élantec
HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

EL2045C

Low-Power 100MHz Gain-of-2 Stable Operational Amplifier

Features

- 100MHz gain-bandwidth at Gain-of-2
- Gain-of-2 stable
- Low supply current
  - 5.2mA at $V_S = \pm 15V$
- Wide supply range
  - ±2V to ±18V dual-supply
  - 2.5V to 36V single-supply
- High slew rate = 275V/µs
- Fast settling = 80ns to 0.1% for a 10V step
- Low differential gain = 0.02% at $A_V = +2$, $R_L = 150\Omega$
- Low differential phase = 0.07° at $A_V = +2$, $R_L = 150\Omega$
- Stable with unlimited capacitive load
- Wide output voltage swing
  - ±13.6V with $V_S = \pm 15V$, $R_L = 1000\Omega$
  - 3.8V/0.3V with $V_S = +5V$, $R_L = 500\Omega$

Applications

- Video amplifier
- Single-supply amplifier
- Active filters/integrators
- High-speed sample-and-hold
- High-speed signal processing
- ADC/DAC buffer
- Pulse/RF amplifier
- Pin diode receiver
- Log amplifier
- Photo multiplier amplifier
- Difference amplifier

Ordering Information

Part No.	Package	Tape & Reel	Outline #
EL2045CN	PDIP-8	-	MDP0031
EL2045CS	SO-8	-	MDP0027
EL2045CS-T7	SO-8	7 in	MDP0027
EL2045CS-T13	SO-8	13 in	MDP0027

General Description

The EL2045C is a high speed, low power, low cost monolithic operational amplifier built on Elantec's proprietary complementary bipolar process. The EL2045C is gain-of-2 stable and features a 275V/µs slew rate and 100MHz gain-bandwidth at gain-of-2 while requiring only 5.2mA of supply current.

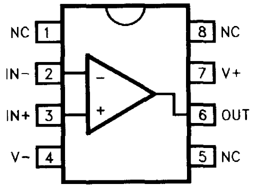
The power supply operating range of the EL2045C is from ±18V down to as little as ±2V. For single-supply operation, the EL2045C operates from 36V down to as little as 2.5V. The excellent power supply operating range of the EL2045C makes it an obvious choice for applications on a single +5V or +3V supply.

The EL2045C also features an extremely wide output voltage swing of ±13.6V with $V_S = \pm 15V$ and $R_L = 1000\Omega$. At ±5V, output voltage swing is a wide ±3.8V with $R_L = 500\Omega$ and ±3.2V with $R_L = 150\Omega$. Furthermore, for single-supply operation at +5V, output voltage swing is an excellent 0.3V to 3.8V with $R_L = 500\Omega$.

At a gain of +2, the EL2045C has a -3dB bandwidth of 100MHz with a phase margin of 50°. It can drive unlimited load capacitance, and because of its conventional voltage-feedback topology, the EL2045C allows the use of reactive or non-linear elements in its feedback network. This versatility combined with low cost and 75mA of output-current drive makes the EL2045C an ideal choice for price-sensitive applications requiring low power and high speed.

Connection Diagrams

DIP and SO Package



December 1995 Rev C

Absolute Maximum Ratings ($T_A = 25°C$)

Supply Voltage (V_S)	±18V or 36V
Peak Output Current (I_{OP})	Short-Circuit Protected
Output Short-Circuit Duration	Infinite
(A heat-sink is required to keep junction temperature below absolute maximum when an output is shorted.)	
Input Voltage (V_{IN})	$\pm V_S$
Differential Input Voltage (dV_{IN})	±10V

Power Dissipation (P_D)	See Curves
Operating Temperature Range (T_A)	0°C to +75°C
Operating Junction Temperature (T_J)	150°C
Storage Temperature (TST)	- 65°C to +150°C

Important Note:

All parameters having Min/Max specifications are guaranteed. Typ values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore: $T_J = T_C = T_A$

