élantec
HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

EL2074/EL2074C

400 MHz GBWP Gain-of-2 Stable Operational Amplifier

ELANTEC INC T-79-06-10

Features

- 400 MHz gain-bandwidth product
- Gain-of-2 stable
- Ultra low video distortion = 0.01%/0.015° @ NTSC/PAL
- Conventional voltage-feedback topology
- Low offset voltage = 200 μV
- Low bias current = 2 μA
- Low offset current = 0.1 μA
- Output current = 50 mA over temperature
- Fast settling = 13 ns to 0.1%
- Low distortion = −55 dB HD2, −70 dB HD3 @ 20 MHz, 2 V_{PP}, $A_V = +2$

Applications

- High resolution video
- Active filters/integrators
- High-speed signal processing
- ADC/DAC buffers
- Pulse/RF amplifiers
- Pin diode receivers
- Log amplifiers
- Photo multiplier amplifiers
- High speed sample-and-holds

Ordering Information

Part No.	Temp. Range	Package	Outline #
EL2074CN	0°C to +75°C	8-Pin P-DIP	MDP0031
EL2074CS	0°C to +75°C	8-Lead SO	MDP0027
EL2074J/883B	−55°C to +125°C	8-Pin CerDIP	MDP0010

General Description

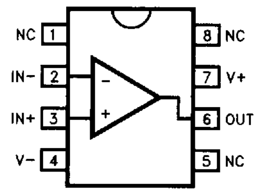
The EL2074 is a precision voltage-feedback amplifier featuring a 400 MHz gain-bandwidth product, fast settling time, excellent differential gain and differential phase performance, and a minimum of 50 mA output current drive over temperature.

The EL2074 is gain-of-2 stable with a −3 dB bandwidth of 400 MHz at $A_V = +2$. It has a very low 200 μV of input offset voltage, only 2 μA of input bias current, and a fully symmetrical differential input. Like all voltage-feedback operational amplifiers, the EL2074 allows the use of reactive or non-linear components in the feedback loop. This combination of speed and versatility makes the EL2074 the ideal choice for all op-amp applications at a noise gain of 2 or greater requiring high speed and precision, including active filters, integrators, sample-and-holds, and log amps. The low distortion, high output current, and fast settling makes the EL2074 an ideal amplifier for signal-processing and digitizing systems.

Elantec products and facilities comply with MIL-STD-883 Revision C, MIL-I-45208A, and other applicable quality specifications. For information on Elantec's military processing, see Elantec document, QRA-2: *Elantec's Military Processing, Monolithic Integrated Circuits.*

Connection Diagram

DIP and SO Package



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August 1992 Rev B

EL2074/EL2074C

ELANTEC INC

400 MHz GBWP Gain-of-2 Stable Operational Amplifier

Absolute Maximum Ratings (T_A = 25°C)

Supply Voltage (V_S)	±7V
Output Current	Output is short-circuit protected to ground, however, maximum reliability is obtained if I_{OUT} does not exceed 70 mA.
Common-Mode Input	$\pm V_S$
Differential Input Voltage	5V
Thermal Resistance	θ_{JA} = 95°C/W P-DIP θ_{JA} = 125°C/W CerDIP θ_{JA} = 175°C/W SO-8
Operating Temperature	
EL2074	−55°C to +125°C
EL2074C	0°C to +75°C
Lead Temperature	
DIP Package (Soldering: <5 seconds −CN; <10 seconds −J)	300°C
SO Package	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
Junction Temperature	175°C
Storage Temperature	−60°C to +150°C

Note: See EL2071/EL2171 for Thermal Impedance curves.

Important Note:
All parameters having Min/Max specifications are guaranteed. The Test Level column indicates the specific device testing actually performed during production and Quality inspection. Elantec performs most electrical tests using modern high-speed automatic test equipment, specifically the LTX77 Series system. Unless otherwise noted, all tests are pulsed tests, therefore $T_J = T_C = T_A$.

Test Level	Test Procedure
I	100% production tested and QA sample tested per QA test plan QCX0002.
II	100% production tested at T_A = 25°C and QA sample tested at T_A = 25°C, T_{MAX} and T_{MIN} per QA test plan QCX0002.
III	QA sample tested per QA test plan QCX0002.
IV	Parameter is guaranteed (but not tested) by Design and Characterization Data.
V	Parameter is typical value at T_A = 25°C for information purposes only.

