élantec
HIGH PERFORMANCE ANALOG INTEGRATED CIRCUITS

EL400/EL400C

T-79-07-10

200 MHz Current Feedback Amplifier

ELANTEC INC

Features

- 200 MHz −3 dB bandwidth, $A_V = 2$
- 12 ns settling to 0.05%
- $V_S = \pm 5V$ @ 15 mA
- Low distortion: HD2, HD3 @ −60 dBc at 20 MHz
- Differential gain 0.02% at NTSC, PAL
- Differential phase 0.01° at NTSC, PAL
- Overload/short-circuit protected
- ±1 to ±8 closed-loop gain range
- Low cost
- Direct replacement for CLC400

Applications

- Video gain block
- Video distribution
- HDTV amplifier
- High-speed A/D conversion
- D/A I-V conversion
- Photodiode, CCD preamps
- IF processors
- High-speed communications

Ordering Information

Part No.	Temp. Range	Package	Outline #
EL400CN	−40°C to +85°C	8-Pin P-DIP	MDP0031
EL400CS	−40°C to +85°C	8-Lead SO	MDP0027
EL400J/883B	−55°C to +125°C	8-Pin CerDIP	MDP0010

5962-8997001 is the SMD version of this device.

General Description

The EL400 is a wide bandwidth, fast settling monolithic amplifier built using an advanced complementary bipolar process. This amplifier uses current-mode feedback to achieve more bandwidth at a given gain than conventional operational amplifiers. Designed for closed-loop gains of ±1 to ±8, the EL400 has a 200 MHz −3 dB bandwidth ($A_V = +2$), and 12 ns settling to 0.05% while consuming only 15 mA of supply current.

The EL400 is an obvious high-performance solution for video distribution and line-driving applications. With low 15 mA supply current, differential gain/phase of 0.02%/0.01°, and a minimum 50 mA output drive, performance in these areas is assured.

The EL400's settling to 0.05% in 12 ns, low distortion, and ability to drive capacitive loads make it an ideal flash A/D driver. The wide 200 MHz bandwidth and extremely linear phase allow unmatched signal fidelity. D/A systems can also benefit from the EL400, especially if linearity and drive levels are important.

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.*

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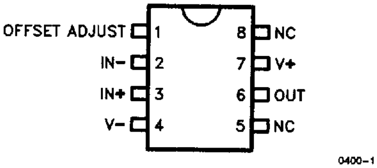
Connection Diagram

DIP and SO Package



Top View

July 1992 Rev C

EL400/EL400C

ELANTEC INC

200 MHz Current Feedback 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 Voltage	$\pm V_S$
Differential Input Voltage	5V
Power Dissipation	See Curves
Operating Temperature	
EL400	−55°C to +125°C
EL400C	−40C to +85C
Lead Temperature (Soldering, 5 Seconds)	300°C
Junction Temperature	175°C
Storage Temperature	−60°C to +150°C
Thermal Resistance	θ_{JA} = 95°C/W P-DIP
	θ_{JA} = 125°C/W CerDIP
	θ_{JA} = 175°C/W SO-8

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		Units
							EL400	EL400C	
V_{OS}	Input Offset Voltage		25°C		2.0	5.5	I	I	mV
			T_{MIN}			8.7	I	III	mV
			T_{MAX}			9.5	I	III	mV
$d(V_{OS})/dT$	Average Offset Voltage Drift	(Note 1)	All		10.0	40.0	IV	IV	μV/°C
$+I_{IN}$	+Input Current		25°C, T_{MAX}		10.0	25.0	I	II	μA
			T_{MIN}			41.0	I	III	μA
$d(+I_{IN})/dT$	Average +Input Current Drift	(Note 1)	All		50.0	200.0	IV	IV	nA/°C
$-I_{IN}$	−Input Current		25°C		10.0	25.0	I	I	μA
			T_{MIN}			41.0	I	III	μA
			T_{MAX}			35.0	I	III	μA
$d(-I_{IN})/dT$	Average −Input Current Drift	(Note 1)	All		100.0	200.0	IV	IV	nA/°C
PSRR	Power Supply Rejection Ratio		All	40.0	50.0		I	II	dB
CMRR	Common-Mode Rejection Ratio		All	40.0	50.0		I	II	dB
I_S	Supply Current—Quiescent	No Load	All		15.0	23.0	I	II	mA

