National Semiconductor

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)

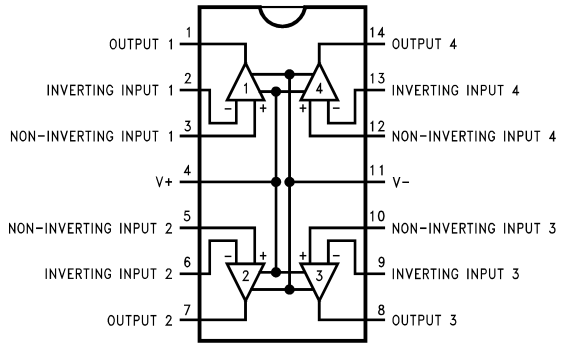
- Low offset voltage: 150 µV
- Operates from 4.5V to 15V single supply
- Ultra low input bias current: 10 fA
- Output swing to within 20 mV of supply rail, 100k load
- Input common-mode range includes V^-
- High voltage gain: 130 dB
- Improved latchup immunity

Applications

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

Connection Diagrams

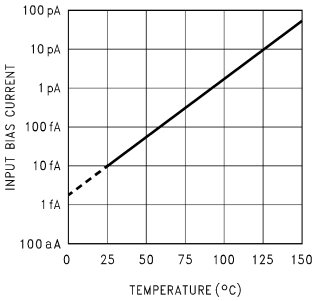
14-Pin DIP/SO



01146701

Top View

Input Bias Current vs Temperature



01146720

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^+) +0.3V, (V^-) −0.3V
Supply Voltage ($V^+ - V^-$)	16V
Output Short Circuit to V^+	(Note 11)
Output Short Circuit to V^-	(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	$-55^\circ C \le T_J \le +125^\circ C$
LMC6084AI, LMC6084I	$-40^\circ C \le T_J \le +85^\circ C$
Supply Voltage	$4.5V \le V^+ \le 15.5V$
Thermal Resistance (θ_{JA}) (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_J = 25˚C. **Boldface** limits apply at the temperature extremes. V^+ = 5V, V^- = 0V, V_{CM} = 1.5V, V_O = 2.5V and R_L > 1M unless otherwise specified.

Symbol	Parameter	Conditions		Typ (Note 5)	LMC6084AM Limit (Note 6)	LMC6084AI Limit (Note 6)	LMC6084I Limit (Note 6)	Units
V_{OS}	Input Offset Voltage			150	350 **1000**	350 **800**	800 **1300**	µV Max
TCV_{OS}	Input Offset Voltage Average Drift			1.0				µV/˚C
I_B	Input Bias Current			0.010	 **100**	 **4**	 **4**	pA Max
I_{OS}	Input Offset Current			0.005	 **100**	 **2**	 **2**	pA Max
R_{IN}	Input Resistance			>10				Tera Ω
CMRR	Common Mode Rejection Ratio	0V ≤ V_{CM} ≤ 12.0V V^+ = 15V		85	75 **72**	75 **72**	66 **63**	dB Min
+PSRR	Positive Power Supply Rejection Ratio	5V ≤ V^+ ≤ 15V V_O = 2.5V		85	75 **72**	75 **72**	66 **63**	dB Min
−PSRR	Negative Power Supply Rejection Ratio	0V ≤ V^- ≤ −10V		94	84 **81**	84 **81**	74 **71**	dB Min
V_{CM}	Input Common-Mode Voltage Range	V^+ = 5V and 15V for CMRR ≥ 60 dB		−0.4	−0.1 **0**	−0.1 **0**	−0.1 **0**	V Max
				$V^+ - 1.9$	$V^+ - 2.3$ **$V^+ - 2.6$**	$V^+ - 2.3$ **$V^+ - 2.5$**	$V^+ - 2.3$ **$V^+ - 2.5$**	V Min
A_V	Large Signal Voltage Gain	R_L = 2 kΩ (Note 7)	Sourcing	1400	400 **300**	400 **300**	300 **200**	V/mV Min
			Sinking	350	180 **70**	180 **100**	90 **60**	V/mV Min
		R_L = 600Ω (Note 7)	Sourcing	1200	400 **150**	400 **150**	200 **80**	V/mV Min
			Sinking	150	100 **35**	100 **50**	70 **35**	V/mV Min

DC Electrical Characteristics (Continued)