Open Loop DC Electrical Characteristics

V_S = ±5V, R_L = 100Ω, unless otherwise specified

Parameter	Description	Test Conditions	Temp	Min	Typ	Max	Test Level EL2074	Test Level EL2074C	Units
V_{OS}	Input Offset Voltage	V_{CM} = 0V	25°C		0.2	1.5	I	I	mV
			T_{MIN}, T_{MAX}			3	I	III	mV
TCV_{OS}	Average Offset Voltage Drift	(Note 1)	All		8		V	V	μV/°C
I_B	Input Bias Current	V_{CM} = 0V	All		2	6	I	II	μA
I_{OS}	Input Offset Current	V_{CM} = 0V	25°C		0.1	1	I	I	μA
			T_{MIN}, T_{MAX}			2	I	III	μA
PSRR	Power Supply Rejection Ratio	(Note 2)	All	60	80		I	II	dB
CMRR	Common Mode Rejection Ratio	(Note 3)	All	65	90		I	II	dB
I_S	Supply Current—Quiescent	No Load	25°C		21	23	I	I	mA
			T_{MIN}, T_{MAX}			25	I	III	mA
R_{IN} (diff)	R_{IN} (Differential)	Open-Loop	25°C		15		V	V	kΩ
C_{IN} (diff)	C_{IN} (Differential)	Open-Loop	25°C		1		V	V	pF
R_{IN} (cm)	R_{IN} (Common-Mode)		25°C		1		V	V	MΩ
C_{IN} (cm)	C_{IN} (Common-Mode)		25°C		1		V	V	pF

Open Loop DC Electrical Characteristics

$V_S = \pm 5V$, $R_L = 100\Omega$, unless otherwise specified — Contd.

Parameter	Description	Test Conditions	Temp	Min	Typ	Max	Test Level EL2074	Test Level EL2074C	Units
R_{OUT}	Output Resistance		25°C		20		V	V	mΩ
CMIR	Common-Mode Input Range		25°C	±3	±3.5		IV	IV	V
			T_{MIN}, T_{MAX}	±2.5			IV	IV	V
I_{OUT}	Output Current		All	50	70		I	II	mA
V_{OUT}	Output Voltage Swing	No Load	All	±3.5	±4		I	II	V
V_{OUT} 100	Output Voltage Swing	100Ω	All	±3	±3.6		I	II	V
V_{OUT} 50	Output Voltage Swing	50Ω	All	±2.5	±3.4		I	II	V
A_{VOL} 100	Open-Loop Gain	100Ω	25°C	500	1000		I	I	V/V
			T_{MIN}, T_{MAX}	400			I	III	V/V
A_{VOL} 50	Open-Loop Gain	50Ω	25°C	400	800		I	I	V/V
			T_{MIN}, T_{MAX}	300			I	III	V/V
eN@ > 1 MHz	Noise Voltage 1–100 MHz		25°C		2.3		V	V	$nV/\sqrt{Hz}$
iN@ > 100 kHz	Noise Current 100k–100 MHz		25°C		3.2		V	V	$pA/\sqrt{Hz}$

Closed Loop AC Electrical Characteristics

$V_S = \pm 5V$, $A_V = +2$, $Rf = Rg = 250\Omega$, $Cf = 3pF$, $R_L = 100\Omega$ unless otherwise specified

Parameter	Description	Test Conditions	Temp	Min	Typ	Max	Test Level EL2074	Test Level EL2074C	Units
SSBW	−3 dB Bandwidth ($V_{OUT} = 0.4V_{PP}$)	$A_V = -1$	25°C		400		V	V	MHz
		$A_V = +2$	25°C	250	400		I	III	MHz
			T_{MIN}, T_{MAX}	250			IV	IV	MHz
		$A_V = +5$	25°C		100		V	V	MHz
		$A_V = +10$	25°C		40		V	V	MHz
GBWP	Gain-Bandwidth Product	$A_V = +10$	25°C		400		V	V	MHz
LSBWa	−3 dB Bandwidth	$V_{OUT} = 2\ V_{PP}$ (Note 4)	All	43	63		IV	IV	MHz
LSBWb	−3 dB Bandwidth	$V_{OUT} = 5\ V_{PP}$ (Note 4)	All	17	25		IV	IV	MHz
GFPL	Peaking (<50 MHz)	$V_{OUT} = 0.4\ V_{PP}$	25°C		0	1	I	III	dB
			T_{MIN}, T_{MAX}			1	IV	IV	dB
GFPH	Peaking (>50 MHz)	$V_{OUT} = 0.4\ V_{PP}$	25°C		0	2	I	III	dB
			T_{MIN}, T_{MAX}			2	IV	IV	dB
GFR	Rolloff (<100 MHz)	$V_{OUT} = 0.4\ V_{PP}$	25°C		0.1	0.5	I	III	dB
			T_{MIN}, T_{MAX}			0.5	I	IV	dB

