National Semiconductor

LMC6042
CMOS Dual Micropower Operational Amplifier

General Description

Ultra-low power consumption and low input-leakage current are the hallmarks of the LMC6042. Providing input currents of only 2 fA typical, the LMC6042 can operate from a single supply, has output swing extending to each supply rail, and an input voltage range that includes ground.

The LMC6042 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 LMC6042 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 LMC6044 for a quad amplifier with these features.

Features

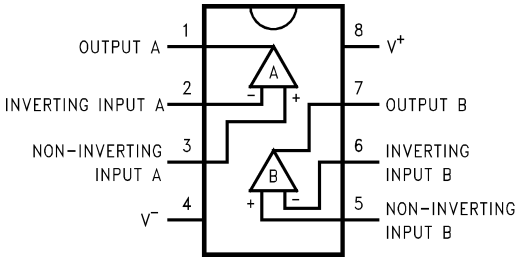
- Low supply current: 10 µA/Amp (typ)
- Operates from 4.5V to 15V single supply
- Ultra low input current: 2 fA (typ)
- Rail-to-rail output swing
- Input common-mode range includes ground

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

8-Pin DIP/SO



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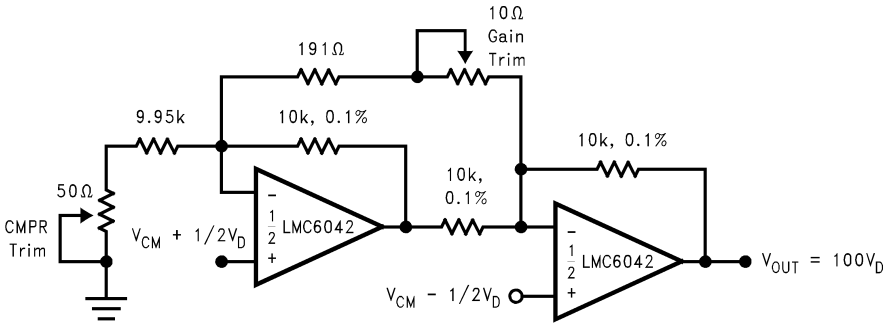
Low-Power Two-Op-Amp Instrumental Amplifier



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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 seconds)	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 Input/Output Pin	(V^+) + 0.3V, (V^-) − 0.3V

Operating Ratings

Temperature Range	
LMC6042AI, LMC6042I	$-40˚C \le T_J \le +85˚C$
Supply Voltage	$4.5V \le V^+ \le 15.5V$
Power Dissipation	(Note 10)
Thermal Resistance (θ_{JA}), (Note 11)	
8-Pin DIP	101˚C/W
8-Pin SO	165˚C/W

Electrical Characteristics

Unless otherwise spec ified, 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)	LMC6042AI Limit (Note 6)	LMC6042I Limit (Note 6)	Units (Limit)
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	$0V \le V_{CM} \le 12.0V$ $V^+ = 15V$		75	68 **66**	62 **60**	dB Min
+PSRR	Positive Power Supply Rejection Ratio	$5V \le V^+ \le 15V$ $V_O = 2.5V$		75	68 **66**	62 **60**	dB Min
−PSRR	Negative Power Supply Rejection Ratio	$0V \le V^- \le -10V$ $V_O = 2.5V$		94	84 **83**	74 **73**	dB Min
CMR	Input Common-Mode Voltage Range	$V^+ = 5V$ and 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 spec ified, all limits guaranteed for $T_A = T_J = 25^\circ C$. **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)	LMC6042AI Limit (Note 6)	LMC6042I Limit (Note 6)	Units (Limit)
V_O	Output Swing	$V^+ = 5V$ $R_L = 100\ k\Omega$ to $V^+/2$	4.987	4.970 **4.950**	4.940 **4.910**	V Min
			0.004	0.030 **0.050**	0.060 **0.090**	V Max
		$V^+ = 5V$ $R_L = 25\ k\Omega$ to $V^+/2$	4.980	4.920 **4.870**	4.870 **4.820**	V Min
			0.010	0.080 **0.130**	0.130 **0.180**	V Max
		$V^+ = 15V$ $R_L = 100\ k\Omega$ 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
		$V^+ = 15V$ $R_L = 25\ k\Omega$ 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 $V^+ = 5V$	Sourcing, $V_O = 0V$	22	16 **10**	13 **8**	mA Min
		Sinking, $V_O = 5V$	21	16 **8**	13 **8**	mA Min
I_{SC}	Output Current $V^+ = 15V$	Sourcing, $V_O = 0V$	40	15 **10**	15 **10**	mA Min
		Sinking, $V_O = 13V$ (Note 12)	39	24 **8**	21 **8**	mA Min
I_S	Supply Current	Both Amplifiers $V_O = 1.5V$	20	34 **39**	45 **50**	μA Max
		Both Amplifiers $V^+ = 15V$	26	44 **51**	56 **65**	μA Max

AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_A = T_J = 25^\circ C$. **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	Typ (Note 5)	LMC6042AI Limit (Note 6)	LMC6042I Limit (Note 6)	Units (Limit)
SR	Slew Rate	(Note 8)	0.02	0.015 **0.010**	0.010 **0.007**	V/μs Min
GBW	Gain-Bandwidth Product		100			kHz
ϕ_m	Phase Margin		60			Deg
	Amp-to-Amp Isolation	(Note 9)	115			dB
e_n	Input-Referred Voltage Noise	f = 1 kHz	83			$nV/\sqrt{Hz}$
i_n	Input-Referred Current Noise	f = 1 kHz	0.0002			$pA/\sqrt{Hz}$

AC Electrical Characteristics (Continued)

Unless otherwise specified, all limits guaranteed for $T_A = T_J = 25^\circ C$. **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	Typ (Note 5)	LMC6042AI Limit (Note 6)	LMC6042I Limit (Note 6)	Units (Limit)
T.H.D.	Total Harmonic Distortion	f = 1 kHz, $A_V = -5$ $R_L = 100\ k\Omega$, $V_O = 2\ V_{PP}$ ±5V Supply	0.01			%

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Conditions 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 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 ±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 at room temperature (standard type face) or at operating temperature extremes (bold face type).

Note 7: $V^+ = 15V$, $V_{CM} = 7.5V$ and R_L connected to 7.5V. For Sourcing tests, $7.5V \le V_O \le 11.5V$. For Sinking tests, $2.5V \le V_O \le 7.5V$.

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 $R_L = 100\ k\Omega$ connected to $V^+/2$. Each amp excited in turn with 100 Hz 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 $P_D = (T_J - T_A)/\theta_{JA}$.

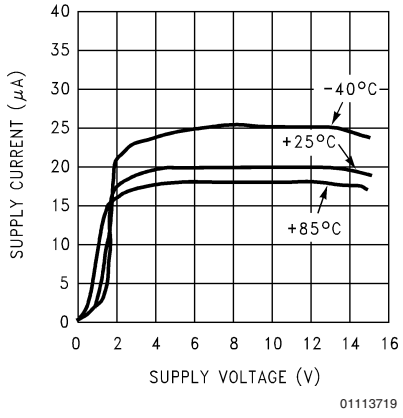
Note 11: All numbers apply for packages soldered directly into a PC board.

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

Typical Performance Characteristics

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

Supply Current vs Supply Voltage



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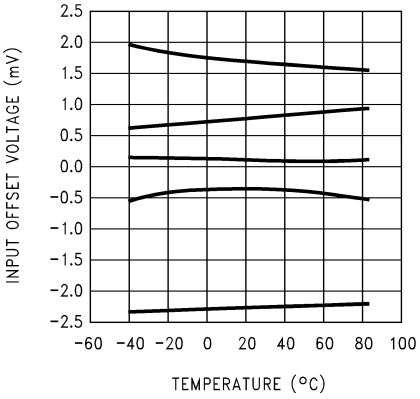
Offset Voltage vs Temperature of Five Representative Units



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Typical Single-Supply Applications (V^+ = 5.0 V_{DC}) (Continued)