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 EL400	Test Level EL400C	Units
$+R_{IN}$	+ Input Resistance		25°C, T_{MAX}	100.0	200.0		I	II	kΩ
			T_{MIN}	50.0			I	III	kΩ
C_{IN}	Input Capacitance		All		0.5	2.0	IV	IV	pF
R_{OUT}	Output Impedance (DC)		All		0.1	0.2	IV	IV	Ω
CMIR	Common-Mode Input Range	(Note 2)	25°C, T_{MAX}	2.0	2.1		IV	IV	V
			T_{MIN}	1.2			IV	IV	V
I_{OUT}	Output Current		25°C, T_{MAX}	50.0	70.0		I	II	mA
			T_{MIN}	35.0			I	III	mA
V_{OUT}	Output Voltage Swing	No Load	All	3.2	3.5		I	II	V
$V_{OUT}L$	Output Voltage Swing	100Ω	25°C	3.0	3.4		I	I	V
R_{OL}	Transimpedance		25°C	30.0	125.0		I	II	V/mA
			T_{MIN}		80.0		V	V	V/mA
			T_{MAX}		140.0		V	V	V/mA

Closed-Loop AC Electrical Characteristics

$V_S = \pm 5V$, $R_F = 250\Omega$, $A_V = +2$, $R_L = 100\Omega$ unless otherwise specified

Parameter	Description	Test Conditions	Temp	Min	Typ	Max	Test Level EL400	Test Level EL400C	Units
FREQUENCY RESPONSE									
SSBW	−3 dB Bandwidth ($V_{OUT} < 0.5\ V_{PP}$)		25°C	150.0	200.0		I	III	MHz
			T_{MIN}	150.0			IV	IV	MHz
			T_{MAX}	120.0			IV	IV	MHz
LSBW	−3 dB Bandwidth ($V_{OUT} < 5.0\ V_{PP}$)	$A_V = +5$	All	35.0	50.0		IV	IV	MHz
GAIN FLATNESS									
GFPL	Peaking $V_{OUT} < 0.5\ V_{PP}$	<40 MHz	25°C		0.0	0.3	I	III	dB
			T_{MIN}, T_{MAX}			0.4	IV	IV	dB
GFPH	Peaking $V_{OUT} < 0.5\ V_{PP}$	>40 MHz	25°C		0.0	0.5	I	III	dB
			T_{MIN}, T_{MAX}			0.7	IV	IV	dB
GFR	Rolloff $V_{OUT} < 0.5\ V_{PP}$	<75 MHz	25°C		0.6	1.0	I	III	dB
			T_{MIN}			1.0	IV	IV	dB
			T_{MAX}			1.3	IV	IV	dB
LPD	Linear Phase Deviation $V_{OUT} < 0.5\ V_{PP}$	<75 MHz	25°C, T_{MIN}		0.2	1.0	IV	IV	°
			T_{MAX}			1.2	IV	IV	°

Closed-Loop AC Electrical Characteristics — Contd.

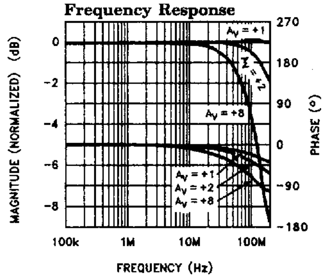
V_S = ±5V, R_F = 250Ω, A_V = +2, R_L = 100Ω unless otherwise specified

