

LMC6044

CMOS Quad Micropower Operational Amplifier

General Description

Ultra-low power consumption and low input-leakage current are the hallmarks of the LMC6044. Providing input currents of only 2 fA typical, the LMC6044 can operate from a single supply, has output swing extending to each supply rail, and an input voltage range that includes ground.

The LMC6044 is ideal for use in systems requiring ultra-low power consumption. In addition, the insensitivity to latch-up, high output drive, and output swing to ground without requiring external pull-down resistors make it ideal for single-supply battery-powered systems.

Other applications for the LMC6044 include bar code reader amplifiers, magnetic and electric field detectors, and hand-held electrometers.

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

See the LMC6041 for a single, and the LMC6042 for a dual amplifier with these features.

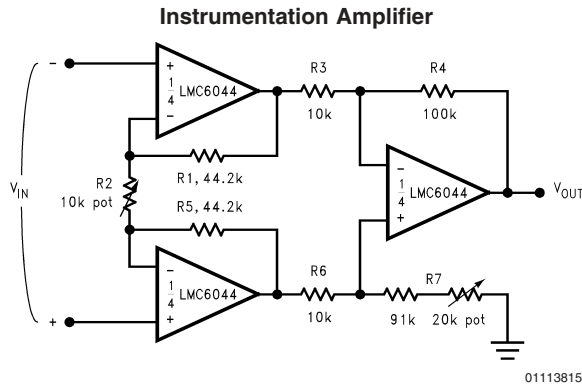
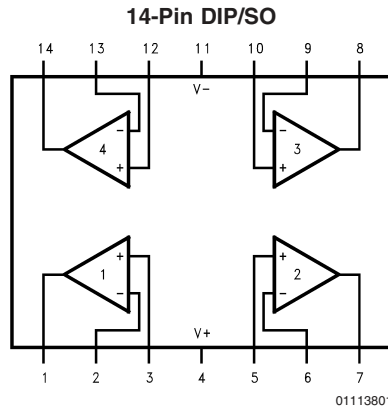
Features

- Low supply current: 10 μ A/Amp (Typ)
- Operates from 4.5V to 15.5V single supply
- Ultra low input current: 2 fA (Typ)
- Rail-to-rail output swing
- Input common-mode range includes ground

Applications

- Battery monitoring and power conditioning
- Photodiode and infrared detector preamplifier
- Silicon based transducer systems
- Hand-held analytic instruments
- pH probe buffer amplifier
- Fire and smoke detection systems
- Charge amplifier for piezoelectric transducers

Connection Diagram



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
Supply Voltage (V ⁺ – V ⁻)	16V
Output Short Circuit to V ⁺	(Note 12)
Output Short Circuit to V ⁻	(Note 2)
Lead Temperature (Soldering, 10 sec.)	260°C
Current at Input Pin	±5 mA
Current at Output Pin	±18 mA
Current at Power Supply Pin	35 mA
Power Dissipation	(Note 3)
Storage Temperature Range	-65°C to +150°C

Junction Temperature (Note 3)	110°C
ESD Tolerance (Note 4)	500V
Voltage at I/O Pin (V ⁺)	+0.3V, (V ⁻) -0.3V

Operating Ratings

Temperature Range LMC6044AI, LMC6044I	-40°C ≤ T _J ≤ +85°C
Supply Voltage	4.5V ≤ V ₊ ≤ 15.5V
Power Dissipation	(Note 10)
Thermal Resistance (θ _{JA}), (Note 11)	
14-Pin DIP	85°C/W
14-Pin SO	115°C/W

Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_A = T_J = 25°C. **Boldface** limits apply at the temperature extremes. V⁺ = 5V, V⁻ = 0V, V_{CM} = 1.5V, V_O = V⁺/2, and R_L > 1M unless otherwise specified.