DC Electrical Characteristics

$V_S = \pm 15V$, $R_L = 1000\Omega$, unless otherwise specified

Parameter	Description	Condition	Temp	Min	Typ	Max	Units
V_{OS}	Input Offset Voltage	$V_S = \pm 15V$	25°C		0.5	7.0	mV
			T_{MIN}, T_{MAX}			9.0	mV
TCV_{OS}	Average Offset Voltage Drift	(Note 2)	All		10.0		µV/°C
I_B	Input Bias Current	$V_S = \pm 15V$	25°C		2.8	8.2	µA
			T_{MIN}, T_{MAX}			9.2	µA
		$V_S = \pm 5V$	25°C		2.8		µA
I_{OS}	Input Offset Current	$V_S = \pm 15V$	25°C		50	300	nA
			T_{MIN}, T_{MAX}			400	nA
		$V_S = \pm 5V$	25°C		50		nA
TCI_{OS}	Average Offset Current Drift	[1]	All		0.3		nA/°C
A_{VOL}	Open-Loop Gain	$V_S = \pm 15V, V_{OUT} = \pm 10V, R_L = 1000\Omega$	25°C	1500	3000		V/V
			T_{MIN}, T_{MAX}	1500			V/V
		$V_S = \pm 5V, V_{OUT} = \pm 2.5V, R_L = 500\Omega$	25°C		2500		V/V
		$V_S = \pm 5V, V_{OUT} = \pm 2.5V, R_L = 150\Omega$	25°C		1750		V/V
PSRR	Power Supply Rejection Ratio	$V_S = \pm 5V$ to $\pm 15V$	25°C	65	85		dB
			T_{MIN}, T_{MAX}	60			dB
CMRR	Common-Mode	$V_{CM} = \pm 12V, V_{OUT} = 0V$	25°C	70	95		dB
	Rejection Ratio		T_{MIN}, T_{MAX}	70			dB
CMIR	Common-Mode Input Range	$V_S = \pm 15V$	25°C		±14.0		V
		$V_S = \pm 5V$	25°C		±4.2		V
		$V_S = +5V$	25°C		4.2/0.1		V
V_{OUT}	Output Voltage Swing	$V_S = \pm 15V, R_L = 1000\Omega$	25°C	±13.4	±13.6		V
			T_{MIN}, T_{MAX}	±13.1			V
		$V_S = \pm 15V, R_L = 500\Omega$	25°C	±12.0	±13.4		V
		$V_S = \pm 5V, R_L = 500\Omega$	25°C	±3.4	±3.8		V
		$V_S = \pm 5V, R_L = 150\Omega$	25°C		±3.2		V
		$V_S = +5V, R_L = 500\Omega$	25°C	3.6/0.4	3.8/0.3		V
			T_{MIN}, T_{MAX}	3.5/0.5			V
I_S	Supply Current	$V_S = \pm 15V$, No Load	25°C		5.2	7	mA
			T_{MIN}, T_{MAX}			7.6	mA
		$V_S = \pm 5V$, No Load	25°C		5.0		mA

DC Electrical Characteristics (Continued)

V_S = ±15V, R_L = 1000Ω, unless otherwise specified

Parameter	Description	Condition	Temp	Min	Typ	Max	Units
I_{SC}	Output Short Circuit Current		25°C	40	75		mA
			T_{MIN}, T_{MAX}	35			mA
R_{IN}	Input Resistance	Differential	25°C		150		kΩ
		Common-Mode	25°C		15		MΩ
C_{IN}	Input Capacitance	A_V = +2@ 10MHz	25°C		1.0		pF
R_{OUT}	Output Resistance	A_V = +2	25°C		50		mΩ
PSOR	Power-Supply Operating Range	Dual-Supply	25°C	±2.0		±18.0	V
		Single-Supply	25°C	2.5		36.0	V