Parameter	Description	Test Conditions	Temp	Min	Typ	Max	Test Level EL400	Test Level EL400C	Units
TIME-DOMAIN RESPONSE									
t_{r1}, t_{f1}	Rise Time, Fall Time	0.5V Step	25°C, T_{MIN}		1.6	2.4	IV	IV	ns
			T_{MAX}			2.9	IV	IV	ns
t_{r2}, t_{f2}	Rise Time, Fall Time	5.0V Step	All		6.5	10.0	IV	IV	ns
t_{s1}	Settling Time to 0.1%	2.0V Step	All		10.0	13.0	IV	IV	ns
t_{s2}	Settling Time to 0.05%	2.0V Step	All		12.0	15.0	IV	IV	ns
OS	Overshoot	0.5V Step	25°C		0.0	10.0	IV	IV	%
			T_{MIN}, T_{MAX}			15.0	IV	IV	%
SR	Slew Rate	A_V = +2	All	430.0	700.0		IV	IV	V/μs
		A_V = −2	All		1600.0		V	V	V/μs
DISTORTION									
HD2	2nd Harmonic Distortion at 20 MHz	2 V_{PP}	25°C		−60.0	−45.0	I	III	dBc
			T_{MIN}			−40.0	IV	IV	dBc
			T_{MAX}			−45.0	IV	IV	dBc
HD3	3rd Harmonic Distortion at 20 MHz	2 V_{PP}	25°C		−60.0	−50.0	I	III	dBc
			T_{MIN}, T_{MAX}			−50.0	IV	IV	dBc
EQUIVALENT INPUT NOISE									
NF	Noise Floor >100 kHz	(Note 3)	25°C		−157.0	−154.0	IV	IV	dBm (1 Hz)
			T_{MIN}			−154.0	IV	IV	dBm (1Hz)
			T_{MAX}			−153.0	IV	IV	dBm (1Hz)
INV	Integrated Noise 100 kHz to 200 MHz	(Note 3)	25°C		40.0	57.0	IV	IV	μV
			T_{MIN}			57.0	IV	IV	μV
			T_{MAX}			63.0	IV	IV	μV
VIDEO PERFORMANCE									
d_G	Differential Gain (Note 4)	NTSC/PAL	25°C		0.02		V	V	% pp
d_P	Differential Phase (Note 4)	NTSC/PAL	25°C		0.01		V	V	° pp
d_G	Differential Gain (Note 4)	30 MHz	25°C		0.05		V	V	% pp
d_P	Differential Phase (Note 4)	30 MHz	25°C		0.05		V	V	° pp
VBW	−0.1 dB Bandwidth (Note 4)		25°C		60.0		V	V	MHz

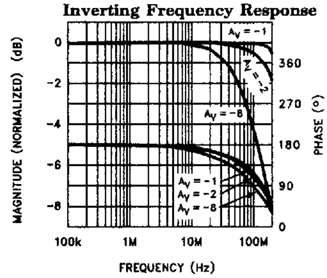
Note 1: Measured from T_{MIN} to T_{MAX}.
Note 2: Common-Mode Input Range for Rated Performance.
Note 3: Noise Tests are Performed from 5 MHz to 200 MHz.
Note 4: Differential Gain/Phase Tests are R_L = 100Ω. For other values of R_L, see curves.

