November 14, 2002 FN7042

## Low Cost, Gain of 1, Video Op Amp

The EL2110 operational amplifier, built using Elantec's complementary bipolar process, offers unprecedented high frequency performance at a very low cost. It is suitable for any application, such as consumer video, where traditional DC performance specifications are of secondary importance to the high frequency specifications. On a 5V supply at a gain of +1 the EL2110 will drive a 150Ω load to +2V, with a bandwidth of 50MHz. This device achieves 0.1dB bandwidth at 5MHz.

The recommended power supply voltage is 5V. At zero and 5V supplies, the inputs will operate to ground. When the outputs are at 0V the amplifier draws only 2.4mA of supply current.

## Features

- Optimized for 5V operation
- Stable at gain of 1
- 50MHz gain bandwidth product
- 130V/µs slew rate
- Drives 150Ω load to video levels
- Input and outputs operate at negative supply rail

## Applications

- Consumer video amplifier
- Active filters/integrators
- Cost sensitive applications
- Single supply amplifiers

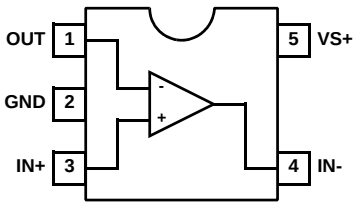
## Ordering Information

| PART NUMBER | PACKAGE | TAPE & REEL | PKG. NO. |
|---|---|---|---|
| EL2110CN | 8-Pin PDIP | - | MDP0031 |
| EL2110CS | 8-Pin SO | - | MDP0027 |
| EL2110CW | 5-Pin SOT-23* | - | MDP0038 |

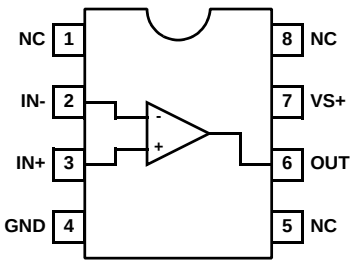
*EL2110CW symbol is .Dxxx where xxx represents date code

## Pinouts

**EL2110**
**(5-PIN SOT23)**
TOP VIEW




**EL2110**
**(8-PIN PDIP, SO)**
TOP VIEW



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

Total Supply Voltage . . . . . .18V
Input Voltage . . . . . .-6$V_S$
Differential Input Voltage . . . . . .6V
Peak Output Current . . . . . .75mA per amplifier
Power Dissipation . . . . . See Curves
Storage Temperature Range . . . . . .-65°C to +150°C
Operating Temperature Range . . . . . -40°C to +85°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: $T_J = T_C = T_A$*

## DC Electrical Specifications

$V_S$ = +5V, $R_L$ = 1kΩ, $V_{IN}$ = 1V, $T_A$ = 25°C unless otherwise specified.

| PARAMETER | DESCRIPTION | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{OS}$ | Input Offset Voltage | | -20 | 10 | 20 | mV |
| $TCV_{OS}$ | Average Offset Voltage Drift | (Note 1) | | -50 | | µV/°C |
| $I_B$ | Input Bias Current | | -15 | -7 | -3 | µA |
| $I_{OS}$ | Input Offset Current | | -1 | 0.3 | 1.0 | µA |
| $TCI_{OS}$ | Average Offset Current Drift | (Note 1) | | -3 | | nA/°C |
| $A_{VOL}$ | Open Loop Gain | $V_{OUT}$ = 0.5, 2.5, $R_L$ = 1kΩ | 160 | 250 | | V/V |
| | | $V_{OUT}$ = 0.5, 2.5, $R_L$ = 150kΩ | 160 | 250 | | V/V |
| PSRR | Power Supply Rejection Ratio | $V_S$ = 4.5V to 5.5V | 43 | 50 | | dB |
| CMRR | Common Mode Rejection Ratio | $V_{CM}$ = 0V to 3.8V | 55 | 65 | | dB |
| CMIR | Common Mode Input Range | | 0.0 | | 3.0 | V |
| $V_{OUT}$ | Output Voltage Swing | $R_{FB}$ = $R_G$ = 1kΩ, $R_L$ = 150Ω | 2.8 | 3.2 | | V |
| $I_{SC}$ | Output Short Circuit Current | Output to Ground (Note 2) | 75 | 125 | | mA |
| $I_S$ | Supply Current | No load (per channel) $V_{IN}$ = 0V | 2.0 | 2.4 | 3.0 | mA |
| $R_{IN}$ | Input Resistance | Differential | | 150 | | kΩ |
| | | Common mode | | 1.5 | | MΩ |
| $C_{IN}$ | Input Capacitance | $A_V$ = 1 @ 10MHz | | 1 | | pF |
| $R_{OUT}$ | Output Resistance | | | 0.150 | | W |
| PSOR | Power Supply Operating Range | Single supply | 4 | | 6 | V |

NOTES:

1. Measured from $T_{MIN}$ to $T_{MAX}$.
2. A heat-sink is required to keep junction temperature below absolute maximum when an output is shorted.