1. Measured from T_{MIN} to T_{MAX}.

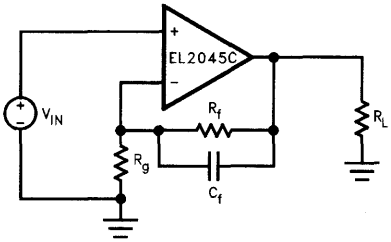
Closed-Loop AC Electrical Characteristics

V_S = ±15V, A_V = +2, R_f = R_g = 1 kΩ, C_f = 3pF, R_L = 1000Ω unless otherwise specified

Parameter	Description	Condition	Temp	Min	Typ	Max	Units
BW	-3dB Bandwidth (V_{OUT} = 0.4V_{PP})	V_S = ±15V, A_V = +2	25°C		100		MHz
		V_S = ±15V, A_V = -1	25°C		75		MHz
		V_S = ±15V, A_V = +5	25°C		20		MHz
		V_S = ±15V, A_V = +10	25°C		10		MHz
		V_S = ±15V, A_V = +20	25°C		5		MHz
		V_S = ±5V, A_V = +2	25°C		75		MHz
GBWP	Gain-Bandwidth Product	V_S = ±15V	25°C		200		MHz
		V_S = ±5V	25°C		150		MHz
PM	Phase Margin	R_L = 1kΩ, C_L = 10pF	25°C		50		°
SR	Slew Rate [1]	V_S = ±15V, R_L = 1000Ω	25°C	200	275		V/µs
		V_S = ±5V, R_L = 500Ω	25°C		200		V/µs
FPBW	Full-Power Bandwidth [2]	V_S = ±15V	25°C	3.2	4.4		MHz
		V_S = ±5V	25°C		12.7		MHz
t_r, t_f	Rise Time, Fall Time	0.1V Output Step	25°C		3.0		ns
OS	Overshoot	0.1V Output Step	25°C		20		%
t_{PD}	Propagation Delay		25°C		2.5		ns
t_s	Settling to +0.1% (A_V = +2)	V_S = ±15V, 10V Step	25°C		80		ns
		V_S = ±5V, 5V Step	25°C		60		ns
dG	Differential Gain [3]	NTSC/PAL	25°C		0.02		%
dP	Differential Phase [3]	NTSC/PAL	25°C		0.07		°
eN	Input Noise Voltage	10kHz	25°C		15.0		nV/Hz
iN	Input Noise Current	10kHz	25°C		1.50		pA/Hz
CI STAB	Load Capacitance Stability	A_V = +2	25°C		Infinite		pF

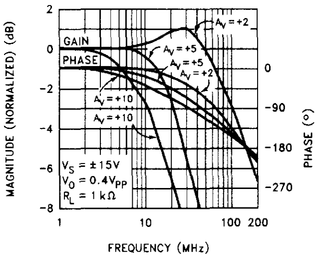
1. Slew rate is measured on rising edge.
2. For V_S = ±15V, V_{OUT} = 20V_{PP}. For V_S = ±5V, V_{OUT} = 5V_{PP}. Full-power bandwidth is based on slew rate measurement using: FPBW = SR/(2π * Vpeak).
3. Video Performance measured at V_S = ±15V, A_V = +2 with 2 times normal video level across R_L = 150Ω. This corresponds to standard video levels across a back-terminated 75Ω load. For other values of R_L, see curves.