Typical Performance Curves

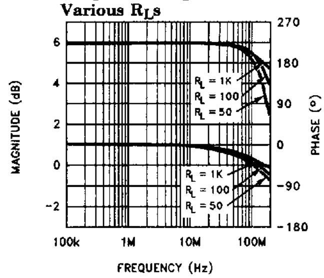
Non-Inverting Frequency Response



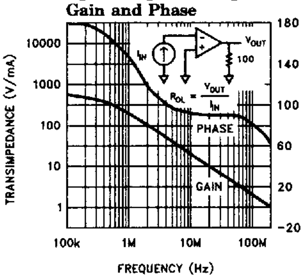
Inverting Frequency Response



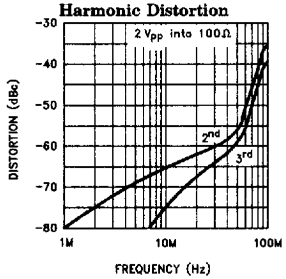
Frequency Response for Various R_Ls



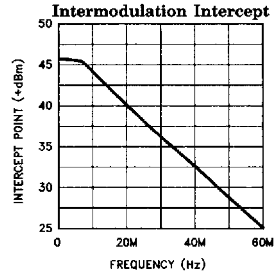
Open-Loop Transimpedance Gain and Phase



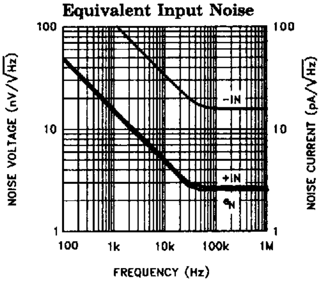
2nd and 3rd Harmonic Distortion



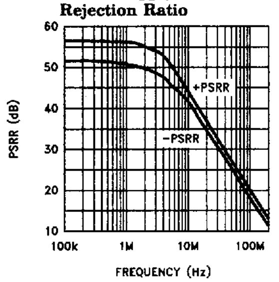
2-Tone 3rd Order Intermodulation Intercept



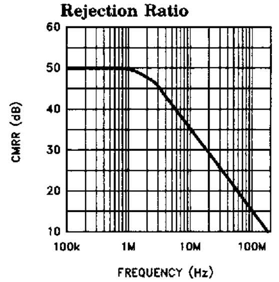
Equivalent Input Noise



Power-Supply Rejection Ratio

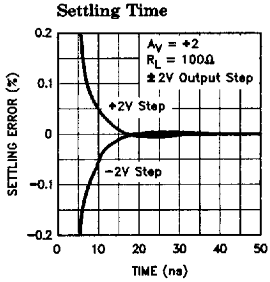


Common-Mode Rejection Ratio

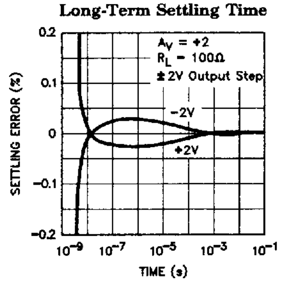


0400–2

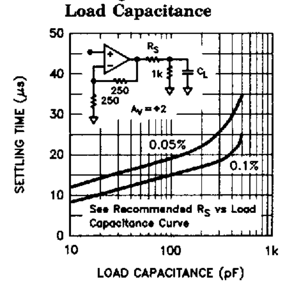
Settling Time



Long-Term Settling Time



Settling Time vs Load Capacitance



0400–3

EL400/EL400C

ELANTEC INC

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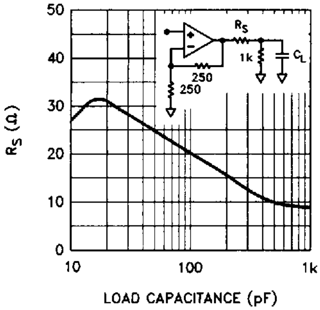
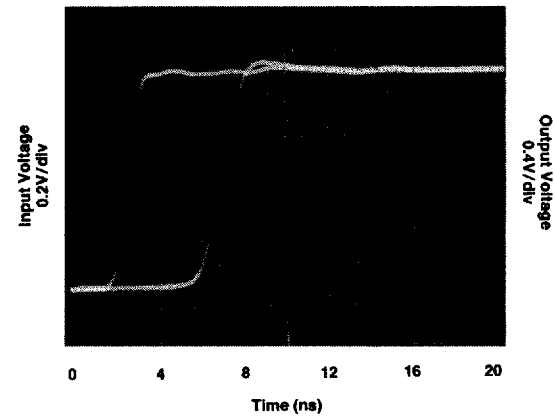
Typical Performance Curves — Contd.