Symbol	Parameter	Conditions	Typical (Note 5)	LMC6044AI	LMC6044I	Units (Limit)	
				Limit (Note 6)	Limit (Note 6)		
V _{OS}	Input Offset Voltage		1	3 3.3	6 6.3	mV max	
TCV _{OS}	Input Offset Voltage Average Drift		1.3			µV/°C	
I _B	Input Bias Current		0.002	4	4	pA max	
I _{OS}	Input Offset Current		0.001	2	2	pA max	
R _{IN}	Input Resistance		>10			TeraΩ	
CMRR	Common Mode Rejection Ratio	0V ≤ V _{CM} ≤ 12.0V V ⁺ = 15V	75	68 66	62 60	dB min	
+PSRR	Positive Power Supply Rejection Ratio	5V ≤ V ⁺ ≤ 15V V _O = 2.5V	75	68 66	62 60	dB min	
-PSRR	Negative Power Supply Rejection Ratio	0V ≤ V ⁻ ≤ -10V V _O = 2.5V	94	84 83	74 73	dB min	
CMR	Input Common-Mode Voltage Range	V ⁺ = 5V & 15V For CMRR ≥ 50 dB	-0.4	-0.1 0	-0.1 0	V max	
			V ⁺ – 1.9V	V ⁺ – 2.3V V⁺ – 2.5V	V ⁺ – 2.3V V⁺ – 2.4V	V min	
A _V	Large Signal Voltage Gain	R _L = 100 kΩ (Note 7)	Sourcing	1000	400 300	300 200	V/mV min
			Sinking	500	180 120	90 70	V/mV min
		R _L = 25 kΩ (Note 7)	Sourcing	1000	200 160	100 80	V/mV min
			Sinking	250	100 60	50 40	V/mV min

Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for $T_A = T_J = 25^\circ\text{C}$. **Boldface** limits apply at the temperature extremes. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.5\text{V}$, $V_O = V^+/2$, and $R_L > 1\text{M}$ unless otherwise specified.

Symbol	Parameter	Conditions	Typical (Note 5)	LMC6044AI	LMC6044I	Units (Limit)
				Limit (Note 6)	Limit (Note 6)	
V_O	Output Swing	$V^+ = 5\text{V}$ $R_L = 100\text{ k}\Omega$ to 2.5V	4.987	4.970 4.950	4.940 4.910	V min
			0.004	0.030 0.050	0.060 0.090	V max
		$V^+ = 5\text{V}$ $R_L = 25\text{ k}\Omega$ to 2.5V	4.980	4.920 4.870	4.870 4.820	V min
			0.010	0.080 0.130	0.130 0.180	V max
		$V^+ = 15\text{V}$ $R_L = 100\text{ k}\Omega$ to $V^+/2$	14.970	14.920 14.880	14.880 14.820	V min
			0.007	0.030 0.050	0.060 0.090	V max
$V^+ = 15\text{V}$ $R_L = 25\text{ k}\Omega$ to $V^+/2$	14.950	14.900 14.850	14.850 14.800	V min		
	0.022	0.100 0.150	0.150 0.200	V max		
I_{SC}	Output Current $V^+ = 5\text{V}$	Sourcing, $V_O = 0\text{V}$	22	16 10	13 8	mA min
		Sinking, $V_O = 5\text{V}$	21	16 8	13 8	mA min
I_{SC}	Output Current $V^+ = 15\text{V}$	Sourcing, $V_O = 0\text{V}$	40	15 10	15 10	mA min
		Sinking, $V_O = 13\text{V}$ (Note 12)	39	24 8	21 8	mA min
I_S	Supply Current	Four Amplifiers $V_O = 1.5\text{V}$	40	65 72	75 82	μA max
		Four Amplifiers $V^+ = 15\text{V}$	52	85 94	98 107	μA max

AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_A = T_J = 25^\circ\text{C}$. **Boldface** limits apply at the temperature extremes. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.5\text{V}$, $V_O = V^+/2$, and $R_L > 1\text{M}$ unless otherwise specified.

Symbol	Parameter	Conditions	Typical (Note 5)	LMC6044AI	LMC6044I	Units (Limit)
				Limit (Note 6)	Limit (Note 6)	
SR	Slew Rate	(Note 8)	0.02	0.015 0.010	0.010 0.007	V/ μs min
GBW	Gain-Bandwidth Product		0.10			MHz
ϕ_m	Phase Margin		60			Deg
	Amp-to-Amp Isolation	(Note 9)	115			dB
e_n	Input-Referred Voltage Noise	$F = 1\text{ kHz}$	83			nV/ $\sqrt{\text{Hz}}$
i_n	Input-Referred Current Noise	$F = 1\text{ kHz}$	0.0002			pA/ $\sqrt{\text{Hz}}$

AC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for $T_A = T_J = 25^\circ\text{C}$. **Boldface** limits apply at the temperature extremes. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.5\text{V}$, $V_O = V^+/2$, and $R_L > 1\text{M}$ unless otherwise specified.