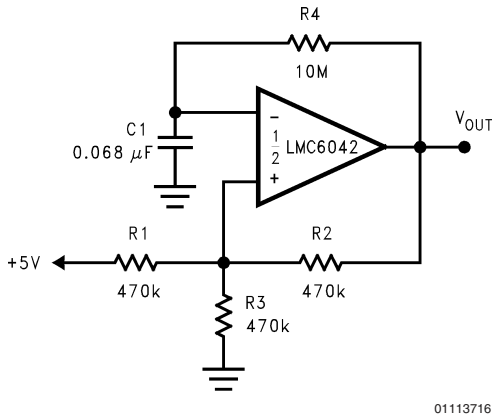


FIGURE 11. 1 Hz Square Wave Oscillator

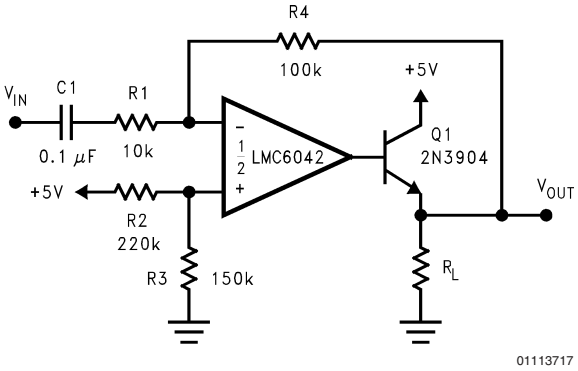


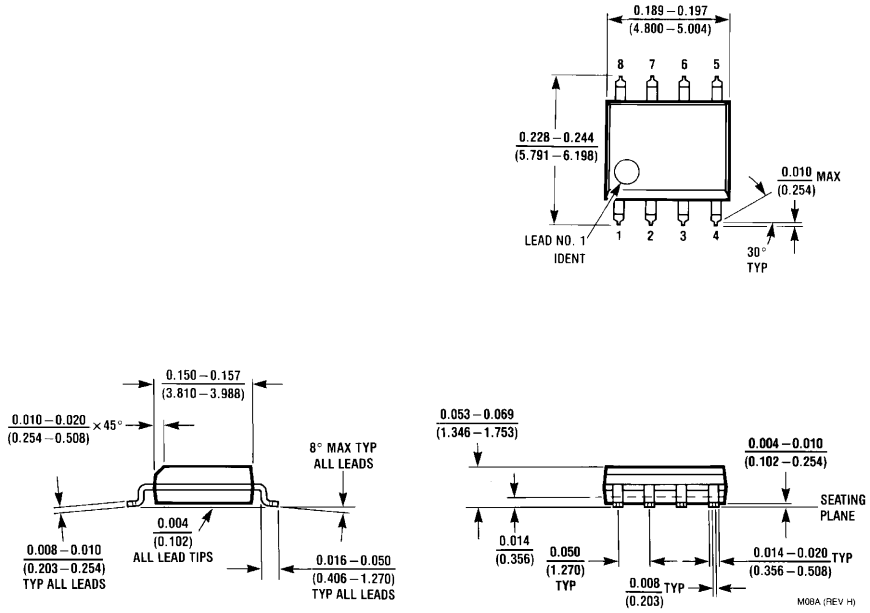
FIGURE 12. AC Coupled Power Amplifier

Ordering Information

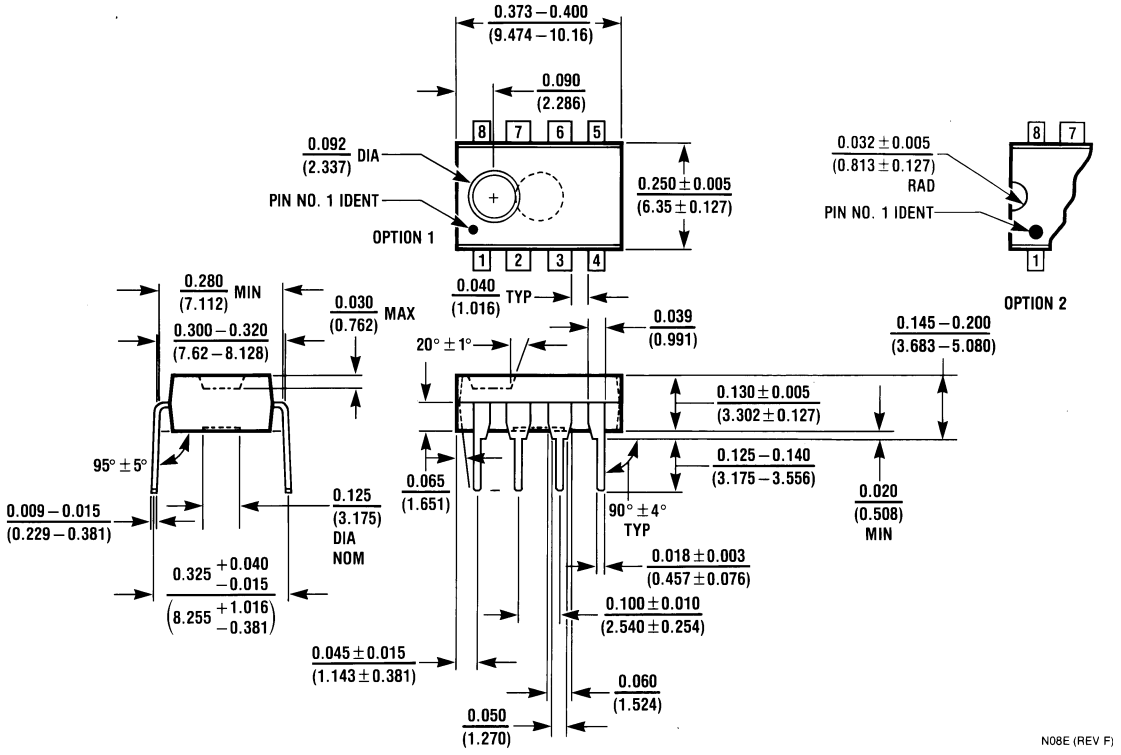
Package	Temperature Range Industrial –40˚C to +85˚C	NSC Drawing	Transport Media
8-Pin Small Outline	LMC6042AIM, LMC6042AIMX LMC6042IM, LMC6042IMX	M08A	Rail Tape and Reel
8-Pin Molded DIP	LMC6042AIN LMC6042IN	N08E	Rail

Physical Dimensions inches (millimeters)

unless otherwise noted



8-Pin Small Outline Package
Order Number LMC6042AIM, LMC6042AIMX, LMC6042IM or LMC6042IMX
NS Package Number M08A



8-Pin Molded Dual-In-Line Package
Order Number LMC6042AIN or LMC6042IN
NS Package Number N08E