

LPC660AM/LPC660AI/LPC660I CMOS Quad Operational Amplifier

General Description

The LPC660 CMOS Quad operational amplifier is ideal for operation from a single supply. It is fully specified for operation from +5V to +15V and features rail-to-rail output swing in addition to an input common-mode range that includes ground. Performance limitations that have plagued CMOS amplifiers in the past are not a problem with this design. Input V_{OS} , drift, and broadband noise as well as voltage gain (into 100 k Ω and 5 k Ω) are all equal to or better than widely accepted bipolar equivalents, while the power supply requirement is less than 1 mW.

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

See the LPC662 datasheet for a Dual CMOS operational amplifier with these same features.

- High-impedance preamplifier
- Active filter
- Sample-and-Hold circuit
- Peak detector

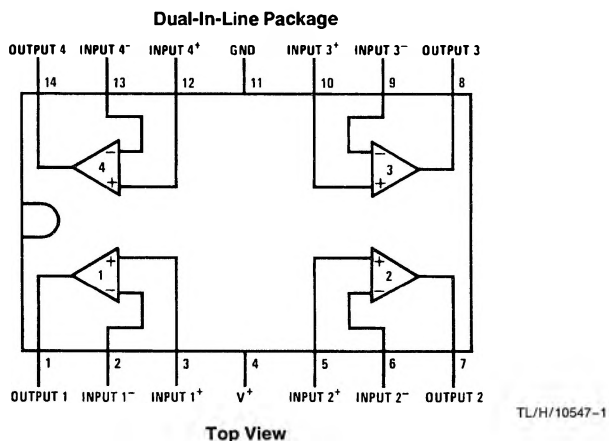
Features

- Rail-to-rail output swing
- Micropower operation (1 mW)
- Specified for 100 k Ω and 5 k Ω loads
- High voltage gain 120 dB
- Low input offset voltage 3 mV max
- Low offset voltage drift 1.3 $\mu\text{V}/^\circ\text{C}$
- Ultra low input bias current 40 fA
- Input common-mode includes GND
- Operation guaranteed from +5V to +15V
- Low distortion 0.01% at 1 kHz
- Slew rate 0.11 V/ μs
- Insensitive to latch-up

Applications

- High-impedance buffer
- Precision current-to-voltage converter
- Long-term integrator

Connection Diagram



Ordering Information

Package	Temperature Range		NSC Drawing
	Military	Industrial	
14-Pin Cavity DIP	LPC660AMD		D14E
14-Pin Small Outline		LPC660AIM or LPC660IM	M14A
14-Pin Molded DIP		LPC660AIN or LPC660IN	N14A

Absolute Maximum Ratings (Note 3)

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

Differential Input Voltage	± Supply Voltage
Either Input beyond V^+ or V^-	0.7V
Supply Voltage ($V^+ - V^-$)	16V
Output Short Circuit to GND (Note 1)	Continuous
Lead Temperature (Soldering, 10 sec.)	260°C
Storage Temp. Range	-65°C to +150°C

Junction Temperature (Note 2)
ESD rating is to be determined.

150°C

Operating Ratings

Temperature Range	-55°C ≤ T _J ≤ +125°C
LPC660AM	-40°C ≤ T _J ≤ +85°C
LPC660AI	-40°C ≤ T _J ≤ +85°C
LPC660I	-40°C ≤ T _J ≤ +85°C
Supply Range	4.75V to 15.5V

DC 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.