Symbol	Parameter	Conditions	Typical (Note 5)	LMC6044AI	LMC6044I	Units (Limit)
				Limit (Note 6)	Limit (Note 6)	
T.H.D.	Total Harmonic Distortion	$F = 1\text{ kHz}$, $A_V = -5$ $R_L = 100\text{ k}\Omega$, $V_O = 2 V_{\text{pp}}$ $\pm 5\text{V}$ 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 110°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 $T_{\text{J(max)}}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{\text{J(max)}} - T_A)/\theta_{\text{JA}}$.

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

Note 5: Typical Values represent the most likely parametric norm.

Note 6: All limits are guaranteed at room temperature (standard type face) or at operating temperature extremes (bold face type).

Note 7: $V^+ = 15\text{V}$, $V_{\text{CM}} = 7.5\text{V}$ and R_L connected to 7.5V . 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 10V step input. Number specified in 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 $V^+/2$. Each amp excited in turn with 100 Hz to produce $V_O = 12 V_{\text{pp}}$.

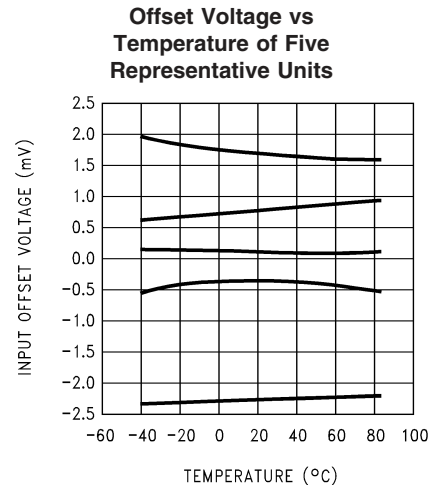
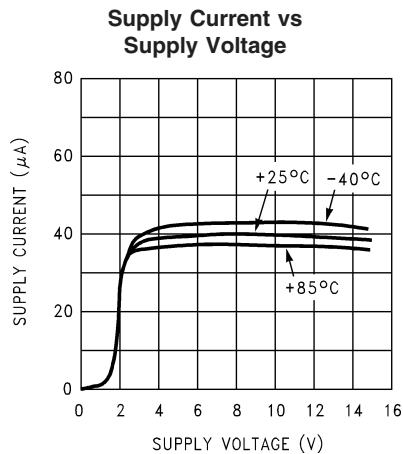
Note 10: For operating at elevated temperatures, the device must be derated based on the thermal resistance θ_{JA} with $P_D = (T_J - T_A)/\theta_{\text{JA}}$.

Note 11: All numbers apply for packages soldered directly into a PC board.

Note 12: Do not connect output to V^+ when V^+ is greater than 13V or reliability may be adversely affected.

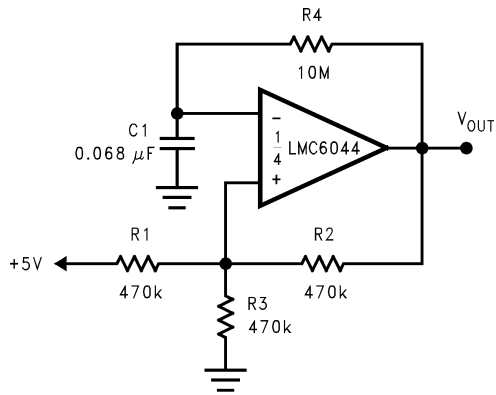
Typical Performance Characteristics

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



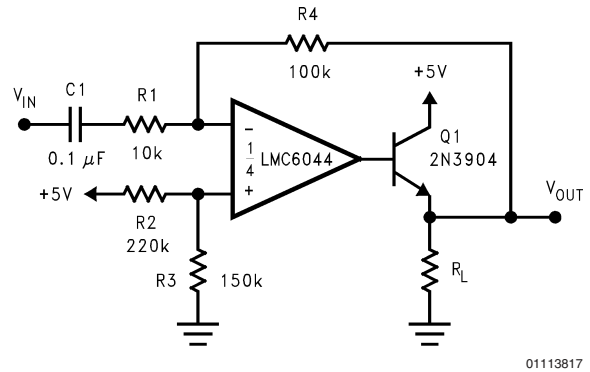
Typical Single-Supply Applications

(V+ = 5.0 V_{DC}) (Continued)