EL2045C Test Circuit

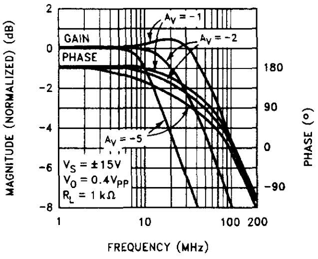


Typical Performance Curves

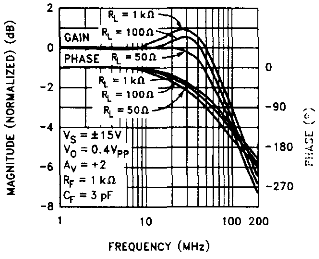
Non-Inverting Frequency Response



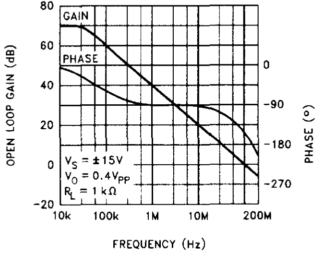
Inverting Frequency Response



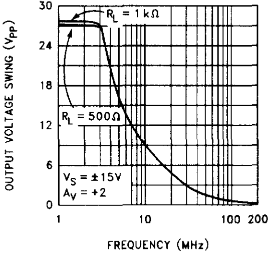
Frequency Response for Various Load Resistances



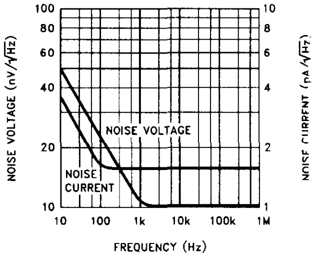
Open-Loop Gain and Phase vs Frequency



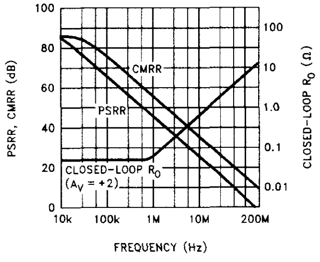
Output Voltage Swing vs Frequency



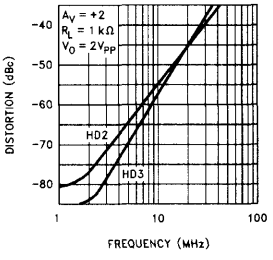
Equivalent Input Noise



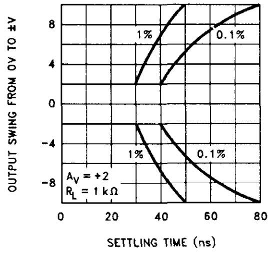
CMRR, PSRR and Closed-Loop Output Resistance vs Frequency



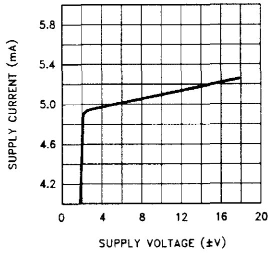
2nd and 3rd Harmonic Distortion vs Frequency



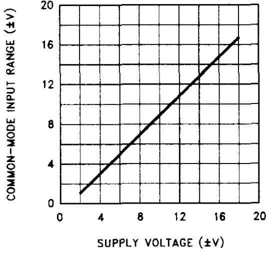
Settling Time vs Output Voltage Change



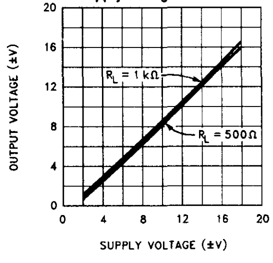
Supply Current vs Supply Voltage



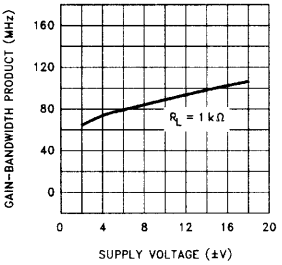
Common-Mode Input Range vs Supply Voltage



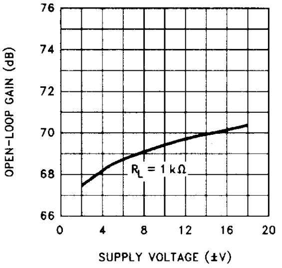
Output Voltage Range vs Supply Voltage



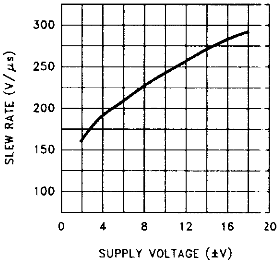
Gain-Bandwidth Product vs Supply Voltage