Closed Loop AC Electrical Characteristics

$V_S = \pm 5V$, $A_V = +2$, Rf = Rg = 250Ω, Cf = 3pF, $R_L = 100\Omega$ unless otherwise specified — Contd.

Parameter	Description	Test Conditions	Temp	Min	Typ	Max	Test Level EL2074	Test Level EL2074C	Units
LPD	Linear Phase Deviation (<100 MHz)	$V_{OUT} = 0.4\ V_{PP}$	All		1	1.8	IV	IV	°
PM	Phase Margin	$A_V = +2$	25°C		50		V	V	°
tr1, tf1	Rise Time, Fall Time	0.4V Step, $A_V = +2$	25°C		1.8		V	V	ns
tr2, tf2	Rise Time, Fall Time	5V Step, $A_V = +2$	25°C		8		V	V	ns
ts1	Settling to 0.1% ($A_V = -1$)	2V Step	25°C		13		V	V	ns
ts2	Settling to 0.01% ($A_V = -1$)	2V Step	25°C		25		V	V	ns
OS	Overshoot	2V Step	25°C		5		V	V	%
SR	Slew Rate	2V Step	All	275	400		IV	IV	V/μs
DISTORTION (Note 5)									
HD2a	2nd Harmonic Distortion	@ 10 MHz, $A_V = +2$	25°C		−65	−55	IV	IV	dBc
HD2c	2nd Harmonic Distortion	@ 20 MHz, $A_V = +2$	25°C		−55	−45	I	III	dBc
			T_{MIN}, T_{MAX}			−45	IV	IV	dBc
HD3a	3rd Harmonic Distortion	@ 10 MHz, $A_V = +2$	25°C		−72	−60	IV	IV	dBc
HD3c	3rd Harmonic Distortion	@ 20 MHz, $A_V = +2$	25°C		−70	−60	I	III	dBc
			T_{MIN}, T_{MAX}			−60	IV	IV	dBc
VIDEO PERFORMANCE (Note 6)									
dG	Differential Gain	NTSC	25°C		0.01	0.05	I	III	$\%_{pp}$
dP	Differential Phase	NTSC	25°C		0.015	0.05	I	III	$°_{pp}$
dG	Differential Gain	30 MHz	25°C		0.1		V	V	$\%_{pp}$
dP	Differential Phase	30 MHz	25°C		0.1		V	V	$°_{pp}$
VBW	±0.1 dB Bandwidth Flatness		25°C	25	50		I	III	MHz

Note 1: Measured from T_{MIN}, T_{MAX}.

Note 2: $\pm V_{CC} = \pm 4.5V$ to 5.5V.

Note 3: $\pm V_{IN} = \pm 2.5V$, $V_{OUT} = 0V$

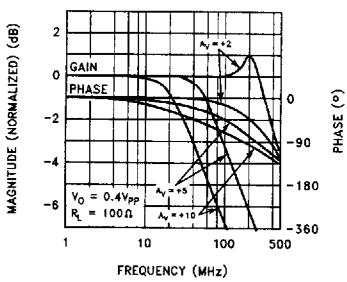
Note 4: Large-signal bandwidth calculated using $LSBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$.

Note 5: All distortion measurements are made with $V_{OUT} = 2\ V_{PP}$, $R_L = 100\Omega$.

