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**150MHz Current Feedback Amplifier**



The EL2071 and EL2171 are wide bandwidth, fast settling monolithic amplifiers built using an advanced

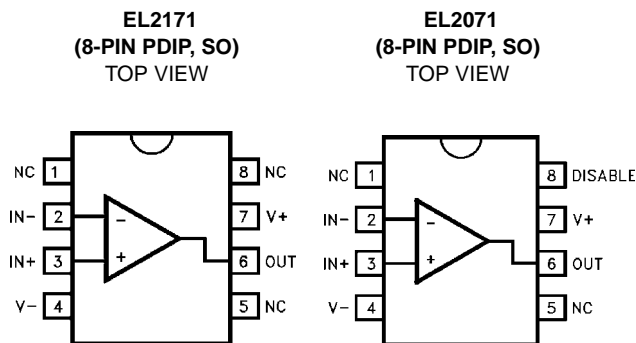
complementary bipolar process. The EL2071 has a disable/enable feature which allows power down and analog multiplexing. These amplifiers use current-mode feedback to achieve more bandwidth at a given gain than conventional operational amplifiers. Designed for closed-loop gains of  $\pm 7$  to  $\pm 50$ , the EL2071 and EL2171 have a 150MHz - 3dB bandwidth ( $A_V = +20$ ), and 2.5ns rise/fall time, while consuming only 15mA of supply current. The EL2071 consumes only 1.5mA when disabled.

The wide 150MHz bandwidth and extremely linear phase (0.2dB deviation from linear at 50MHz) allow superior signal fidelity. These features make the EL2071 and EL2171 especially suited for many digital communication system applications.

The EL2071's and EL2171's settling to 0.1% in 10ns and ability to drive capacitive loads make them ideal in flash A/D applications. D/A systems can also benefit from the EL2071 and EL2171, especially if linearity and drive levels are important.

Elantec products and facilities comply with MIL-I-45208A, and other applicable quality specifications. For information on Elantec's processing, see Elantec document, QRA-1: Elantec's Processing, Monolithic Integrated Circuits.

**Pinout**



Manufactured under U.S. Patent No. 4,893,091

**Features**

- 150MHz - 3dB bandwidth,  $A_V = 20$
- 10ns settling to 0.1%
- $V_S = \pm 5V @ 15mA$
- 2.5ns rise/fall times (2V step)
- Overload/short-circuit protected
- $\pm 7$  to  $\pm 50$  closed-loop gain range
- Low cost
- EL2171 is direct replacement for CLC401
- Disable capability on EL2071

**Applications**

- Line drivers
- DC-coupled log amplifiers
- High-speed modems, radios
- High-speed A/D conversion
- D/A I-V conversion
- Photodiode, CCD preamps
- IF processors
- High-speed communications
- Analog multiplexing (using disable—EL2071)
- Power down mode (using disable—EL2071)

**Ordering Information**

PART NUMBER	TEMP. RANGE	PACKAGE	PKG. NO.
EL2171CN	-40°C to +85°C	8-Pin PDIP	MDP0031
EL2171CS	-40°C to +85°C	8-Pin SO	MDP0027
EL2071CN	-40°C to +85°C	8-Pin PDIP	MDP0031
EL2071CS	-40°C to +85°C	8-Pin SO	MDP0027

# EL2071, EL2171

## Absolute Maximum Ratings ( $T_A = 25^\circ\text{C}$ )

Supply Voltage ( $V_S$ ) . . . . .  $\pm 7\text{V}$   
 (Output Current Output is short-circuit protected to ground, however, maximum reliability is obtained if  $I_{OUT}$  does not exceed 70mA.)