Parameter	Conditions	Typ	LPC660AM	LPC660AI	LPC660I	Units
			Limit (Note 4)	Limit (Note 4)	Limit (Note 4)	
Input Offset Voltage		1	3	3	6	mV
			3.5	3.3	6.3	max
Input Offset Voltage Average Drift		1.3				μV/°C
Input Bias Current	(Note 8)	0.04	20	20	20	pA
			100	4	4	max
Input Offset Current	(Note 8)	0.01	20	20	20	pA
			100	2	2	max
Input Resistance		> 1				Tera Ω
Common Mode Rejection Ratio	0V ≤ V _{CM} ≤ 12.0V V ⁺ = 15V	83	70	70	63	dB
			68	68	61	min
Positive Power Supply Rejection Ratio	5V ≤ V ⁺ ≤ 15V V _O = 2.5V	83	70	70	63	dB
			68	68	61	min
Negative Power Supply Rejection Ratio	0V ≤ V ⁻ ≤ -10V	94	84	84	74	dB
			82	83	73	min
Input Common Mode Voltage Range	V ⁺ = 5V & 15V For CMRR > 50 dB	-0.4	-0.1	-0.1	-0.1	V
			0	0	0	max
		V ⁺ - 1.9	V ⁺ - 2.3	V ⁺ - 2.3	V ⁺ - 2.3	V
			V⁺ - 2.6	V⁺ - 2.5	V⁺ - 2.5	min
Large Signal Voltage Gain	R _L = 100 kΩ (Note 5) Sourcing	1000	400	400	300	V/mV
			250	300	200	min
	Sinking	500	180	180	90	V/mV
			70	120	70	min
	R _L = 5 kΩ (Note 5) Sourcing	1000	200	200	100	V/mV
			150	160	80	min
	Sinking	250	100	100	50	V/mV
			35	60	40	min

DC Electrical Characteristics

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

Parameter	Conditions	Typ	LPC660AM	LPC660AI	LPC660I	Units
			Limit (Note 4)	Limit (Note 4)	Limit (Note 4)	
Output Swing	$V^+ = 5\text{V}$ $R_L = 100\text{ k}\Omega$ to $V^+ / 2$	4.987	4.970	4.970	4.940	V min
			4.950	4.950	4.910	
		0.004	0.030	0.030	0.060	V max
			0.050	0.050	0.090	
	$V^+ = 5\text{V}$ $R_L = 5\text{ k}\Omega$ to $V^+ / 2$	4.940	4.850	4.850	4.750	V min
			4.750	4.750	4.650	
		0.040	0.150	0.150	0.250	V max
			0.250	0.250	0.350	
	$V^+ = 15\text{V}$ $R_L = 100\text{ k}\Omega$ to $V^+ / 2$	14.970	14.920	14.920	14.880	V min
			14.880	14.880	14.820	
		0.007	0.030	0.030	0.060	V max
			0.050	0.050	0.090	
	$V^+ = 15\text{V}$ $R_L = 5\text{ k}\Omega$ to $V^+ / 2$	14.840	14.680	14.680	14.580	V min
			14.600	14.600	14.480	
		0.110	0.220	0.220	0.320	V max
			0.300	0.300	0.400	
Output Current $V^+ = 5\text{V}$	Sourcing, $V_O = 0\text{V}$	22	16	16	13	mA min
			12	14	11	
	Sinking, $V_O = 5\text{V}$	21	16	16	13	mA min
			12	14	11	
Output Current $V^+ = 15\text{V}$	Sourcing, $V_O = 0\text{V}$	40	19	28	23	mA min
			19	25	20	
	Sinking, $V_O = 13\text{V}$	39	19	28	23	mA min
			19	24	19	
Supply Current	All Four Amplifiers $V_O = 1.5\text{V}$	160	200	200	240	μA max
			250	230	270	

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. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{CM} = 1.5\text{V}$, $V_O = V^+/2$, and $R_L > 1\text{M}$ unless otherwise specified.