Recommended R_S vs Load Capacitance



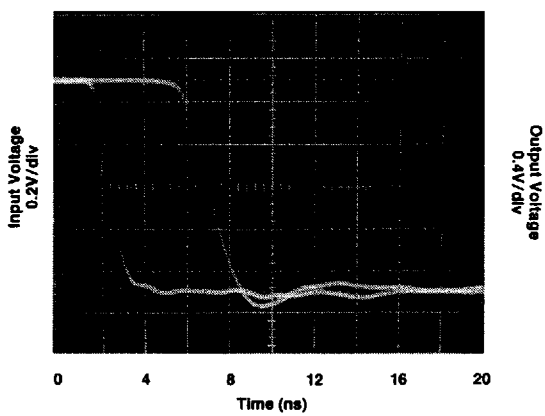
0400-4

Pulse Response A_V = +2



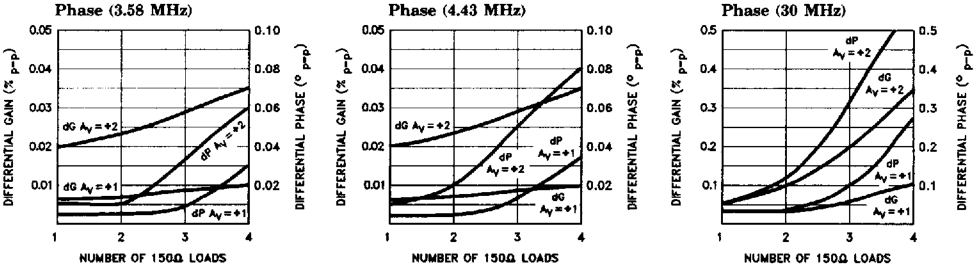
0400-5

Pulse Response A_V = +2



0400-6

Differential Gain and Phase (3.58 MHz) **Differential Gain and Phase (4.43 MHz)** **Differential Gain and Phase (30 MHz)**

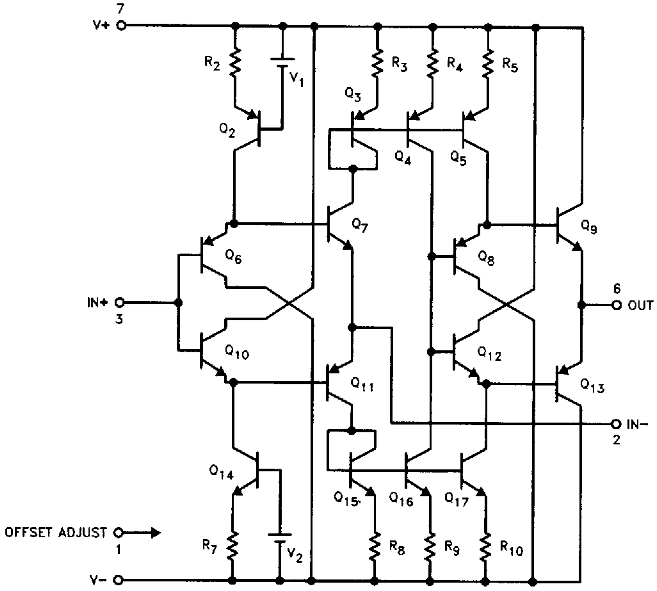


0400-7

EL400/EL400C

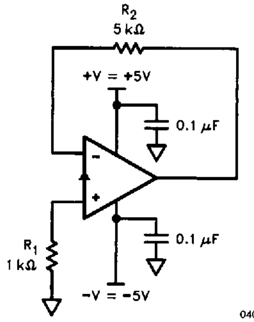
200 MHz Current Feedback Amplifier

Equivalent Circuit



0400-8

Burn-In Circuit



0400-9

ALL PACKAGES USE THE SAME SCHEMATIC.

Applications Information

Theory of Operation

The EL400 has a unity gain buffer from the non-inverting input to the inverting input. The error signal of the EL400 is a current flowing into (or out of) the inverting input. A very small change in current flowing through the inverting input will cause a large change in the output voltage. This current amplification is called the transimpedance (R_{OL}) of the EL400 [$V_{OUT} = (R_{OL}) * (-I_{IN})$]. Since R_{OL} is very large, the current flowing into the inverting input in the steady-state (non-slewing) condition is very small.