Common Mode Input Voltage . . . . .  $\pm V_S$   
 Differential Input Voltage . . . . .  $.5\text{V}$   
 Power Dissipation . . . . . See Curves

Operating Temperature . . . . .  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Operating Junction Temperature  
 Ceramic Packages . . . . .  $175^\circ\text{C}$   
 Plastic Packages . . . . .  $150^\circ\text{C}$   
 Storage Temperature . . . . .  $-60^\circ\text{C}$  to  $+150^\circ\text{C}$

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

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

## Open-Loop DC Electrical Specifications

$V_S = \pm 5\text{V}$ ,  $R_L = 100\Omega$ , unless otherwise specified

PARAMETER	DESCRIPTION	TEST CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
$V_{OS}$	Input Offset Voltage		$25^\circ\text{C}$		3	6	mV
			$T_{MIN}$ , $T_{MAX}$			10	mV
$TC V_{OS}$	Average Offset Voltage Drift	(Note 1)	All		20	50	$\mu\text{V}/^\circ\text{C}$
$+I_{IN}$	+Input Current		$25^\circ\text{C}$ , $T_{MAX}$		10	20	$\mu\text{A}$
			$T_{MIN}$			36	$\mu\text{A}$
$TC (+I_{IN})$	Average +Input Current Drift	(Note 1)	All		100	200	$\text{nA}/^\circ\text{C}$
$-I_{IN}$	-Input Current		$25^\circ\text{C}$		10	30	$\mu\text{A}$
			$T_{MIN}$			46	$\mu\text{A}$
			$T_{MAX}$			40	$\mu\text{A}$
$TC (-I_{IN})$	Average -Input Current Drift	(Note 1)	All		100	200	$\text{nA}/^\circ\text{C}$
PSRR	Power Supply Rejection Ratio	(Note 2)	All	50	55		dB
CMRR	Common-Mode Rejection Ratio		All	40	50		dB
$I_S$	Supply Current—Quiescent	No Load	All		15	21	mA
$I_{SOFF}$	Supply Current—Disabled	EL2071 (Note 3)	All		1.5	3.0	mA
$+R_{IN}$	+Input Resistance		$25^\circ\text{C}$ , $T_{MAX}$	100	200		k $\Omega$
			$T_{MIN}$	50			k $\Omega$
$C_{IN}$	Input Capacitance		All		0.5	2.5	pF
$R_{OUT}$	Output Resistance (DC)		All		0.2	0.3	$\Omega$
$R_{OUTD}$	Output Resistance (DC)	EL2071 Disabled	All	100	200		k $\Omega$
$C_{OUTD}$	Output Capacitance (DC)	EL2071 Disabled	All		0.5	2.0	pF
CMIR	Common-Mode Input Range	(Note 4)	$25^\circ\text{C}$ , $T_{MAX}$	$\pm 2.5$	$\pm 2.8$		V
			$T_{MIN}$	$\pm 2$			V
$I_{OUT}$	Output Current		$25^\circ\text{C}$ , $T_{MAX}$	50	70		mA
			$T_{MIN}$	35			mA
$V_{OUT}$	Output Voltage Swing	No Load	$25^\circ\text{C}$ , $T_{MAX}$	3.2	3.5		V
			$T_{MIN}$	3			V

## EL2071, EL2171

### Open-Loop DC Electrical Specifications

$V_S = \pm 5V$ ,  $R_L = 100\Omega$ , unless otherwise specified (Continued)

PARAMETER	DESCRIPTION	TEST CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
$V_{OUTL}$	Output Voltage Swing	$R_L = 100\Omega$	25°C	3.2	3.4		V
$R_{OL}$	Transimpedance		25°C	250	1000		V/mA
$I_{LOGIC}$	Pin 8 Current @+5V	EL2071	All		500	750	$\mu A$
$V_{DIS}$	Minimum Pin 8 V to Disable	EL2071	25°C	4.3			
			$T_{MIN}$	4.0			V
			$T_{MAX}$	4.6			
$V_{EN}$	Maximum Pin 8 V to Enable	EL2071	All			0.7	V
$I_{DIS}$	Minimum Pin 8 I to Disable	EL2071	All	750			$\mu A$
$I_{EN}$	Maximum Pin 8 I to Enable	EL2071	All			35	$\mu A$

#### NOTES:

1. Measured from  $T_{MIN}$  to  $T_{MAX}$ .
2. PSRR is measured at  $V_S = \pm 4.5V$  and  $V_S = \pm 5.5V$ . Both supplies are changed simultaneously.
3. Supply current when disabled is measured at the negative supply.
4. Common-Mode Input Range for Rated Performance.