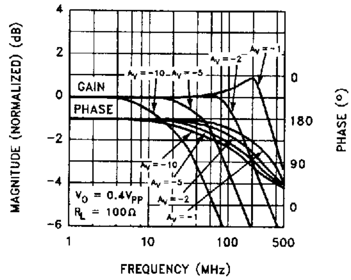
Note 6: Video performance measured at $A_V = +2$ with 2 times normal video level across $R_L = 100\Omega$. This corresponds to standard video levels across a back-terminated 50Ω load, i.e., 0–100 IRE, 40IREpp giving a 1 V_{PP} video signal across the 50Ω load. For other values of R_L, see curves.

Typical Performance Curves (T_A = 25°C)

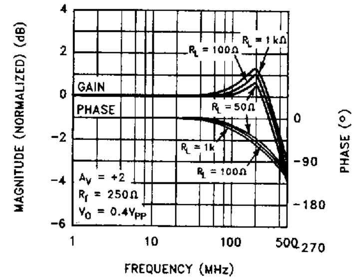
Non-Inverting Frequency Response



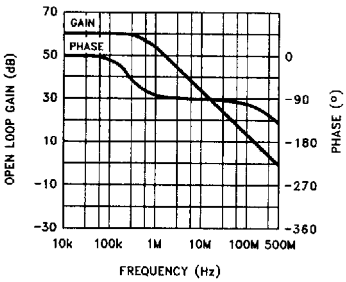
Inverting Frequency Response



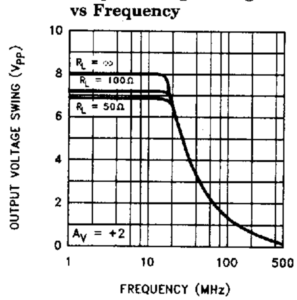
Frequency Response for Various R_Ls



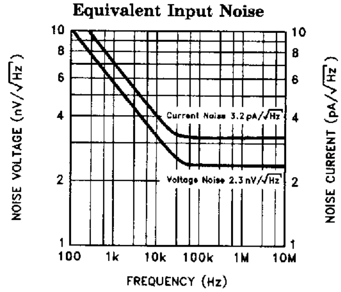
Open Loop Gain and Phase



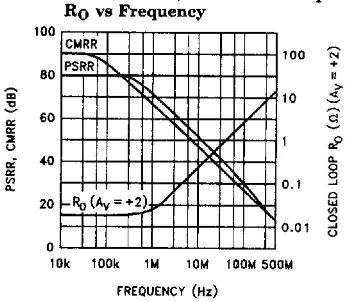
Output Voltage Swing vs Frequency



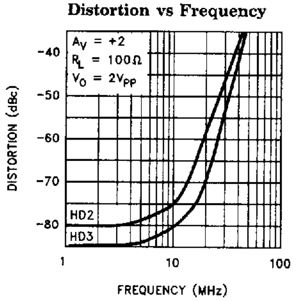
Equivalent Input Noise



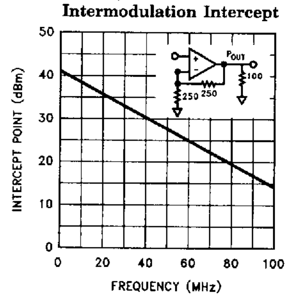
PSRR, CMRR, and Closed-Loop R_O vs Frequency



2nd and 3rd Harmonic Distortion vs Frequency



2-Tone, 3rd Order Intermodulation Intercept



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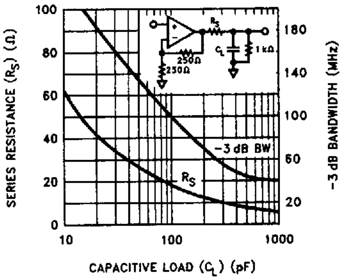
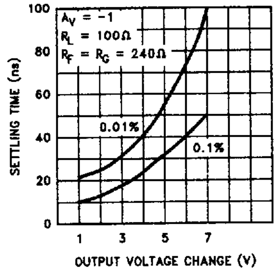
Typical Performance Curves (T_A = 25°C unless otherwise specified) — Contd.

