National Semiconductor

LMC6061
Precision CMOS Single Micropower Operational Amplifier

General Description

The LMC6061 is a precision single low offset voltage, micropower operational amplifier, capable of precision 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 power consumption, make the LMC6061 ideally suited for battery powered applications.

Other applications using the LMC6061 include precision full-wave rectifiers, integrators, references, sample-and-hold circuits, and true instrumentation amplifiers.

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

For designs that require higher speed, see the LMC6081 precision single operational amplifier.

For a dual or quad operational amplifier with similar features, see the LMC6062 or LMC6064 respectively.

PATENT PENDING

Features

(Typical Unless Otherwise Noted)

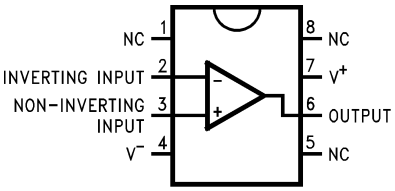
- Low offset voltage: 100 µV
- Ultra low supply current: 20 µA
- Operates from 4.5V to 15V single supply
- Ultra low input bias current: 10 fA
- Output swing within 10 mV of supply rail, 100k load
- Input common-mode range includes V^-
- High voltage gain: 140 dB
- Improved latchup immunity

Applications

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

Connection Diagram

8-Pin DIP/SO



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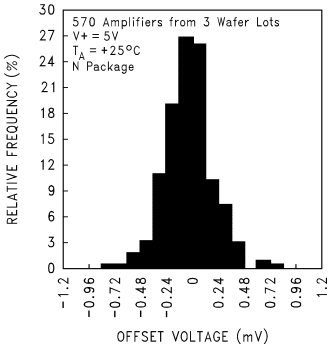
Top View

Distribution of LMC6061 Input Offset Voltage (T_A = +25°C)



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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
Voltage at Input/Output Pin	(V^+) +0.3V, (V^-) −0.3V
Supply Voltage ($V^+ - V^-$)	16V
Output Short Circuit to V^+	(Note 10)
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	
LMC6061AM	$-55^\circ C \le T_J \le +125^\circ C$
LMC6061AI, LMC6082I	$-40^\circ C \le T_J \le +85^\circ C$
Supply Voltage	$4.5V \le V^+ \le 15.5V$
Thermal Resistance (θ_{JA}) (Note 11)	
N Package, 8-Pin Molded DIP	115˚C/W
M Package, 8-Pin Surface Mount	193˚C/W
Power Dissipation	(Note 9)

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 9)	LMC6061AM Limit (Note 6)	LMC6061AI Limit (Note 6)	LMC6061I Limit (Note 6)	Units
V_{OS}	Input Offset Voltage			100	350 **1200**	350 **900**	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 **70**	75 **72**	66 **63**	dB Min
+PSRR	Positive Power Supply Rejection Ratio	5V ≤ V^+ ≤ 15V V_O = 2.5V		85	75 **70**	75 **72**	66 **63**	dB Min
−PSRR	Negative Power Supply Rejection Ratio	0V ≤ V^- ≤ −10V		100	84 **70**	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 = 100 kΩ (Note 7)	Sourcing	4000	400 **200**	400 **300**	300 **200**	V/mV Min
			Sinking	3000	180 **70**	180 **100**	90 **60**	V/mV Min
		R_L = 25 kΩ (Note 7)	Sourcing	3000	400 **150**	400 **150**	200 **80**	V/mV Min
			Sinking	2000	100 **35**	100 **50**	70 **35**	V/mV Min

DC Electrical Characteristics (Continued)