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FIGURE 11. 1 Hz Square-Wave Oscillator



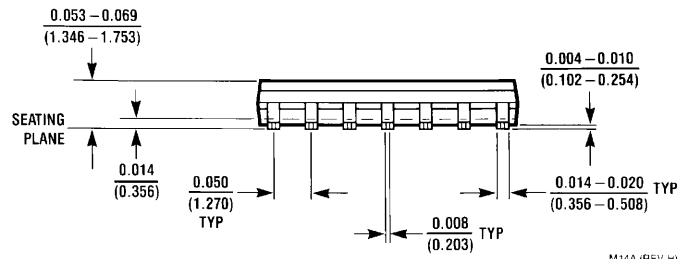
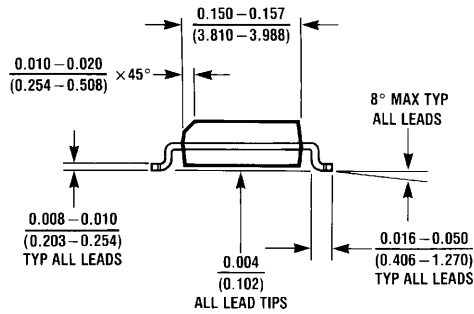
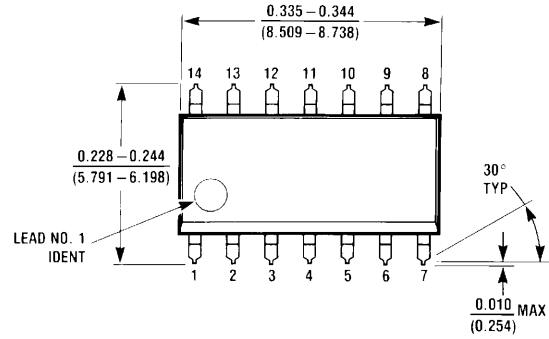
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FIGURE 12. AC Coupled Power Amplifier

Ordering Information

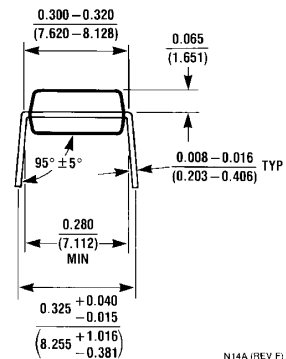
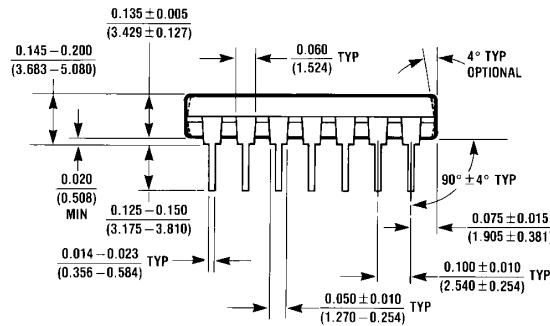
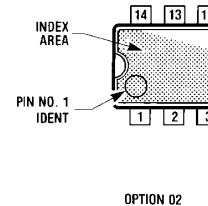
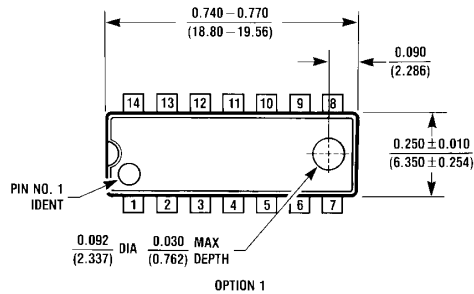
Package	Temperature Range	NSC Drawing	Transport Media
	Industrial -40°C to +85°C		
14-Pin Small Outline	LMC6044AIM, LMC6044AIMX	M14A	Rail Tape and Reel
14-Pin Molded DIP	LMC6044AIN LMC6044IN	N14A	Rail

Physical Dimensions inches (millimeters)
 unless otherwise noted



M14A (REV H)

14-Pin Small Outline
 Order Package Number LMC6044AIM, LMC6044AIMX, LMC6044IM or LMC6044IMX
 NS Package Number M14A



N14A (REV F)

14-Pin Molded DIP
 Order Package Number LMC6044AIN or LMC6044IN
 NS Package Number N14A