### Closed-Loop AC Electrical Specifications

$V_S = \pm 5V$ ,  $R_F = 1.5k\Omega$ ,  $A_V = +20$ ,  $R_L = 100\Omega$  unless otherwise specified

PARAMETER	DESCRIPTION	TEST CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
<b>FREQUENCY RESPONSE</b>							
SSBW	-3dB Bandwidth ( $V_{OUT} < 2.0 V_{PP}$ )		25°C	100	150		MHz
			$T_{MIN}$	100			MHz
			$T_{MAX}$	70			MHz
LSBW	-3dB Bandwidth ( $V_{OUT} < 5.0 V_{PP}$ )		25°C, $T_{MIN}$	65	100		MHz
			$T_{MAX}$	55			MHz
<b>GAIN FLATNESS</b>							
GFPL	Peaking $V_{OUT} < 2.0 V_{PP}$	< 25MHz	25°C		0.0	0.1	dB
			$T_{MIN}, T_{MAX}$			0.1	dB
GFPH	Peaking $V_{OUT} < 2.0 V_{PP}$	> 25MHz	25°C		0.0	0.2	dB
			$T_{MIN}, T_{MAX}$			0.2	dB
GFR	Rolloff $V_{OUT} < 2.0 V_{PP}$	< 50MHz	25°C		0.2	1.0	dB
			$T_{MIN}$			1.0	dB
			$T_{MAX}$			1.3	dB
LPD	Linear Phase Deviation $V_{OUT} < 2.0 V_{PP}$	< 50MHz	25°C, $T_{MIN}$		0.2	1.0	°
			$T_{MAX}$			1.5	°
<b>TIME-DOMAIN RESPONSE</b>							
$t_{R1}, t_{F1}$	Rise Time, Fall Time	2.0V Step	25°C, $T_{MIN}$		2.5	3.5	ns
			$T_{MAX}$			5	ns
$t_{R2}, t_{F2}$	Rise Time, Fall Time	5.0V Step	25°C, $T_{MIN}$		5	7	ns
			$T_{MAX}$			8	ns
$t_S$	Settling Time to 0.1%	2.0V Step	All		10	15	ns

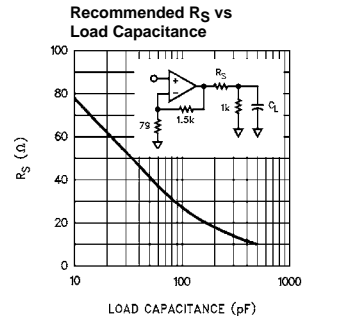
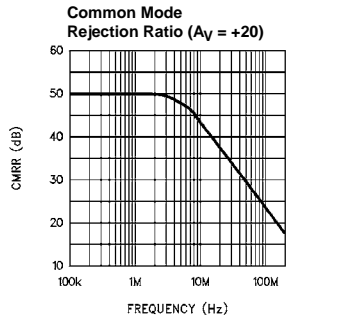
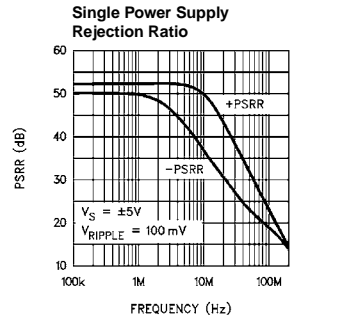
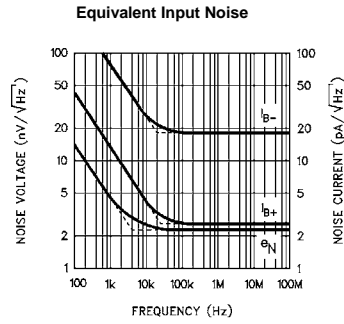
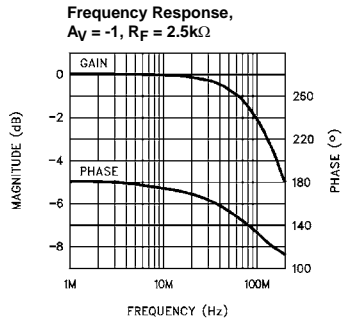
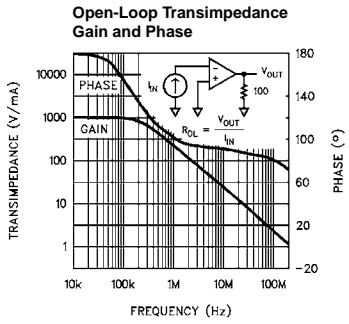
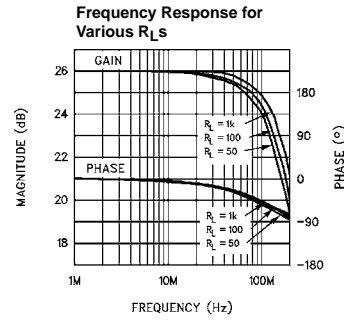
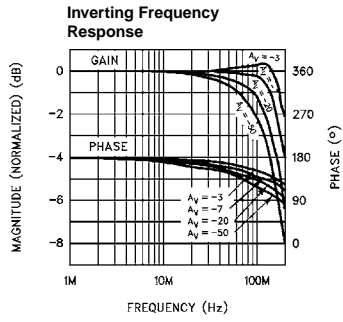
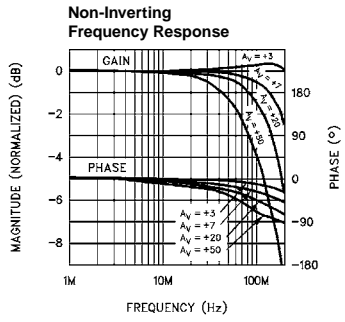
## EL2071, EL2171