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 9)	LMC6061AM Limit (Note 6)	LMC6061AI Limit (Note 6)	LMC6061I Limit (Note 6)	Units
V_O	Output Swing	V^+ = 5V R_L = 100 kΩ to 2.5V	4.995	4.990 **4.970**	4.990 **4.980**	4.950 **4.925**	V Min
			0.005	0.010 **0.030**	0.010 **0.020**	0.050 **0.075**	V Max
		V^+ = 5V R_L = 25 kΩ to 2.5V	4.990	4.975 **4.955**	4.975 **4.965**	4.950 **4.850**	V Min
			0.010	0.020 **0.045**	0.020 **0.035**	0.050 **0.150**	V Max
		V^+ = 15V R_L = 100 kΩ to 7.5V	14.990	14.975 **14.955**	14.975 **14.965**	14.950 **14.925**	V Min
			0.010	0.025 **0.050**	0.025 **0.035**	0.050 **0.075**	V Max
		V^+ = 15V R_L = 25 kΩ to 7.5V	14.965	14.900 **14.800**	14.900 **14.850**	14.850 **14.800**	V Min
			0.025	0.050 **0.200**	0.050 **0.150**	0.100 **0.200**	V Max
I_O	Output Current V^+ = 5V	Sourcing, V_O = 0V	22	16 **8**	16 **10**	13 **8**	mA Min
		Sinking, V_O = 5V	21	16 **7**	16 **8**	16 **8**	mA Min
I_O	Output Current V^+ = 15V	Sourcing, V_O = 0V	25	15 **9**	15 **10**	15 **10**	mA Min
		Sinking, V_O = 13V (Note 10)	26	20 **7**	20 **8**	20 **8**	mA Min
I_S	Supply Current	V^+ = +5V, V_O = 1.5V	20	24 **35**	24 **32**	32 **40**	µA Max
		V^+ = +15V, V_O = 7.5V	24	30 **40**	30 **38**	40 **48**	µA 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)	LMC6061AM Limit (Note 6)	LMC6061AI Limit (Note 6)	LMC6061I Limit (Note 6)	Units
SR	Slew Rate	(Note 8)	35	20 **8**	20 **10**	15 **7**	V/ms Min
GBW	Gain-Bandwidth Product		100				kHz
θ_m	Phase Margin		50				Deg
e_n	Input-Referred Voltage Noise	F = 1 kHz	83				$nV/\sqrt{Hz}$
i_n	Input-Referred Current Noise	F = 1 kHz	0.0002				$pA/\sqrt{Hz}$
T.H.D.	Total Harmonic Distortion	F = 1 kHz, A_V = −5 R_L = 100 kΩ, V_O = 2 V_{PP} ±5V Supply	0.01				%

AC Electrical Characteristics (Continued)

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. Continous 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, $7.5V \le V_O \le 11.5V$. 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: 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 10: Do not connect output to V^+, when V^+ is greater than 13V or reliability witll be adversely affected.

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

Note 12: For guaranteed Military Temperature Range parameters see RETSMC6061X.

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

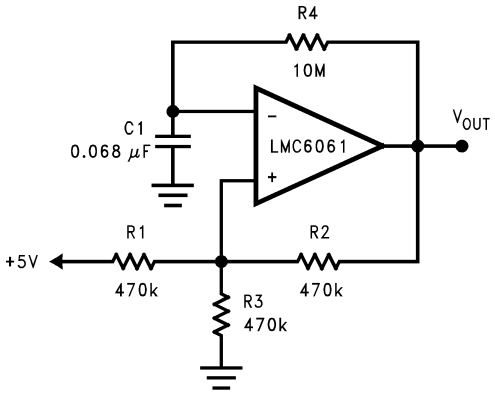
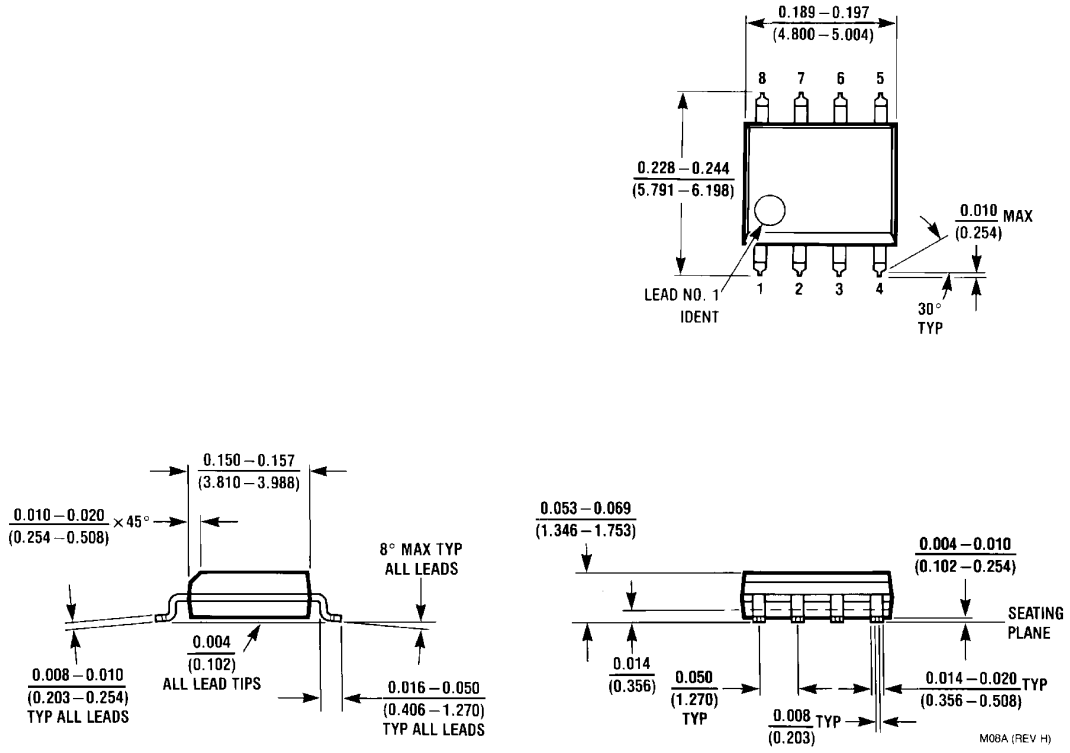