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

Symbol	Parameter	Conditions	Typ (Note 5)	LMC6084AM Limit (Note 6)	LMC6084AI Limit (Note 6)	LMC6084I Limit (Note 6)	Units
V_O	Output Swing	$V^+ = 5V$	4.87	4.80	4.80	4.75	V
		$R_L = 2\ k\Omega$ to 2.5V		**4.70**	**4.73**	**4.67**	Min
			0.10	0.13	0.13	0.20	V
				0.19	**0.17**	**0.24**	Max
		$V^+ = 5V$	4.61	4.50	4.50	4.40	V
		$R_L = 600\Omega$ to 2.5V		**4.24**	**4.31**	**4.21**	Min
			0.30	0.40	0.40	0.50	V
				0.63	**0.50**	**0.63**	Max
		$V^+ = 15V$	14.63	14.50	14.50	14.37	V
		$R_L = 2\ k\Omega$ to 7.5V		**14.30**	**14.34**	**14.25**	Min
			0.26	0.35	0.35	0.44	V
				0.48	**0.45**	**0.56**	Max
		$V^+ = 15V$	13.90	13.35	13.35	12.92	V
		$R_L = 600\Omega$ to 7.5V		**12.80**	**12.86**	**12.44**	Min
			0.79	1.16	1.16	1.33	V
				1.42	**1.32**	**1.58**	Max
I_O	Output Current	Sourcing, $V_O = 0V$	22	16	16	13	mA
	$V^+ = 5V$			**8**	**10**	**8**	Min
		Sinking, $V_O = 5V$	21	16	16	13	mA
				11	**13**	**10**	Min
I_O	Output Current	Sourcing, $V_O = 0V$	30	28	28	23	mA
	$V^+ = 15V$			**18**	**22**	**18**	Min
		Sinking, $V_O = 13V$	34	28	28	23	mA
		(Note 11)		**19**	**22**	**18**	Min
I_S	Supply Current	All Four Amplifiers	1.8	3.0	3.0	3.0	mA
		$V^+ = +5V$, $V_O = 1.5V$		**3.6**	**3.6**	**3.6**	Max
		All Four Amplifiers	2.2	3.4	3.4	3.4	mA
		$V^+ = +15V$, $V_O = 7.5V$		**4.0**	**4.0**	**4.0**	Max

AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25˚C, **Boldface** limits apply at the temperature extremes. V^+ = 5V, V^- = 0V, V_{CM} = 1.5V, V_O = 2.5V and R_L > 1M 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 **0.5**	0.8 **0.6**	0.8 **0.6**	V/µs Min
GBW	Gain-Bandwidth Product		1.3				MHz
ϕ_m	Phase Margin		50				Deg
	Amp-to-Amp Isolation	(Note 9)	140				dB
e_n	Input-Referred Voltage Noise	F = 1 kHz	22				nV/$\sqrt{\text{Hz}}$
i_n	Input-Referred Current Noise	F = 1 kHz	0.0002				pA/$\sqrt{\text{Hz}}$
T.H.D.	Total Harmonic Distortion	F = 10 kHz, A_V = –10 R_L = 2 kΩ, V_O = 8 V_{PP} ±5V 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˚C. Output currents in excess of ±30 mA over long term may adversely affect reliability.

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

Note 4: Human body model, 1.5 kΩ in series with 100 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^+ = 15V, V_{CM} = 7.5V and R_L connected to 7.5V. For Sourcing tests, 7.5V ≤ V_O ≤ 11.5V. For Sinking tests, 2.5V ≤ V_O ≤ 7.5V.

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

Note 9: Input referred V^+ = 15V and R_L = 100 kΩ connected to 7.5V. Each amp excited in turn with 1 kHz to produce V_O = 12 V_{PP}.

Note 10: For operating at elevated temperatures the device must be derated based on the thermal resistance θ_{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 13V or reliability will be adversely affected.

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

Typical Single-Supply Applications (Continued)