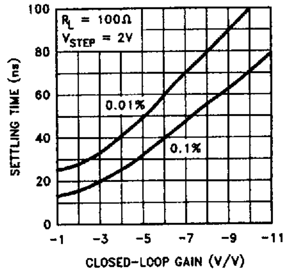
Series Resistor and Resulting Bandwidth vs Capacitive Load



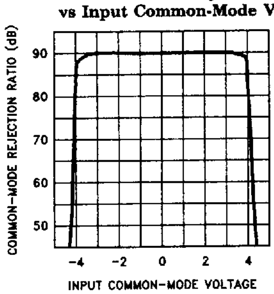
Settling Time vs Output Voltage Change



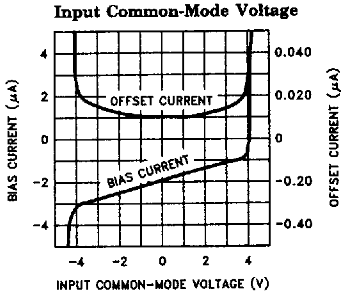
Settling Time vs Closed-Loop Gain



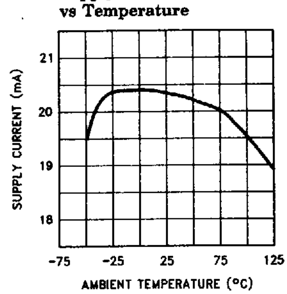
Common-Mode Rejection Ratio vs Input Common-Mode Voltage



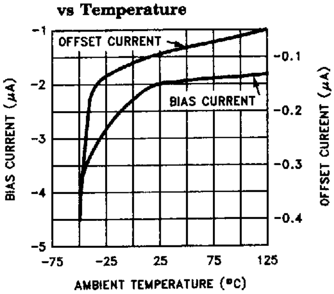
Bias and Offset Current vs Input Common-Mode Voltage



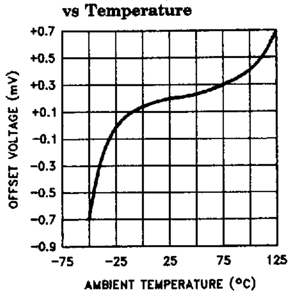
Supply Current vs Temperature



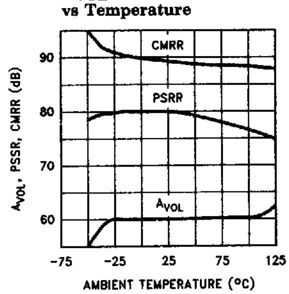
Bias and Offset Current vs Temperature



Offset Voltage vs Temperature



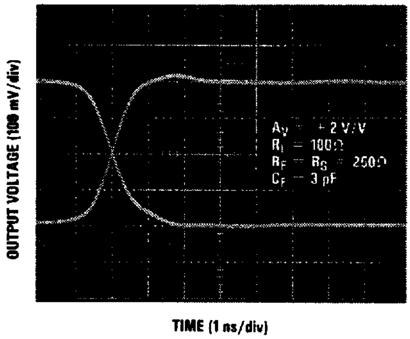
A_{VOL}, PSRR, and CMRR vs Temperature



2074-3

Typical Performance Curves (T_A = 25°C) — Contd.

Small-Signal Transient Response



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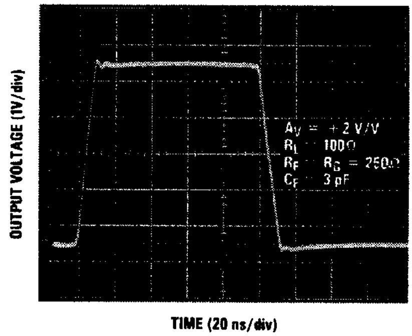
Large-Signal Transient Response



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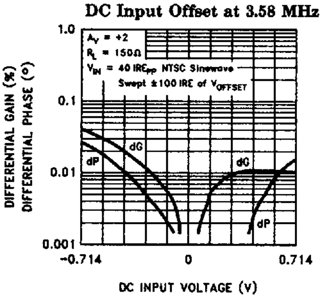
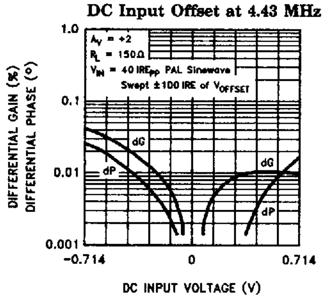
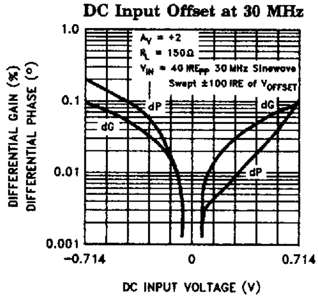
Differential Gain and Phase vs DC Input Offset at 3.58 MHz