FIGURE 9. 1 Hz Square Wave Oscillator

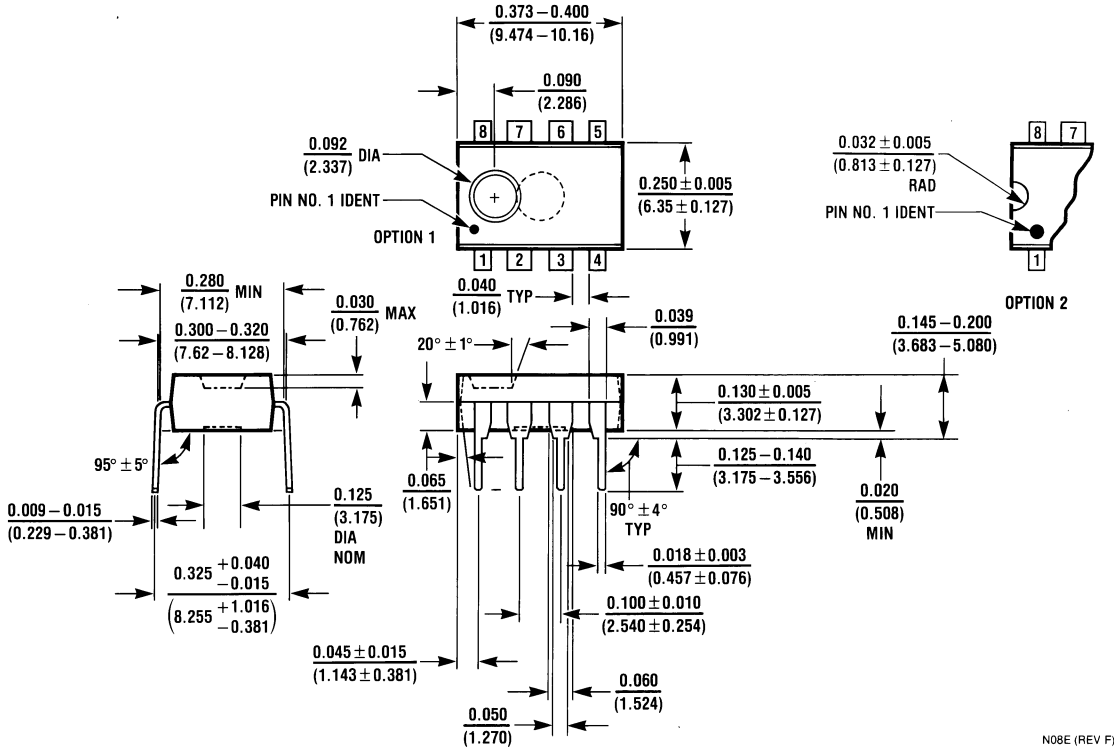
Ordering Information

Package	Temperature Range		NSC Drawing	Transport Media
	Military −55˚C to +125˚C	Industrial −40˚C to +85˚C		
8-Pin Molded DIP		LMC6061AIN LMC6061IN	N08E	Rail
8-Pin Small Outline		LMC6061AIM, LMC606AIMX LMC6061IM, LMC6061IMX	M08A	Rail Tape and Reel
8-Pin Ceramic DIP	LMC6061AMJ/883		J08A	Rail

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



8-Pin Small Outline Package
Order Number LMC6061AIM, LMC6061AIMX, LMC6061IM or LMC6061IMX
NS Package Number M08A



8-Pin Molded Dual-In-Line Package
Order Number LMC6061AIN or LMC6061IN
NS Package Number N08E