Therefore we can still use op-amp assumptions as a first-order approximation for circuit analysis, namely that:

1. The voltage across the inputs is approximately 0V.
2. The current into the inputs is approximately 0 mA.

Resistor Value Selection and Optimization

The value of the feedback resistor (and an internal capacitor) sets the AC dynamics of the EL400. The nominal value for the feedback resistor is 250Ω, which is the value used for production testing. This value guarantees stability. For a given closed-loop gain the bandwidth may be increased by decreasing the feedback resistor and, conversely, the bandwidth may be decreased by increasing the feedback resistor.

Reducing the feedback resistor too much will result in overshoot and ringing, and eventually oscillations. Increasing the feedback resistor results in a lower −3 dB frequency. Attenuation at high frequency is limited by a zero in the closed-loop transfer function which results from stray capacitance between the inverting input and ground. Consequently, it is very important to keep stray capacitance to a minimum at the inverting input.

Differential Gain/Phase

An industry-standard method of measuring the distortion of a video component is to measure the amount of differential gain and phase error it introduces. To measure these, a 40 IRE_{PP} reference signal is applied to the device with 0V DC offset (0IRE) at 3.58 MHz for NTSC, 4.43 MHz for

EL400/EL400C

200 MHz Current Feedback Amplifier

Applications Information — Contd.

PAL, and 30 MHz for HDTV. A second measurement is then made with a 0.714V DC offset (100IRE). 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. Typically, the maximum positive and negative deviations are summed to give peak values.

In general, 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 reduced by half; therefore a gain of 2 configuration is typically used to compensate for the attenuation. In a gain of 2 configuration, with output swing of 2 V_{PP}, with each back-terminated load at 150Ω. The EL400 is capable of driving up to 4 back-terminated loads with excellent video performance. Please refer to the typical curves for more information on video performance with respect to frequency, gain, and loading.

Capacitive Feedback

The EL400 relies on its feedback resistor for proper compensation. A reduction of the impedance of the feedback element results in less stability, eventually resulting in oscillation. Therefore, circuit implementations which have capacitive feedback should not be used because of the capacitor's impedance reduction with frequency. Similarly, oscillations can occur when using the technique of placing a capacitor in parallel with the feedback resistor to compensate for shunt capacitances from the inverting input to ground.

Offset Adjustment Pin

Output offset voltage of the EL400 can be nulled by tying a 10k potentiometer between $+V_S$ and $-V_S$ with the slider attached to pin 1. A full-range variation of the voltage at pin 1 to ±5V results in an offset voltage adjustment of at least ±10 mV. For best settling performance pin 1 should be bypassed to ground with a ceramic capacitor located near to the package, even if the offset voltage adjustment feature is not being used.

Printed Circuit Layout

As with any high frequency device, good PCB layout is necessary for optimum performance. Ground plane construction is a requirement, as is good power-supply and Offset Adjust bypassing close to the package. The inverting input is sensitive to stray capacitance, therefore connections at the inverting input should be minimal, close to the package, and constructed with as little coupling the ground plane as possible.

Capacitance at the output node will reduce stability, eventually resulting in peaking, and finally oscillation if the capacitance is large enough. The design of the EL400 allows a larger capacitive load than comparable products, yet there are occasions when a series resistor before the capacitance may be needed. Please refer to the graphs to determine the proper resistor value needed.