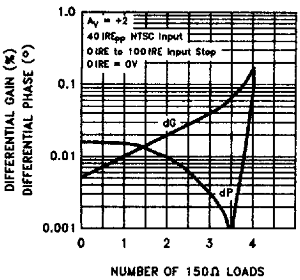
Differential Gain and Phase vs DC Input Offset at 4.43 MHz



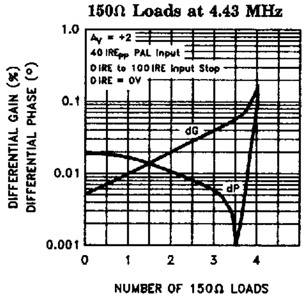
Differential Gain and Phase vs DC Input Offset at 30 MHz



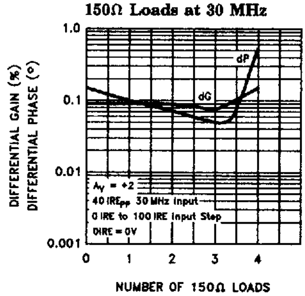
Differential Gain and Phase vs Number of 150Ω Loads at 3.58 MHz



Differential Gain and Phase vs Number of 150Ω Loads at 4.43 MHz



Differential Gain and Phase vs Number of 150Ω Loads at 30 MHz



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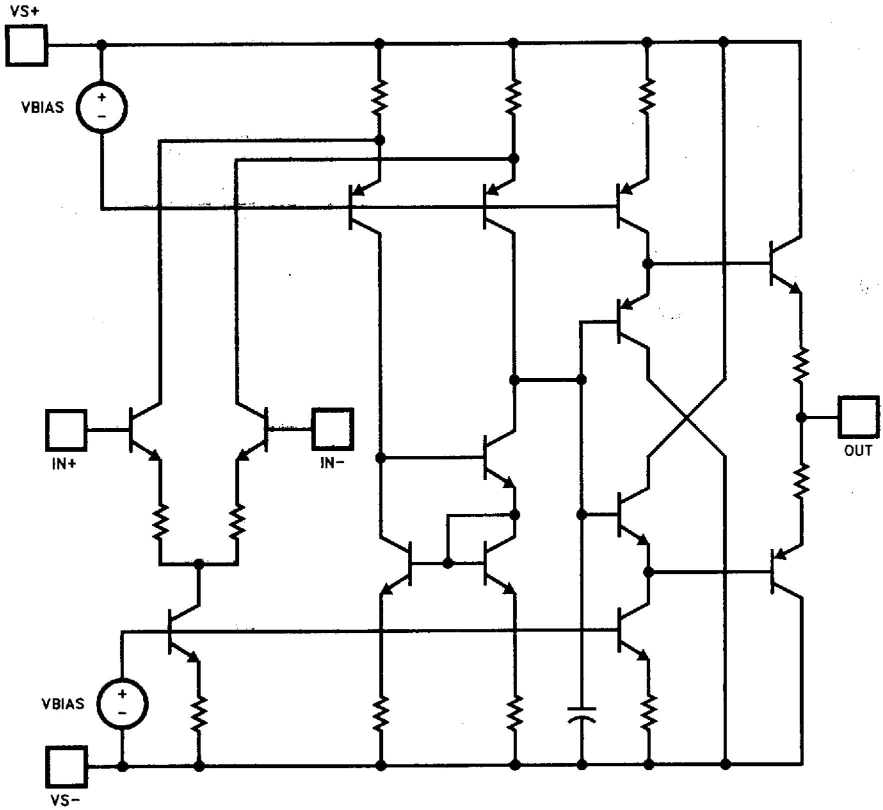
EL2074/EL2074C

400 MHz GBWP Gain-of-2 Stable Operational Amplifier

Equivalent Circuit



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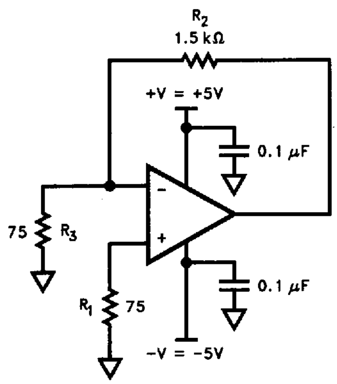
Burn-In Circuit