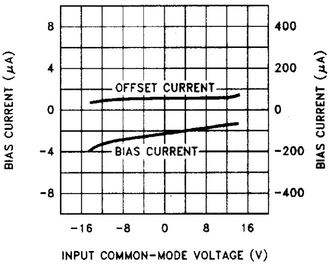
Open-Loop Gain vs Supply Voltage



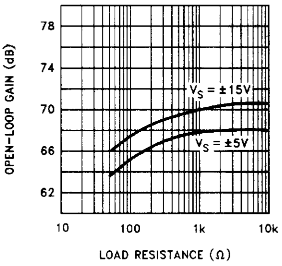
Slew-Rate vs Supply Voltage



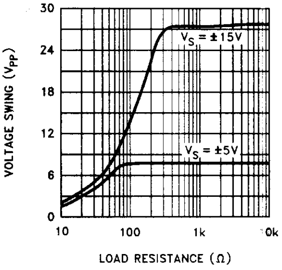
Bias and Offset Current vs Input Common-Mode Voltage



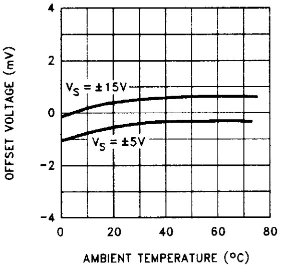
Open-Loop Gain vs Load Resistance



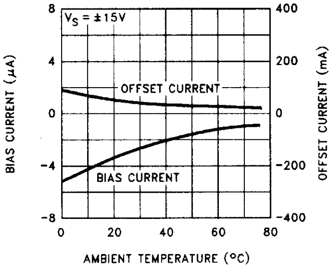
Voltage Swing vs Load Resistance



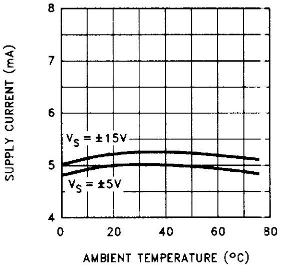
Offset Voltage vs Temperature



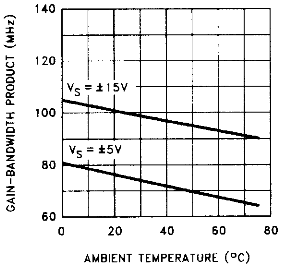
Bias and Offset Current vs Temperature



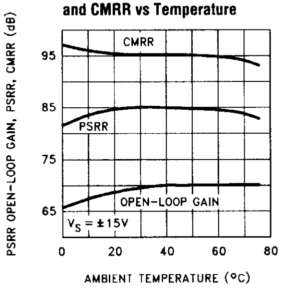
Supply Current vs Temperature



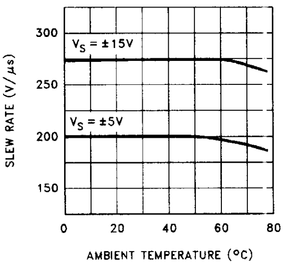
Gain-Bandwidth Product vs Temperature



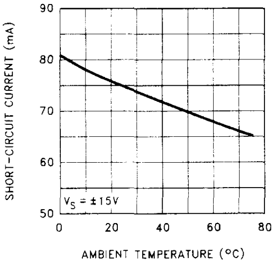
Open-Loop Gain PSRR and CMRR vs Temperature



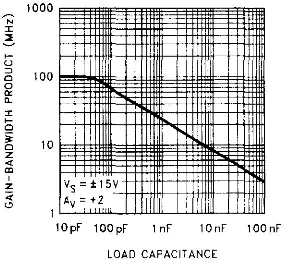
Slew Rate vs Temperature



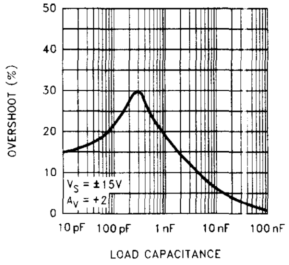
Short-Circuit Current vs Temperature



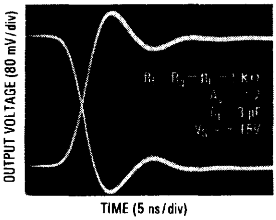
Gain-Bandwidth Product vs Load Capacitance



