup> - 1.9	V <sup>+</sup> - 2.3 <b>V<sup>+</sup> - 2.6</b>	V <sup>+</sup> - 2.3 <b>V<sup>+</sup> - 2.5</b>	V <sup>+</sup> - 2.3 <b>V<sup>+</sup> - 2.5</b>	V Min	
A <sub>V</sub>	Large Signal Voltage Gain	R <sub>L</sub> = 2 kΩ (Note 7)	Sourcing	1400	400 <b>300</b>	400 <b>300</b>	300 <b>200</b>	V/mV Min
			Sinking	350	180 <b>70</b>	180 <b>100</b>	90 <b>60</b>	V/mV Min
		R <sub>L</sub> = 600Ω (Note 7)	Sourcing	1200	400 <b>150</b>	400 <b>150</b>	200 <b>80</b>	V/mV Min
			Sinking	150	100 <b>35</b>	100 <b>50</b>	70 <b>35</b>	V/mV Min

## DC Electrical Characteristics (Continued)

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

Symbol	Parameter	Conditions	Typ (Note 5)	LMC6084AM Limit (Note 6)	LMC6084AI Limit (Note 6)	LMC6084I Limit (Note 6)	Units
$V_{\text{O}}$	Output Swing	$V^+ = 5\text{V}$ $R_{\text{L}} = 2\text{ k}\Omega$ to $2.5\text{V}$	4.87	4.80	4.80	4.75	V
			0.10	0.13	0.13	0.20	V
			<b>0.19</b>	<b>0.17</b>	<b>0.24</b>	Max	
		$V^+ = 5\text{V}$ $R_{\text{L}} = 600\Omega$ to $2.5\text{V}$	4.61	4.50	4.50	4.40	V
			<b>4.24</b>	<b>4.31</b>	<b>4.21</b>	Min	
		$V^+ = 15\text{V}$ $R_{\text{L}} = 2\text{ k}\Omega$ to $7.5\text{V}$	0.30	0.40	0.40	0.50	V
			<b>0.63</b>	<b>0.50</b>	<b>0.63</b>	Max	
			14.63	14.50	14.50	14.37	V
$V^+ = 15\text{V}$ $R_{\text{L}} = 600\Omega$ to $7.5\text{V}$	<b>14.30</b>	<b>14.34</b>	<b>14.25</b>	Min			
	0.26	0.35	0.35	0.44	V		
	<b>0.48</b>	<b>0.45</b>	<b>0.56</b>	Max			
	13.90	13.35	13.35	12.92	V		
	<b>12.80</b>	<b>12.86</b>	<b>12.44</b>	Min			
	0.79	1.16	1.16	1.33	V		
	<b>1.42</b>	<b>1.32</b>	<b>1.58</b>	Max			
	$I_{\text{O}}$	Output Current $V^+ = 5\text{V}$	Sourcing, $V_{\text{O}} = 0\text{V}$	22	16	16	13
<b>8</b>			<b>10</b>	<b>8</b>	Min		
		Sinking, $V_{\text{O}} = 5\text{V}$	21	16	16	13	mA
		<b>11</b>	<b>13</b>	<b>10</b>	Min		
$I_{\text{O}}$	Output Current $V^+ = 15\text{V}$	Sourcing, $V_{\text{O}} = 0\text{V}$	30	28	28	23	mA
			<b>18</b>	<b>22</b>	<b>18</b>	Min	
		Sinking, $V_{\text{O}} = 13\text{V}$ (Note 11)	34	28	28	23	mA
			<b>19</b>	<b>22</b>	<b>18</b>	Min	
$I_{\text{S}}$	Supply Current	All Four Amplifiers $V^+ = +5\text{V}$ , $V_{\text{O}} = 1.5\text{V}$	1.8	3.0	3.0	3.0	mA
		<b>3.6</b>	<b>3.6</b>	<b>3.6</b>	Max		
		All Four Amplifiers $V^+ = +15\text{V}$ , $V_{\text{O}} = 7.5\text{V}$	2.2	3.4	3.4	3.4	mA
		<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	Max		

## AC Electrical Characteristics

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

Symbol	Parameter	Conditions	Typ (Note 5)	LMC6084AM Limit (Note 6)	LMC6084AI Limit (Note 6)	LMC6084I Limit (Note 6)	Units
SR	Slew Rate	(Note 8)	1.5	0.8	0.8	0.8	V/ $\mu\text{s}$
				<b>0.5</b>	<b>0.6</b>	<b>0.6</b>	Min
GBW	Gain-Bandwidth Product		1.3				MHz
$\phi_m$	Phase Margin		50				Deg
	Amp-to-Amp Isolation	(Note 9)	140				dB
$e_n$	Input-Referred Voltage Noise	$F = 1\text{ kHz}$	22				$\text{nV}/\sqrt{\text{Hz}}$
$i_n$	Input-Referred Current Noise	$F = 1\text{ kHz}$	0.0002				$\text{pA}/\sqrt{\text{Hz}}$
T.H.D.	Total Harmonic Distortion	$F = 10\text{ kHz}$ , $A_V = -10$ $R_L = 2\text{ k}\Omega$ , $V_O = 8\text{ V}_{PP}$ $\pm 5\text{V}$ Supply	0.01				%

**Note 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.

**Note 2:** Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of  $150^\circ\text{C}$ . Output currents in excess of  $\pm 30\text{ mA}$  over long term may adversely affect reliability.

**Note 3:** The maximum power dissipation is a function of  $T_{J(\text{Max})}$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(\text{Max})} - T_A) / \theta_{JA}$ .

**Note 4:** Human body model,  $1.5\text{ k}\Omega$  in series with  $100\text{ pF}$ .

**Note 5:** Typical values represent the most likely parametric norm.

**Note 6:** All limits are guaranteed by testing or statistical analysis.

**Note 7:**  $V^+ = 15\text{V}$ ,  $V_{CM} = 7.5\text{V}$  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,  $2.5\text{V} \leq V_O \leq 7.5\text{V}$ .

**Note 8:**  $V^+ = 15\text{V}$ . Connected as Voltage Follower with  $10\text{V}$  step input. Number specified is the slower of the positive and negative slew rates.

**Note 9:** Input referred  $V^+ = 15\text{V}$  and  $R_L = 100\text{ k}\Omega$  connected to  $7.5\text{V}$ . Each amp excited in turn with  $1\text{ kHz}$  to produce  $V_O = 12\text{ V}_{PP}$ .

**Note 10:** For operating at elevated temperatures the device must be derated based on the thermal resistance  $\theta_{JA}$  with  $P_D = (T_J - T_A) / \theta_{JA}$ . All numbers apply for packages soldered directly into a PC board.

**Note 11:** Do not connect output to  $V^+$ , when  $V^+$  is greater than  $13\text{V}$  or reliability will be adversely affected.

**Note 12:** All numbers apply for packages soldered directly into a PC board.