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All Packages Use The Same Schematic

EL2074/EL2074C

400 MHz GBWP Gain-of-2 Stable Operational Amplifier

Applications Information

Product Description

The EL2074 is a wideband monolithic operational amplifier built on a high-speed complementary bipolar process. The EL2074 uses a classical voltage-feedback topology which allows it to be used in a variety of applications requiring a noise gain ≥2 where current-feedback amplifiers are not appropriate because of restrictions placed upon the feedback element used with the amplifier. The conventional topology of the EL2074 allows, for example, a capacitor to be placed in the feedback path, making it an excellent choice for applications such as active filters, sample-and-holds, or integrators. Similarly, because of the ability to use diodes in the feedback network, the EL2074 is an excellent choice for applications such as log amplifiers.

The EL2074 also has excellent DC specifications: 200 μV, V_{OS}, 2 μA I_B, 0.1 μA I_{OS}, and 90 dB of CMRR. These specifications allow the EL2074 to be used in DC-sensitive applications such as difference amplifiers. Furthermore, the current noise of the EL2074 is only 3.2 pA/$\sqrt{\text{Hz}}$, making it an excellent choice for high-sensitivity transimpedance amplifier configurations.

Gain-Bandwidth Product

The EL2074 has a gain-bandwidth product of 400 MHz. For gains greater than 8, its closed-loop −3 dB bandwidth is approximately equal to the gain-bandwidth product divided by the noise gain of the circuit. For gains less than 8, higher-order poles in the amplifier's transfer function contribute to even higher closed loop bandwidths. For example, the EL2074 has a −3 dB bandwidth of 400 MHz at a gain of +2, dropping to 200 MHz at a gain of +4. It is important to note that the EL2074 has been designed so that this "extra" bandwidth in low-gain applications does not come at the expense of stability. As seen in the typical performance curves, the EL2074 in a gain of +2 only exhibits 1 dB of peaking with a 100Ω load.

Parasitic Capacitances and Stability

When used in positive-gain configurations, the EL2074 can be quite sensitive to parasitic capacitances at the inverting input, especially with values ≥250Ω for the gain resistor. The problem stems from the feedback and gain resistance in conjunction with the approximately 3pF of board-related parasitic capacitance from the inverting input to ground. Assuming a gain-of-2 configuration with Rf = Rg = 250Ω, a feedback pole occurs at 424 MHz, which is equivalent to a zero in the forward path at the same frequency. This zero reduces stability by reducing the effective phase-margin from about 50° to about 30°.

A common solution to this problem is to add an additional capacitor from the inverting input to the output. This capacitor, in conjunction with the parasitic capacitance, maintains a constant voltage-divider between the output and the inverting input. This technique is used for AC testing of the EL2074. A 3pF capacitor is placed in parallel with the feedback resistor for all AC tests. When this capacitor is used, it is also possible to increase the resistance values of the feedback and gain resistors without loss of stability, resulting in less loading of the EL2074 from the feedback network.

Video Performance

An industry-standard method of measuring the video distortion of a component such as the EL2074 is to measure the amount of differential gain (dG) and differential phase (dP) that it introduces. To make these measurements, a 0.286 V_{PP} (40 IRE) signal is applied to the device with 0V DC offset (0 IRE) at either 3.58 MHz for NTSC, 4.43 MHz for PAL, or 30 MHz for HDTV. A second measurement is then made at 0.714V DC offset (100 IRE). Differential gain is a measure of the change in amplitude of the sine wave, and is measured in percent. Differential phase is a measure of the change in phase, and is measured in degrees.

EL2074/EL2074C

400 MHz GBWP Gain-of-2 Stable Operational Amplifier

Applications Information — Contd.

For signal transmission and distribution, a back-terminated cable (75Ω in series at the drive end, and 75Ω to ground at the receiving end) is preferred since the impedance match at both ends will absorb any reflections. However, when double termination is used, the received signal is halved; therefore a gain of 2 configuration is typically used to compensate for the attenuation.

The EL2074 has been designed to be among the best video amplifiers in the marketplace today. It has been thoroughly characterized for video performance in the topology described above, and the results have been included as minimum dG and dP specifications and as typical performance curves. In a gain of +2, driving 150Ω, with standard video test levels at the input, the EL2074 exhibits dG and dP of only 0.01% and 0.015° at NTSC and PAL. Because dG and dP vary with different DC offsets, the superior video performance of the EL2074 has been characterized over the entire DC offset range from −0.714V to +0.714V. For more information, refer to the curves of dG and dP vs DC Input Offset.