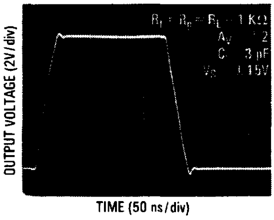
Overshoot vs Load Capacitance



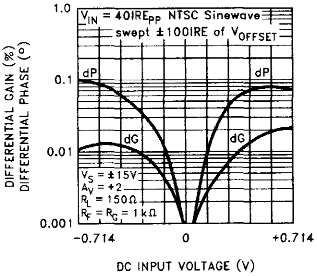
Small-Signal Step Response



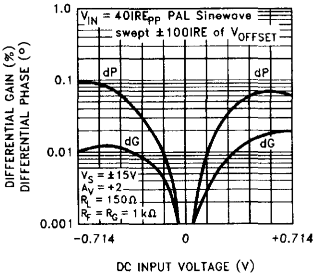
Large-Signal Step Response



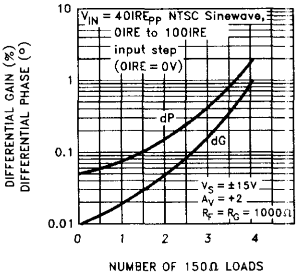
Differential Gain and Phase vs DC Input Offset at 3.58MHz



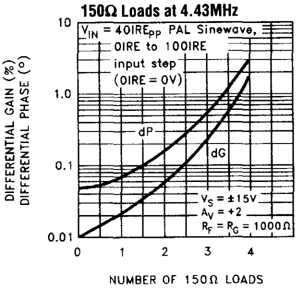
Differential Gain and Phase vs DC Input Offset at 4.43MHz



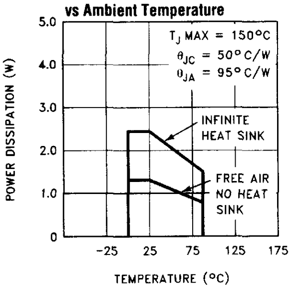
Differential Gain and Phase vs Number of 150Ω Loads at 3.58MHz



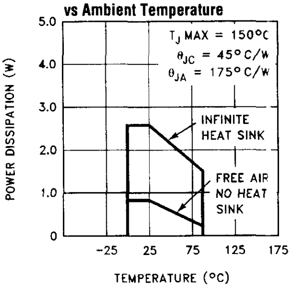
Differential Gain and Phase vs Number of 150Ω Loads at 4.43MHz



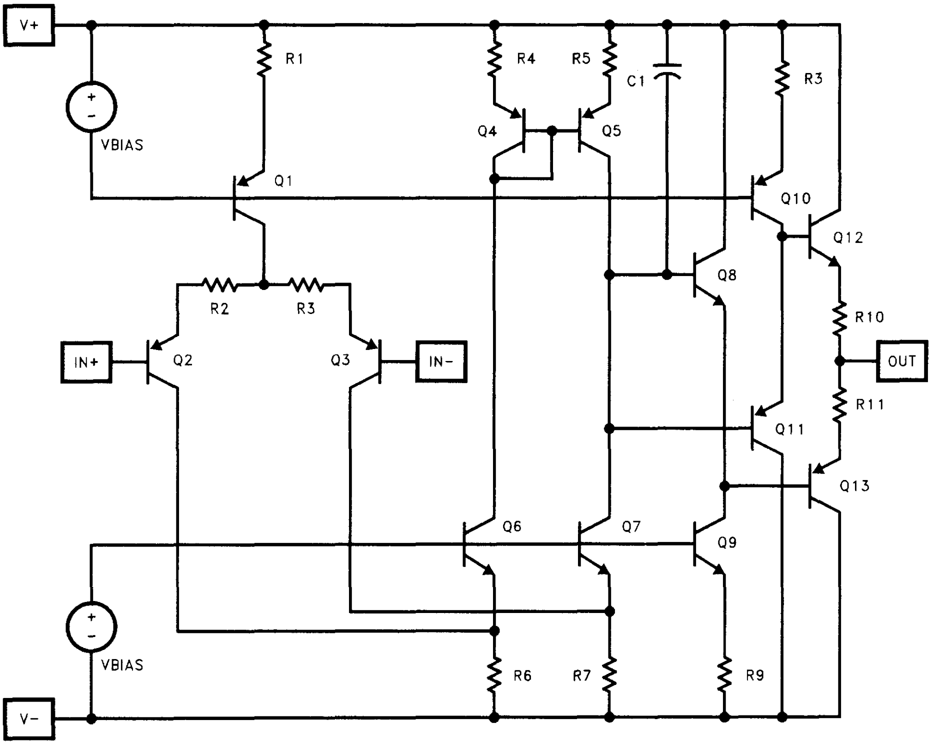
8-Pin Plastic DIP Maximum Power Dissipation vs Ambient Temperature