Parameter	Conditions	Typ	LPC660AM	LPC660AI	LPC660I	Units
			Limit (Note 4)	Limit (Note 4)	Limit (Note 4)	
Slew Rate	(Note 6)	0.11	0.07	0.07	0.05	$\text{V}/\mu\text{s}$ min
			0.04	0.05	0.03	
Gain-Bandwidth Product		0.35				MHz
Phase Margin		50				Deg
Gain Margin		17				dB
Amp-to-Amp Isolation	(Note 7)	130				dB
Input Referred Voltage Noise	$F = 1\text{ kHz}$	42				$\text{nV}/\sqrt{\text{Hz}}$
Input Referred Current Noise	$F = 1\text{ kHz}$	0.0002				$\text{pA}/\sqrt{\text{Hz}}$
Total Harmonic Distortion	$F = 10\text{ kHz}$, $A_V = -10$ $R_L = 100\text{ k}\Omega$, $V_O = 8\text{ V}_{pp}$	0.01				%

Note 1: Applies to both single supply and split supply operation. Continuous short circuit operation at elevated ambient temperature and/or multiple Op Amp shorts can result in exceeding the maximum allowed junction temperature of 150°C .

Note 2: The junction-to-ambient thermal resistance of the molded plastic DIP (N) is $101^\circ\text{C}/\text{W}$, the molded plastic SO (M) package is $152^\circ\text{C}/\text{W}$, and the cavity DIP (D) package is $124^\circ\text{C}/\text{W}$. All numbers apply for packages soldered directly into a PC board.

Note 3: 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 4: These limits are guaranteed and are used in calculating outgoing AQL.

Note 5: $V^+ = 15\text{V}$, $V_{CM} = 7.5\text{V}$ 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, $2.5\text{V} \leq V_O \leq 7.5\text{V}$.

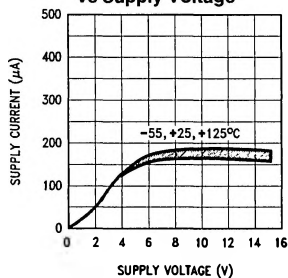
Note 6: $V^+ = 15\text{V}$. Connected as Voltage Follower with 10V step input. Number specified is the slower of the positive and negative slew rates.

Note 7: Input referred. $V^+ = 15\text{V}$ and $R_L = 100\text{ k}\Omega$ connected to $V^+/2$. Each amp excited in turn with 1 kHz to produce $V_O = 13\text{ V}_{pp}$.

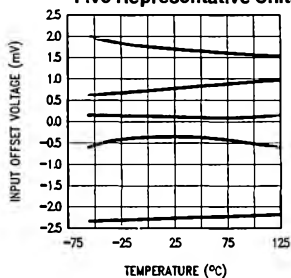
Note 8: The LPC660AI and the LPC660I input bias current and input offset current specifications over the temperature range are guaranteed through correlation techniques; these numbers reflect the true performance of the part. All other input bias and offset current specifications (other than the typical) are measured; these numbers are degraded in order to reduce the test time (and the cost of the part) taken in measuring these parameters.

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

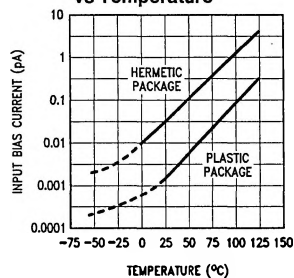
Supply Current vs Supply Voltage



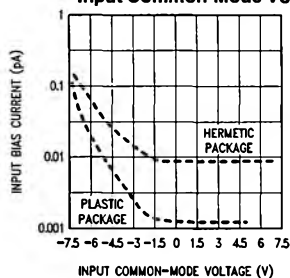
Offset Voltage vs Temperature of Five Representative Units



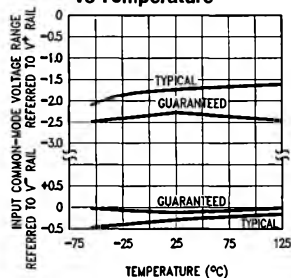
Input Bias Current vs Temperature



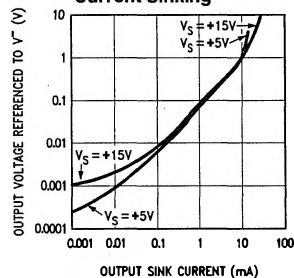
Input Bias Current vs Input Common-Mode Voltage