The excellent output drive capability of the EL2074 allows it to drive up to 4 back-terminated loads with excellent video performance. With 4 150Ω loads, dG and dP are only 0.15% and 0.08° at NTSC and PAL. For more information, refer to the curves for Video Performance vs Number of 150Ω Loads.

Output Drive Capability

The EL2074 has been optimized to drive 50Ω and 75Ω loads. It can easily drive 6 V_{PP} into a 50Ω load. This high output drive capability makes the EL2074 an ideal choice for RF, IF and video applications. Furthermore, the current drive of the EL2074 remains a minimum of 50 mA at low temperatures. The EL2074 is current-limited at the output, allowing it to withstand momentary shorts to ground. However, power dissipation with the output shorted can be in excess of the power-dissipation capabilities of the package.

Capacitive Loads

Although the EL2074 has been optimized to drive resistive loads as low as 50Ω, capacitive loads will decrease the amplifier's phase margin which may result in peaking, overshoot, and possible oscillation. For optimum AC performance, capacitive loads should be reduced as much as possible or isolated via a series output resistor. Coax lines can be driven, as long as they are terminated with their characteristic impedance. When properly terminated, the capacitance of coaxial cable will not add to the capacitive load seen by the amplifier. Capacitive loads greater than 10 pF should be buffered with a series resistor (Rs) to isolate the load capacitance from the amplifier output. A curve of recommended Rs vs Cload has been included for reference. Values of Rs were chosen to maximize resulting bandwidth without peaking.

Printed-Circuit Layout

As with any high-frequency device, good PCB layout is necessary for optimum performance. Ground-plane construction is highly recommended, as is good power supply bypassing. A 1 μF–10 μF tantalum capacitor is recommended in parallel with a 0.01 μF ceramic capacitor. All lead lengths should be as short as possible, and all bypass capacitors should be as close to the device pins as possible. Parasitic capacitances should be kept to an absolute minimum at both inputs and at the output. Resistor values should be kept under 1000Ω to 2000Ω because of the RC time constants associated with the parasitic capacitance. Metal-film and carbon resistors are both acceptable, use of wire-wound resistors is not recommended because of parasitic inductance. Similarly, capacitors should be low-inductance for best performance. If possible, solder the EL2074 directly to the PC board without a socket. Even high quality sockets add parasitic capacitance and inductance which can potentially degrade performance. Because of the degradation of AC performance due to parasitics, the use of surface-mount components (resistors, capacitors, etc.) is also recommended.

EL2074 Macromodel

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*
* Connections:                    +input
*                                 | -input
*                                 | | +Vsupply
*                                 | | | -Vsupply
*                                 | | | | output
*                                 | | | | |
.subckt M2074                     3 2 7 4 6
*
*Input Stage
*
ie 37 4 1 mA
r6 36 37 125
r7 38 37 125
rc1 7 30 200
rc2 7 39 200
q1 30 3 36 qn
q2 39 2 38 qna
ediff 33 0 39 30 1
rdiff 33 0 1 Meg
*
* Compensation Section
*
ga 0 34 33 0 2m
rh 34 0 500K
ch 34 0 0.8 pF
rc 34 40 50
cc 40 0 0.05 pF
*
* Poles
*
ep 41 0 40 0 1
rpa 41 42 150
cpa 42 0 0.5 pF
rpb 42 43 50
cpb 43 0 0.5 pF
*
* Output Stage
*
ios1 7 50 3.0 mA
ios2 51 4 3.0 mA
q3 4 43 50 qp
q4 7 43 51 qn
q5 7 50 52 qn
q6 4 51 53 qp
ros1 52 6 2
ros2 6 53 2
*
Power Supply Current
*
ips 7 4 11.4 mA
*
Models
*
.model qna npn(is=800e-18 bf=170 tf=0.2 ns)
.model qn  npn(is=810e-18 bf=200 tf=0.2 ns)
.model qp  pnp(is=800e-18 bf=200 tf=0.2 ns)
.ends
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ELANTEC INC

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EL2074 Macromodel — Contd.