### Closed-Loop AC Electrical Specifications

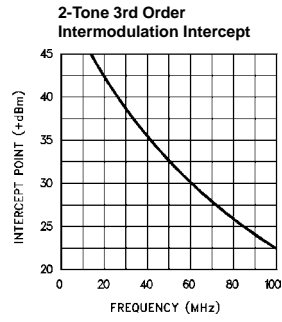
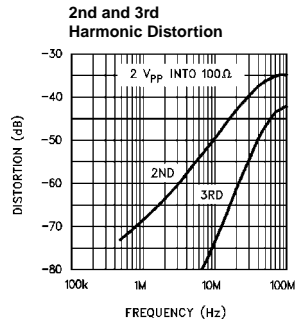
$V_S = \pm 5V$ ,  $R_F = 1.5k\Omega$ ,  $A_V = +20$ ,  $R_L = 100\Omega$  unless otherwise specified **(Continued)**

PARAMETER	DESCRIPTION	TEST CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
OS	Overshoot	2.0V Step	All		0	10	%
SR	Slew Rate		25°C, $T_{MIN}$	800	1200		V/ $\mu$ s
			$T_{MAX}$	700			V/ $\mu$ s
<b>DISTORTION</b>							
HD2	2nd Harmonic Distortion @20MHz	2V <sub>PP</sub>	25°C		-45	-35	dBc
			$T_{MIN}$ , $T_{MAX}$			-35	dBc
HD3	3rd Harmonic Distortion @20MHz	2V <sub>PP</sub>	25°C		-60	-50	dBc
			$T_{MIN}$			-50	dBc
			$T_{MAX}$			-45	dBc
<b>EQUIVALENT INPUT NOISE</b>							
NF	Noise Floor >100kHz		25°C		-158	-155	dBm (1Hz)
			$T_{MIN}$			-155	dBm (1Hz)
			$T_{MAX}$			-154	dBm (1Hz)
INV	Integrated Noise 100kHz to 200MHz		25°C		35	50	$\mu$ V
			$T_{MIN}$			50	$\mu$ V
			$T_{MAX}$			55	$\mu$ V
<b>DISABLE/ENABLE PERFORMANCE—EL2071C</b>							
$T_{OFF}$	$V_{OUT} = 2 V_{PP}$ Disable Time to >40dB	20MHz	All		70	200	ns
$T_{ON}$	Enable Time		All		40	100	ns
ISO	Off Isolation	20MHz	All	50	55		dB