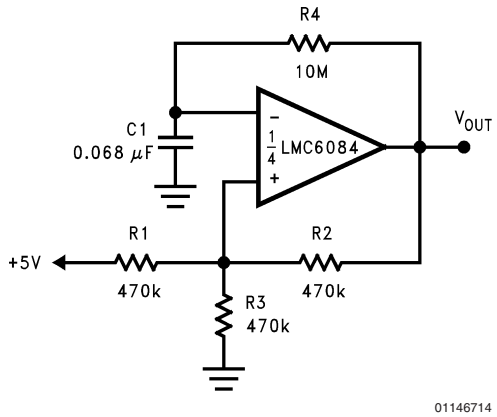


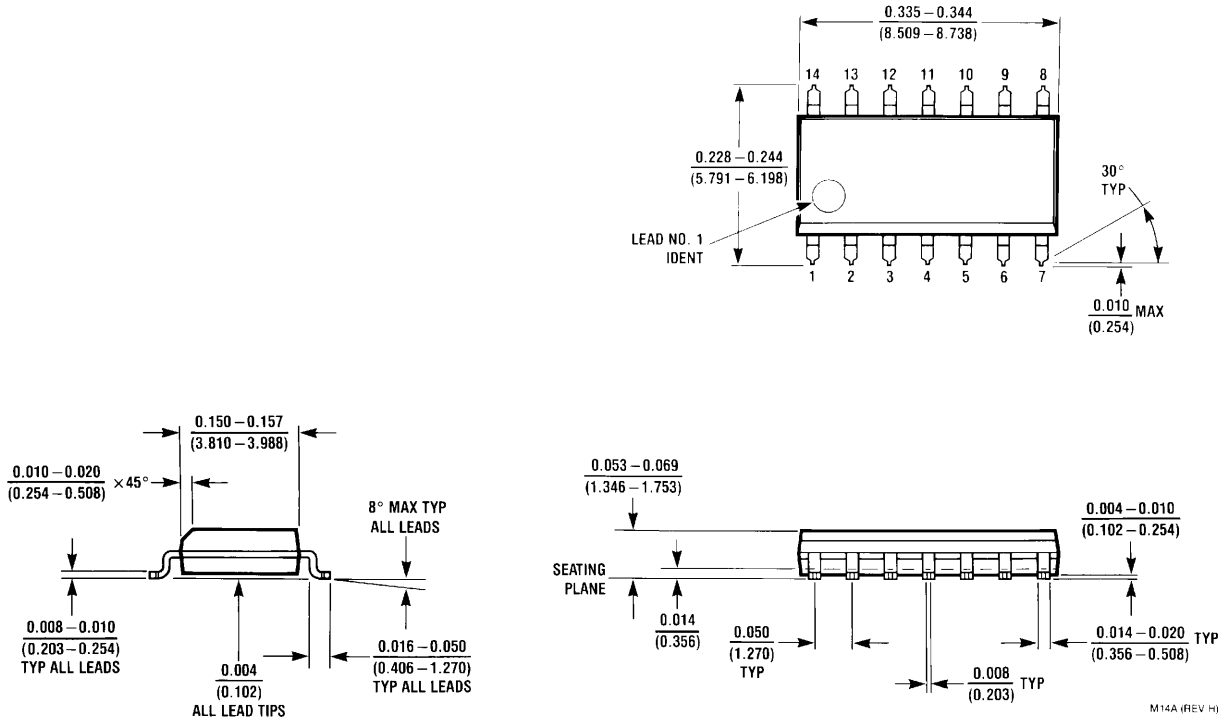
FIGURE 9. 1 Hz Square Wave Oscillator

Ordering Information

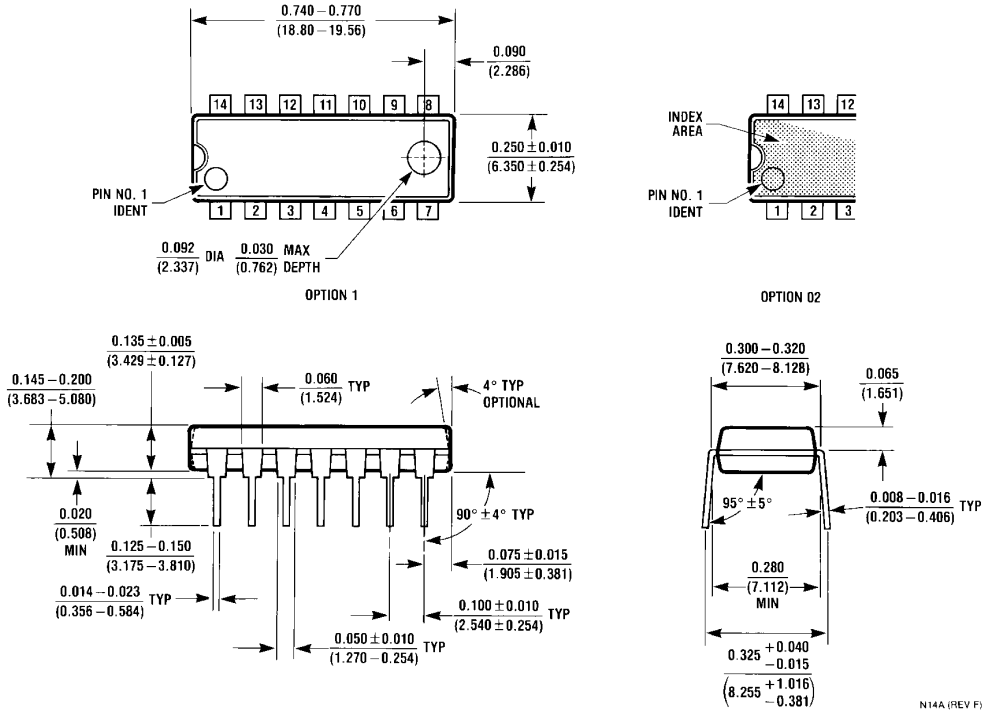
Package	Temperature Range		NSC Drawing	Transport Media
	Military –55˚C to +125˚C	Industrial –40˚C to +85˚C		
14-Pin Molded DIP		LMC6084AIN LMC6084IN	N14A	Rail
14-Pin Small Outline		LMC6084AIM, LMC6084AIMX LMC6084IM, LMC6084IMX	M14A	Rail Tape and Reel

For MIL-STD-883C qualified products, please contact your local National Semiconductor Sales Office or Distributor for availability and specification information.

Physical Dimensions inches (millimeters) unless otherwise noted



14-Pin Small Outline Package (M)
Order Number LMC6084AIM, LMC6084AIMX, LMC6084IM or LMC6084IMX
NS Package Number M14A



14-Pin Molded Dual-In-Line Package (N)
Order Number LMC6084AIN or LMC6084IN
NS Package Number N14A