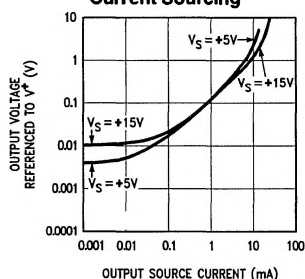
Common-Mode Voltage Range vs Temperature



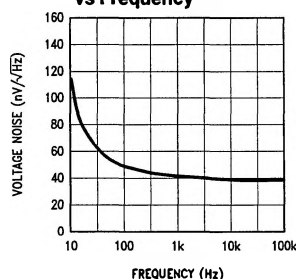
Output Characteristics Current Sinking



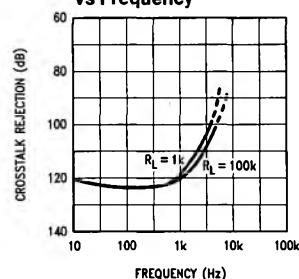
Output Characteristics Current Sourcing



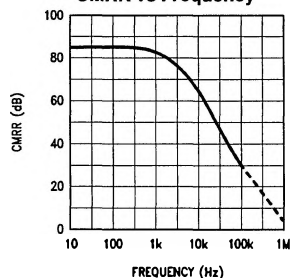
Input Voltage Noise vs Frequency



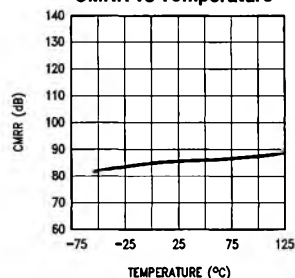
Crosstalk Rejection vs Frequency



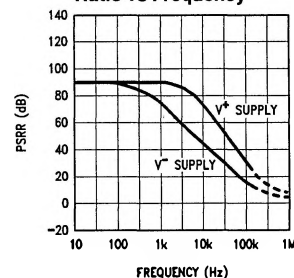
CMRR vs Frequency



CMRR vs Temperature



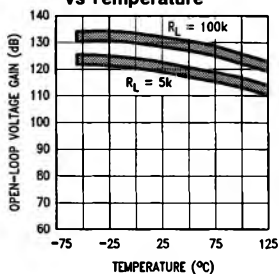
Power Supply Rejection Ratio vs Frequency



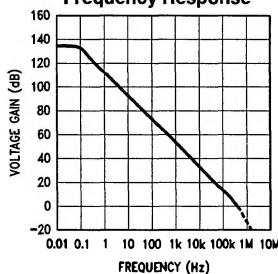
TL/H/10547-2

Typical Performance Characteristics $V_S = \pm 7.5V$, $T_A = 25^\circ C$ unless otherwise specified (Continued)

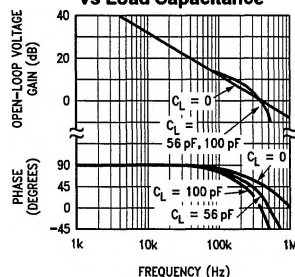
Open-Loop Voltage Gain vs Temperature



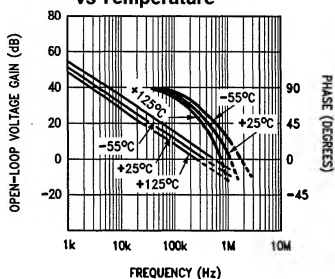
Open-Loop Frequency Response



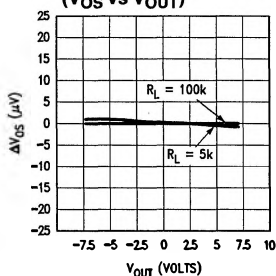
Gain and Phase Responses vs Load Capacitance



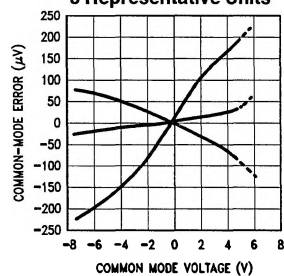
Gain and Phase Responses vs Temperature



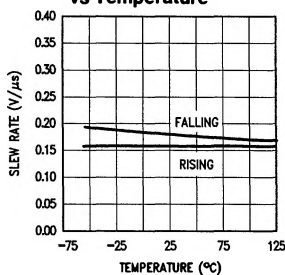
Gain Error (V_{OS} vs V_{OUT})