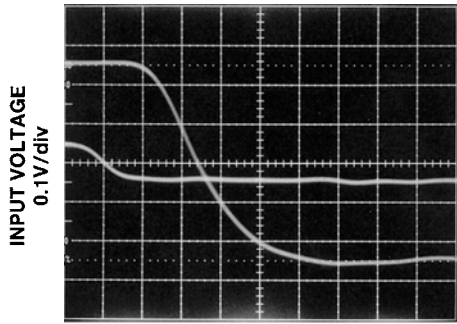
Typical Performance Curves



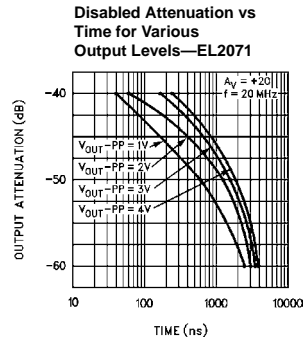
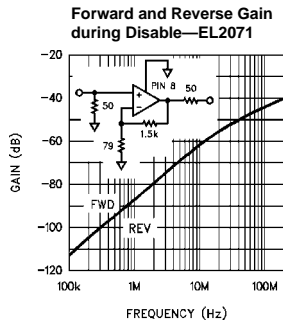
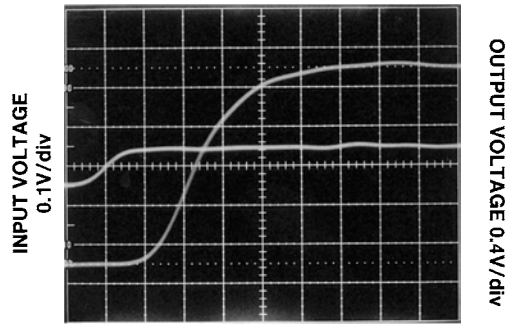
Typical Performance Curves (Continued)



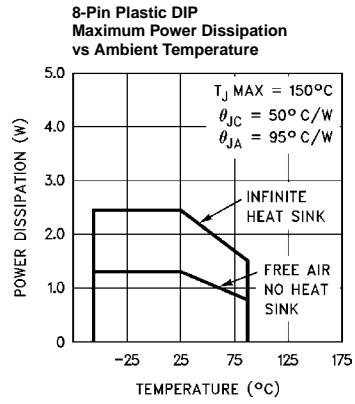
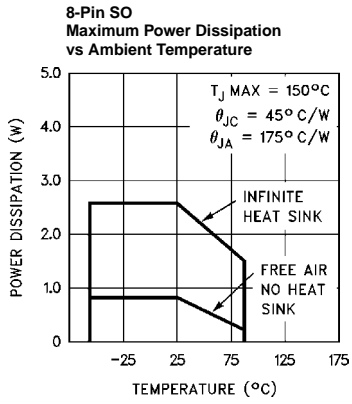
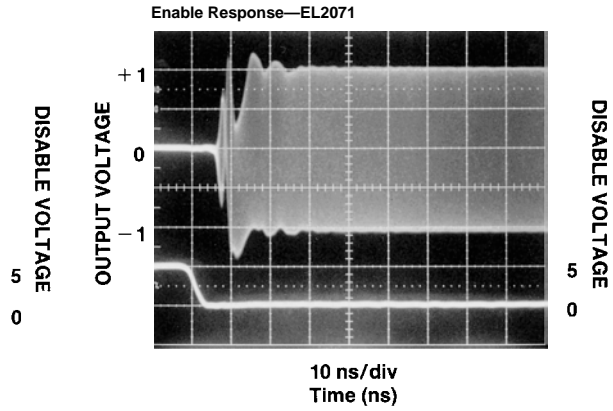
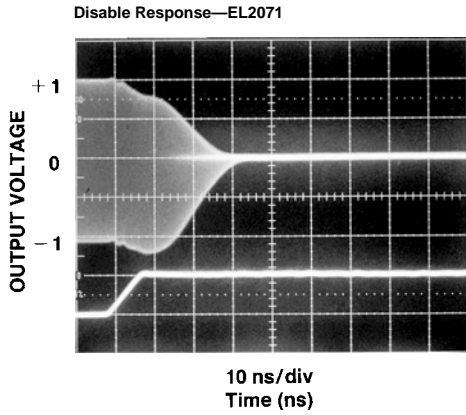
Pulse Response  $A_V = +20$