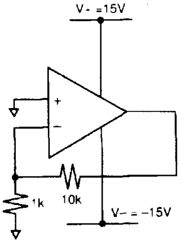
8-Lead SO Maximum Power Dissipation vs Ambient Temperature



Simplified Schematic



Burn-In Circuit



All Packages Use the Same Schematic

Applications Information

Product Description

The EL2045C is a low-power wideband, gain-of-2 stable monolithic operational amplifier built on Elantec's proprietary high-speed complementary bipolar process. The EL2045C uses a classical voltage-feedback topology which allows it to be used in a variety of applications where current-feedback amplifiers are not appropriate because of restrictions placed upon the feedback element used with the amplifier. The conventional topology of the EL2045C 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 EL2045C is an excellent choice for applications such as fast log amplifiers.

Single-Supply Operation

The EL2045C has been designed to have a wide input and output voltage range. This design also makes the EL2045C an excellent choice for single-supply operation. Using a single positive supply, the lower input voltage range is within 100mV of ground (R_L = 500Ω), and the lower output voltage range is within 300mV of ground. Upper input voltage range reaches 4.2V, and output voltage range reaches 3.8V with a 5V supply and R_L = 500Ω. This results in a 3.5V output swing on a single 5V supply. This wide output voltage range also allows single-supply operation with a supply voltage as high as 36V or as low as 2.5V. On a single 2.5V supply, the EL2045C still has 1V of output swing.

Gain-Bandwidth Product and the -3dB Bandwidth

The EL2045C has a bandwidth at gain-of-2 of 100MHz while using only 5.2mA of supply current. For gains greater than 4, its closed-loop -3dB bandwidth is approximately equal to the gain-bandwidth product divided by the noise gain of the circuit. For gains less than 4, higher-order poles in the amplifier's transfer function contribute to even higher closed loop bandwidths. For example, the EL2045C has a -3dB bandwidth of 100MHz at a gain of +2, dropping to 20MHz at a gain of +5. It is important to note that the EL2045C 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 EL2045C in a gain of +2 only exhibits 1.0dB of peaking with a 1000Ω load.

Video Performance

An industry-standard method of measuring the video distortion of a component such as the EL2045C is to measure the amount of differential gain (dG) and differential phase (dP) that it introduces. To make these measurements, a 0.286V_{PP} (40 IRE) signal is applied to the device with 0V DC offset (0 IRE) at either 3.58MHz for NTSC or 4.43MHz for PAL. 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.

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 EL2045C has been designed as an economical solution for applications requiring low video distortion. It has been thoroughly characterized for video performance in the topology described above, and the results have been included as typical 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 EL2045C exhibits dG and dP of only 0.02% and 0.07° at NTSC and PAL. Because dG and dP can vary with different DC offsets, the video performance of the EL2045C 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 output drive capability of the EL2045C allows it to drive up to 2 back-terminated loads with good video performance. For more demanding applications such as greater output drive or better video distortion, a number of alternatives such as the EL2120C, EL400C, or EL2074C should be considered.