## Closed-Loop AC Electrical Specifications

$V_S$ = 5V, AC Test Figure, $T_A$ = 25°C unless otherwise specified.

| PARAMETER | DESCRIPTION | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| BW | -3dB Bandwidth ($V_{OUT}$ = 0.4m$V_{P-P}$) | $A_V$ = 1 | | 100 | | MHz |
| | ±0.1dB Bandwidth ($V_{OUT}$ = 0.4m$V_{P-P}$) | $A_V$ = 1 | | 10 | | MHz |
| GBWP | Gain Bandwidth Product | | | 50 | | MHz |
| PM | Phase Margin | | | 55 | | ° |
| SR | Slew Rate | | 85 | 130 | | V/µs |
| FBWP | Full Power Bandwidth | (Note 1) | 8 | 11 | | MHz |
| $t_R$, $t_F$ | Rise Time, Fall Time | 0.1V step | | 2 | | ns |
| OS | Overshoot | 0.1V step | | 15 | | % |

## Closed-Loop AC Electrical Specifications

$V_S$ = 5V, AC Test Figure, $T_A$ = 25°C unless otherwise specified. **(Continued)**

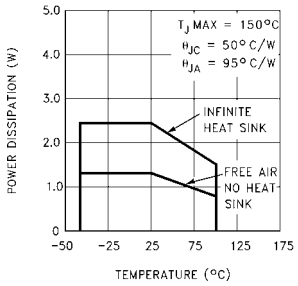
| PARAMETER | DESCRIPTION | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{PD}$ | Propagation Delay | | | 3.5 | | ns |
| $t_S$ | Settling to 0.1% ($A_V$ = 1) | VS = 5V, 2V step | | 80 | | ns |
| dG | Differential Gain (Note 2) | NTSC/PAL | | 0.1 | | % |
| dP | Differential Phase (Note 2) | NTSC/PAL | | 0.2 | | ° |
| $e_N$ | Input Noise Voltage | 10kHz | | 15 | | nV/√Hz |
| $i_N$ | Input Noise Current | 10kHz | | 1.5 | | nV/√Hz |
| CS | Channel Separation | P = 5MHz | | 55 | | dB |

NOTES:

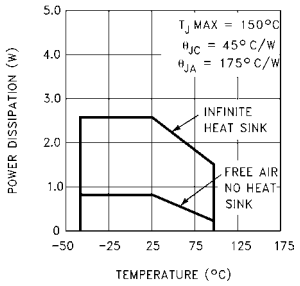
1. For $V_S$ = 5V, $V_{OUT} = 4V_{P-P}$. Full power bandwidth is based on slew rate measurement using: FPBW = SR/(2pi*$V_{PEAK}$)
2. Video performance measured at $V_S$ = 5V, $A_V$ = 2 with 2 times normal video level across $R_L$ = 150Ω

## Typical Performance Curves

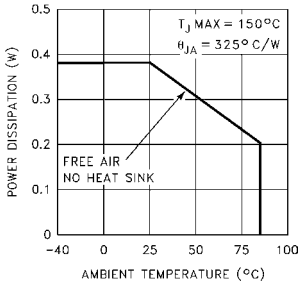
**8-Pin Plastic DIP**
**Maximum Power Dissipation**
**vs Ambient Temperature**



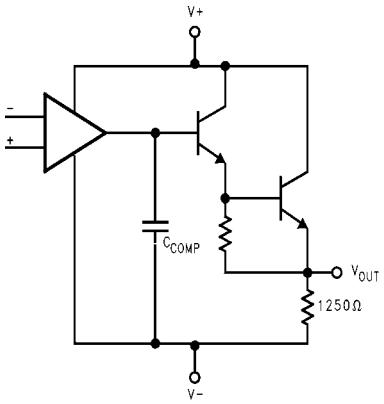

**8-Pin SO**
**Maximum Power Dissipation**
**vs Ambient Temperature**




**5-Pin SOT23**
**Maximum Power Dissipation**
**vs Ambient Temperature**




## Simplified Block Diagram




## Applications Information

### Product Description

The EL2110 operational amplifier is stable at a gain of 1. It is built on Elantec's proprietary complimentary bipolar process. This topology allows it to be used in a variety of applications where current mode amplifiers are not appropriate because of restrictions placed on the feedback elements. This product is especially designed for applications where high bandwidth and good video performance characteristics are desired but the higher cost of more flexible and sophisticated products are prohibitive.

### Power Supplies

The EL2110 is designed to work at a supply voltage difference of 4.5V to 5.5V. It will work on any combination of ± supplies. All electrical characteristics are measured with a 5V supply.