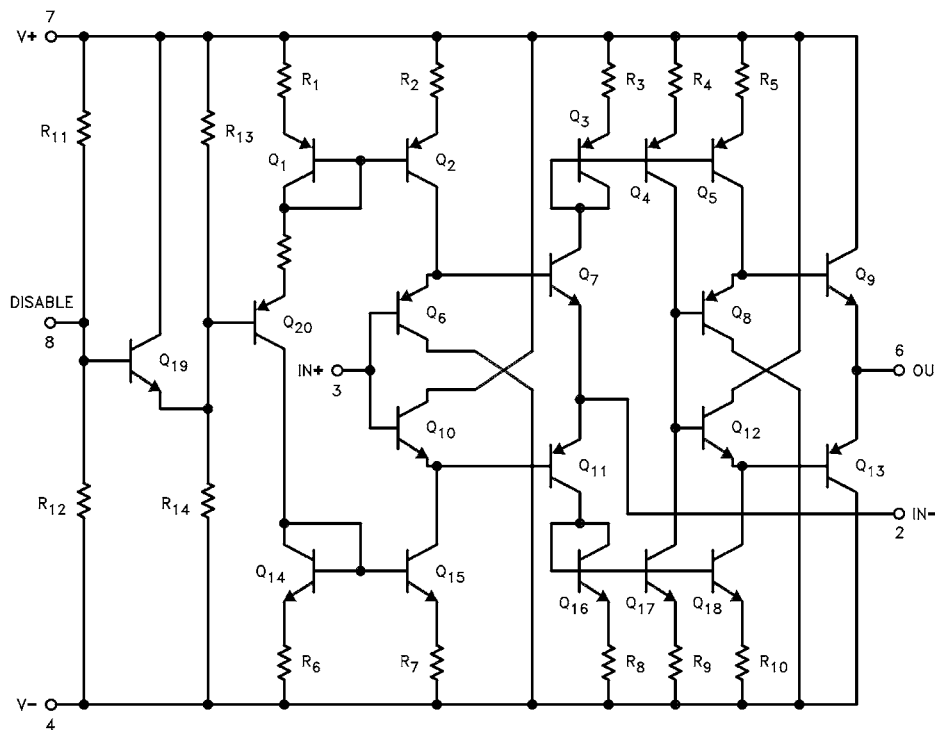
Pulse Response  $A_V = +20$



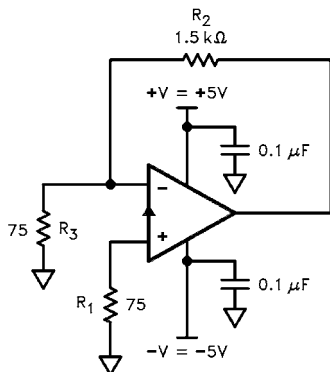
Typical Performance Curves (Continued)



**Equivalent Circuit**



**Burn-In Circuit**



ALL PACKAGES USE THE SAME SCHEMATIC.

**Applications Information**

**Theory of Operation**

The EL2071/EL2171 have a unity gain buffer from the non-inverting input to the inverting input. The error signal of the EL2071/EL2171 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 EL2071/EL2171 [ $V_{OUT} = (R_{OL}) * (-I_{IN})$ ]. 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 0mA.

**Resistor Value Selection and Optimization**

The value of the feedback resistor (and an internal capacitor) sets the AC dynamics of the EL2071/EL2171. The nominal value for the feedback resistor is 1.5kΩ, 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 -3dB 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.



**Capacitive Feedback**

The EL2071/EL2171 rely on their 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.