EL400 Macromodel

```
* Revision A. March 1992
* Enhancements include PSRR, CMRR, and Slew Rate Limiting
* Connections:  +input
*                |    -input
*                |    |    +Vsupply
*                |    |    |    -Vsupply
*                |    |    |    |    output
*                |    |    |    |    |
.subckt M400     3    2    7    4    6
*
* Input Stage
*
e1 10 0 3 0 1.0
vis 10 9 0V
h2 9 12 vxx 1.0
r1 2 11 50
l1 11 12 48nH
iinp 3 0 8μA
iinm 2 0 8μA
*
* Slew Rate Limiting
*
h1 13 0 vis 600
r2 13 14 1K
d1 14 0 dclamp
d2 0 14 dclamp
*
* High Frequency Pole
*
*e2 30 0 14 0 0.00166666666
l3 30 17 0.1μH
c5 17 0 0.1pF
r5 17 0 500
*
* Transimpedance Stage
*
g1 0 18 17 0 1.0
rol 18 0 150K
cdp 18 0 2.8pF
*
* Output Stage
*
q1 4 18 19 qp
q2 7 18 20 qn
q3 7 19 21 qn
q4 4 20 22 qp
r7 21 6 2
r8 22 6 2
```

EL400/EL400C

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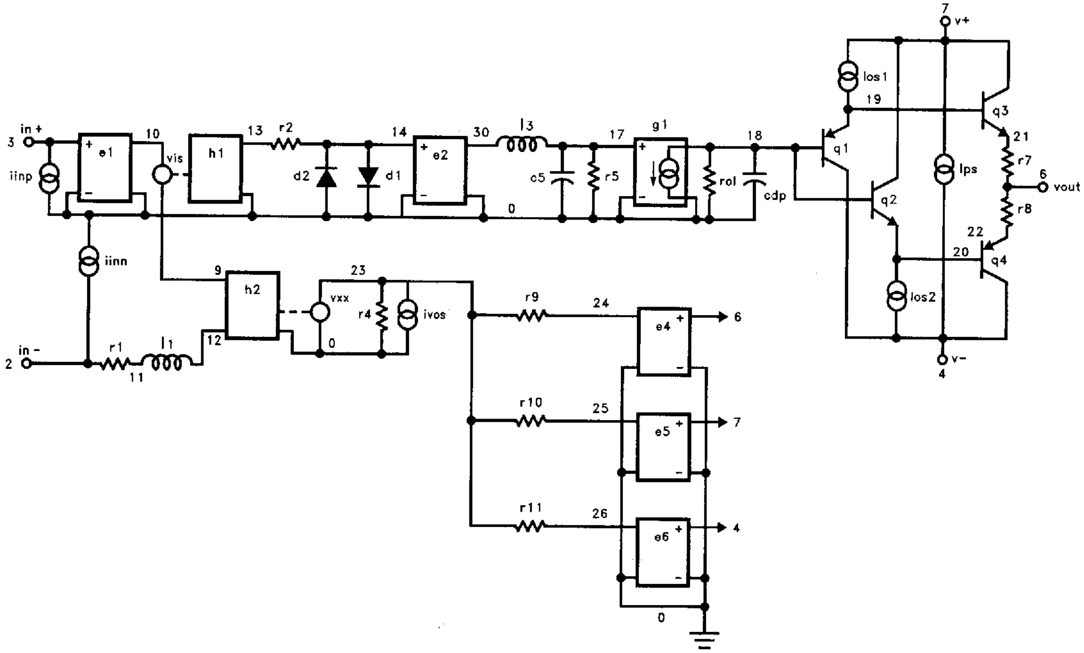
EL400 Macromodel — Contd.

```
ios1 7 19 2.5mA
ios2 20 4 2.5mA
*
* Supply Current
*
ips 7 4 9mA
*
* Error Terms
*
ivos 0 23 5mA
vxx 23 0 0V
e4 24 0 6 0 1.0
e5 25 0 7 0 1.0
e6 26 0 4 0 1.0
r9 24 23 3K
r10 25 23 1K
r11 26 23 1K
*
* Models
*
.model qn npn (is=5e-15 bf=200 tf=0.5nS)
.model qp pnp (is=5e-15 bf=200 tf=0.5nS)
.model dclamp d(is=1e-30 ibv=0.266 bv=1.3 n=4)
.ends
```

EL400 Macromodel — Contd.



0400-10