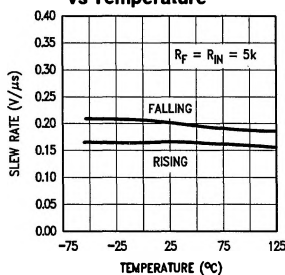
Common-Mode Error of 3 Representative Units



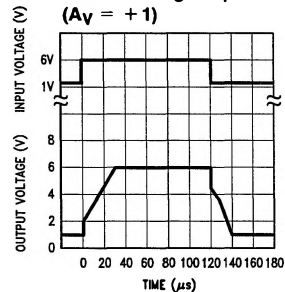
Non-Inverting Slew Rate vs Temperature



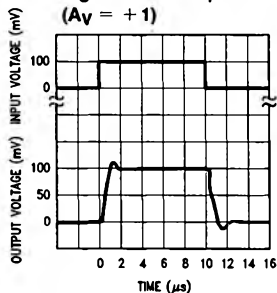
Inverting Slew Rate vs Temperature



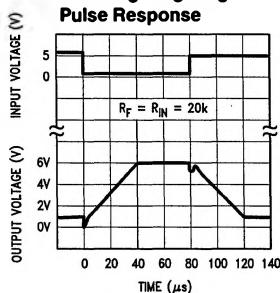
Large-Signal Pulse Non-Inverting Response ($A_V = +1$)



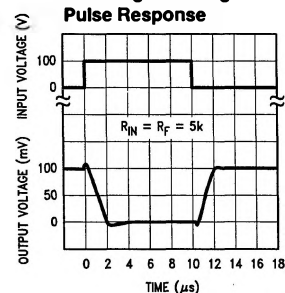
Non-Inverting Small Signal Pulse Response ($A_V = +1$)



Inverting Large-Signal Pulse Response

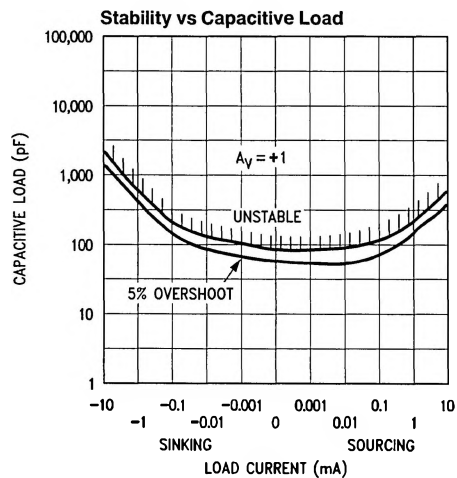


Inverting Small-Signal Pulse Response



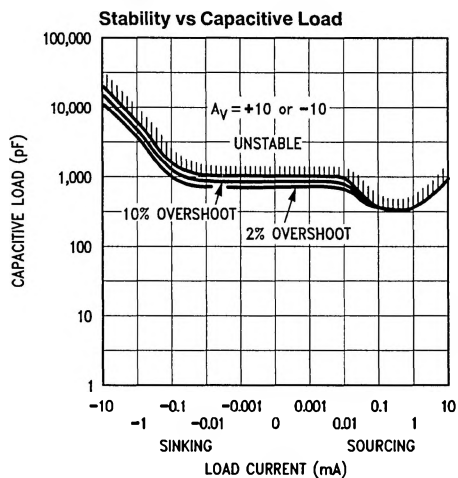
TL/H/10547-3

Typical Performance Characteristics $V_S = \pm 7.5V$, $T_A = 25^\circ C$ (Continued)



TL/H/10547-4

Note: Avoid resistive loads of less than 500Ω , as they may cause instability.



TL/H/10547-5