Output Drive Capability

The EL2045C has been designed to drive low impedance loads. It can easily drive $6V_{PP}$ into a 150Ω load. This high output drive capability makes the EL2045C an ideal choice for RF, IF and video applications. Furthermore, the current drive of the EL2045C remains a minimum of 35mA at low temperatures. The EL2045C is current-limited at the output, allowing it to withstand shorts to ground. However, power dissipation with the output shorted can be in excess of the power-dissipation capabilities of the package.

Capacitive Loads

For ease of use, the EL2045C has been designed to drive any capacitive load. However, the EL2045C remains stable by automatically reducing its gain-bandwidth product as capacitive load increases. Therefore, for maximum bandwidth, capacitive loads should be reduced as much as possible or isolated via a series output resistor (Rs). Similarly, coax lines can be driven, but best AC performance is obtained when they are terminated with their characteristic impedance so that the capacitance of the coaxial cable will not add to the capacitive load seen by the amplifier. Although stable with all capacitive loads, some peaking still occurs as load capacitance increases. A series resistor at the output of the EL2045C can be used to reduce this peaking and further improve stability.

Printed-Circuit Layout

The EL2045C is well behaved, and easy to apply in most applications. However, a few simple techniques will help assure rapid, high quality results. 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 0.1µF ceramic capacitor is recommended for bypassing both supplies. Lead lengths should be as short as possible, and bypass capacitors should be as close to the device pins as possible. For good AC performance, parasitic capacitances should be kept to a minimum at both inputs and at the output. Resistor values should be kept under 5kΩ 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 their parasitic inductance. Similarly, capacitors should be low-inductance for best performance.

The EL2045C Macromodel

This macromodel has been developed to assist the user in simulating the EL2045C with surrounding circuitry. It has been developed for the PSPICE simulator (copywritten by the Microsim Corporation), and may need to be rearranged for other simulators. It approximates DC, AC, and transient response for resistive loads, but does not accurately model capacitive loading. This model is slightly more complicated than the models used for low-frequency op-amps, but it is much more accurate for AC analysis.

The model does not simulate these characteristics accurately:

noise	non-linearities
settling-time	temperature effects
CMRR PSRR	manufacturing variations

EL2045C Macromodel

```
* Connections:  +input
*               |    -input
*               |    |    +Vsupply
*               |    |    |    -Vsupply
*               |    |    |    |    output
*               |    |    |    |    |
.subckt M2045   3    2    7    4    6
*
* Input stage
*
ie 7 37 0.9 mA
r6 36 37 400
r7 38 37 400
rc1 4 30 850
rc2 4 39 850
q1 30 3 36 qp
q2 39 2 38 qpa
ediff 33 0 39 30 1.0
rdiff 33 0 1 Meg
*
* Compensation Section
*
ga 0 34 33 0 1 m
rh 34 0 2 Meg
ch 34 0 1.5 pF
rc 34 40 1 K
cc 40 0 1 pF
*
* Poles
*
ep 41 0 40 0 1
rpa 41 42 200
cpa 42 0 2 pF
rpb 42 43 200
cpb 43 0 2 pF
*
* Output Stage
*
ios1 7 50 1.0 mA
ios2 51 4 1.0 mA
q3 4 43 50 qp
q4 7 43 51 qn
q5 7 50 52 qn
q6 4 51 53 qp
ros1 52 6 25
ros2 6 53 25
*
* Power Supply Current
*
ips 7 4 2.7 mA
*
* Models
*
.model qn npn(is=800E-18 bf=200 tf=0.2nS)
.model qpa pnp(is=864E-18 bf=100 tf=0.2nS)
.model qp pnp(is=800E-18 bf=125 tf=0.2nS)
.ends
```

EL2045C Macromodel