**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 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 to 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 EL2071/EL2171 allow 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.

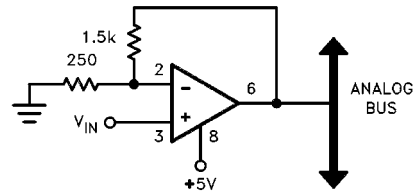
**Disable/Enable Operation for EL2071**

The EL2071 has a disable/enable control input at pin 8. The device is enabled and operates normally when pin 8 is left open or returned to ground. When the voltage at pin 8 is brought to within 0.4V of pin 7 ( $V_{S+}$ ), the EL2071 is disabled. The output becomes a high impedance, the inverting input is no longer driven to the positive input voltage, and the supply current is reduced to less than 2.2mA. There are internal resistors which limit the current at pin 8 to a safe level ( $\sim \pm 500\mu A$ ) if pin 8 is shorted to either supply.

Typically, analog and digital circuits should have separate power supplies. This usually leads to slight differences between the power supply voltages. The EL2071's disable feature is dependent on the voltage at pins 8 and 7. Therefore, to operate the disable feature of the EL2071 dependably over temperature, it is recommended that the logic circuitry which drives pin 8 of the EL2071 operate from the same +5V supply as the EL2071 to avoid voltage differences between the digital and analog power supplies. Since  $V_{D1S}$  is temperature dependent, it is recommended that 5V CMOS logic (with a  $V_{OH} > 4.6V$  sourcing  $> 750\mu A$  over temperature) be used to drive the disable pin of the EL2071.

When disabled, (as well as in enabled mode), care must be taken to prevent a differential voltage between the + and - inputs greater than 5.0V. For example, in the figure below,

the EL2071 is connected in a gain of +7 configuration and is disabled while the analog bus is driven externally to +5V. Pin 2 is consequently at +0.71V, and if  $V_{IN}$  is driven to -5V, then 5.71V appears between pins 3 and 2. Internally, this voltage appears across a forward biased  $V_{BE}$  in series with a reverse biased  $V_{BE}$  and is past the threshold for zenering the reverse biased  $V_{BE}$ . In a typical application, a 50Ω or 75Ω terminating resistor from pin 3 to ground will prevent pin 3 from approaching -5V.

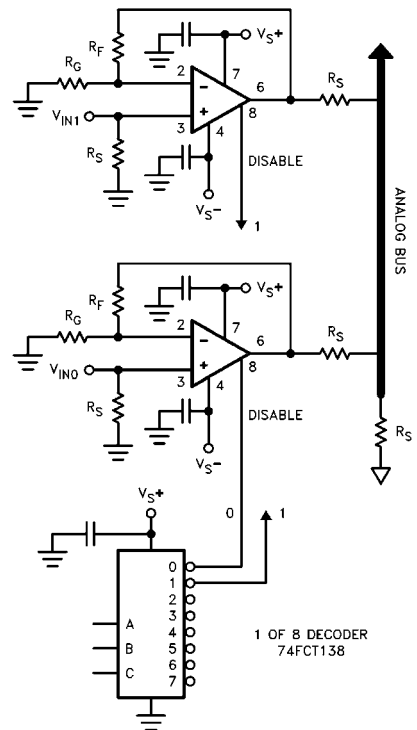


**Using the EL2071 as a Multiplexer**

An interesting use of the enable feature is to combine several amplifiers in parallel with their outputs in common. This combination then acts similar to a MUX in front of an amplifier. A typical circuit is shown. The series resistance at each output helps to further increase isolation between amplifiers.

When the EL2071 is disabled, the DC output impedance is  $> 100k\Omega$  in parallel with 2pF capacitance.

To operate properly, the decoder that is used must have a  $V_{OH} > (V_{S+}) - 0.4V$  with  $I_{OH} = 750\mu A$ , and should be connected to the same power supply as the EL2071.



**EL2071 Macromodel**

\* Revision A. March 1992  
 \* Enhancements include PSRR, CMRR, and Slew Rate Limiting

\* Connections: +input  
 \* | -input  
 \* | | +Vsupply  
 \* | | | -Vsupply  
 \* | | | | output  
 \* | | | | |  
 .subckt M2071 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 2  
 l1 11 12 1nH  
 iinp 3 0 10µA  
 iinm 2 0 10µA  
 \*

\* Slew Rate Limiting  
 \*

\*h1 13 0 vis 1K  
 h1 13 0 vis 600  
 r2 13 14 100  
 d1 14 0 dclamp  
 d2 0 14 dclamp  
 \*

\* High Frequency Pole  
 \*

\*e2 30 0 14 0 0.00166666666  
 e2 30 0 14 0 0.001  
 l3 30 17 1.0µH  
 c5 17 0 0.1pF  
 r5 17 0 500  
 \*

\* Transimpedance Stage  
 \*

g1 0 18 17 0 1.0  
 rol 18 0 1Meg  
 cdp 18 0 0.88pF  
 \*

\* 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  
 ios1 7 19 2.5mA  
 ios2 20 4 2.5mA  
 \*

\* Supply Current  
 \*

ips 7 4 9mA  
 \*

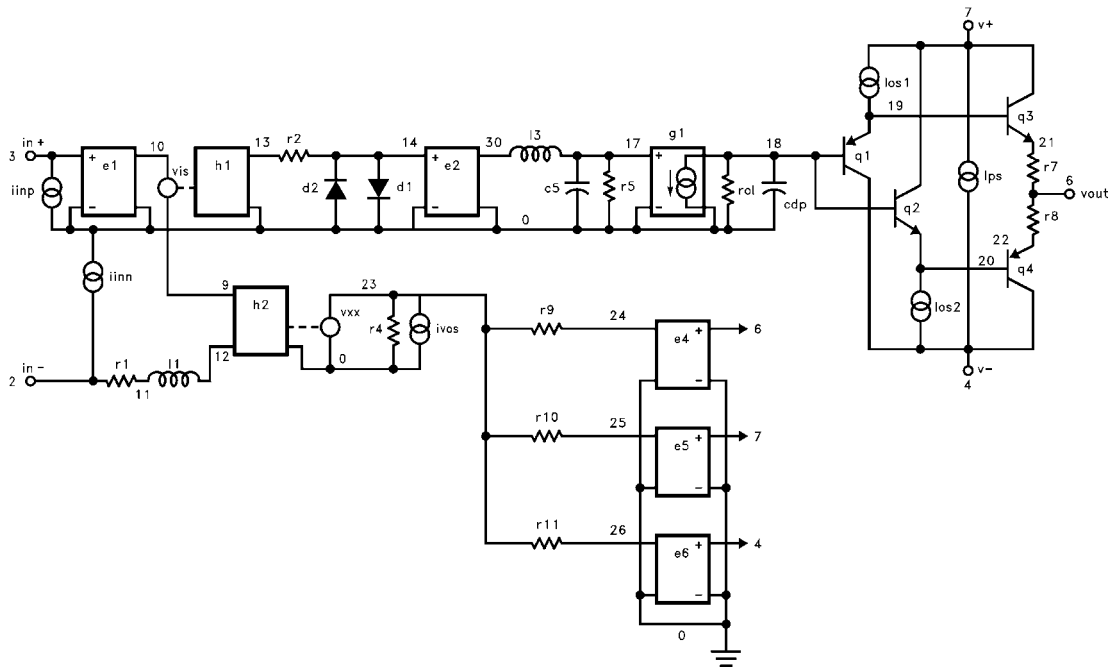
\* Error Terms  
 \*

**EL2071 Macromodel** (Continued)

```
ivos 0 23 3mA
vxx 23 0 0V
e4 24 0 3 0 1.0
e5 25 0 7 0 1.0
e6 26 0 4 0 1.0
r9 24 23 316
r10 25 23 562
r11 26 23 562
```

\*  
\* Models  
\*

```
.model qn npn (is=5e-15 bf=500 tf=0.05nS)
.model qp pnp (is=5e-15 bf=500 tf=0.05nS)
.model dclamp d(is=1e-30 ibv=1pA bv=3.5 n=4)
.ends
```



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