### Output Swing vs Load

Please refer to the simplified block diagram. This amplifier provides an NPN pull-up transistor output and a passive 1250Ω pull-down resistor to the most negative supply. In a application where the load is connected to $V_S$- the output voltage can swing to within 200mV of $V_S$-.

### Output Drive Capability

This device does not have short circuit protection. Each output is capable of than 100mA into a shorted output. Care must be used in the design to limit the output current with a series resistor.

### Single 5V Supply Video Cable Driver

These amplifiers may be used as a direct coupled video cable driver with a gain of 2. With a 75Ω back matching resistor driving a terminated 75Ω cable the output at the cable load will be original video level (1V NTSC). The best operating mode is with direct coupling. The input signal must be offset to keep the entire signal within the range of the amplifier. The required offset voltage can be set with a resistor divider and a bypass capacitor in the video path (*Figure 1*). The input DC offset should be between 0.3V and 0.5V. With $R_A$ = 68k and $R_B$ = 4.7k the input offset will be 0.32V. Since these amplifiers require a DC load at their outputs it is good design practice to add a 250Ω resistor to ground directly at the amplifier output. Then if the 75Ω cable termination resistor were inadvertently removed there would still be an output signal. The values in Figure 1 give an output range of 0V to 2.6V.

Output capacitive coupling also has some restrictions. These amplifiers require a DC load at their outputs. A 75Ω back

matching resistor to a cable and a 75Ω load to ground at the end of the cable provide a 150Ω DC load. But output capacitive coupling opens this DC path so an extra pulldown resistor on the amplifier output to ground is required. Figure 4 shows a 250Ω resistor. Capacitively coupling the output will require that we shift the output offset voltage higher than in the direct coupled case. Using $R_A$ = 43k and $R_B$ = 4.7k will make the quiescent output offset voltage about 1V. The output dynamic range will be 0.6V to 3V.

Input capacitive coupling will increase the needed dynamic range of the amplifier. The standard NTSC video signal is 1V peak to peak plus 143mV for the color AC peak. The video signal is made up of the -286mV sync pulse plus the 714mV picture signal which may very from 0V to 714mV. The video signal average value for a black picture is about 28mV (*Figure 2*) and with a white picture level is about 583mV (*Figure 3*). This gives a maximum change in average value of about 555mV. A direct coupled amplifier with a standard NTSC video signal needs a dynamic range of 1.143V. But with input capacitance coupling the dynamic range requirements are the sum of the 1.143V video plus the average picture value change of 0.555V or 1.698$V_{P-P}$. At a gain of two this doubles to 3.394V. These amplifiers do not have this much dynamic range so a gain of less than 2 must be used to avoid waveform compression under all conditions.

Capacitively coupling the input and output is worse than a capacitor only on the input. Without any special compromises you can only take a gain of one. But if the backmatch resistor is reduced to 36Ω, reducing the output

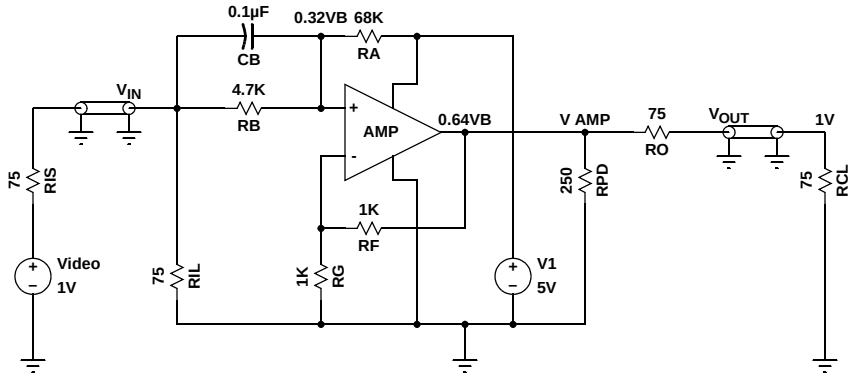



**FIGURE 1. VIDEO PATH**

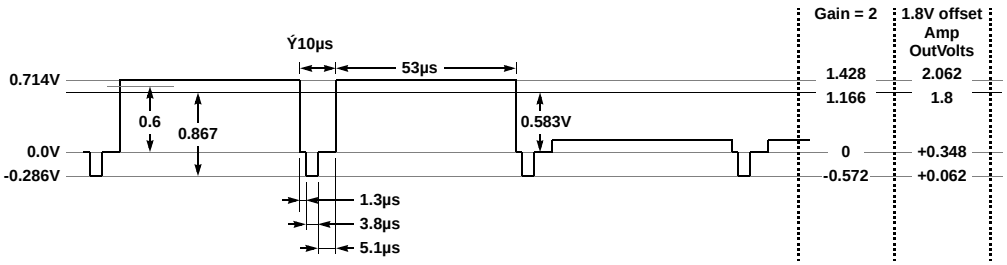



**FIGURE 2. WHITE LEVEL VIDEO**

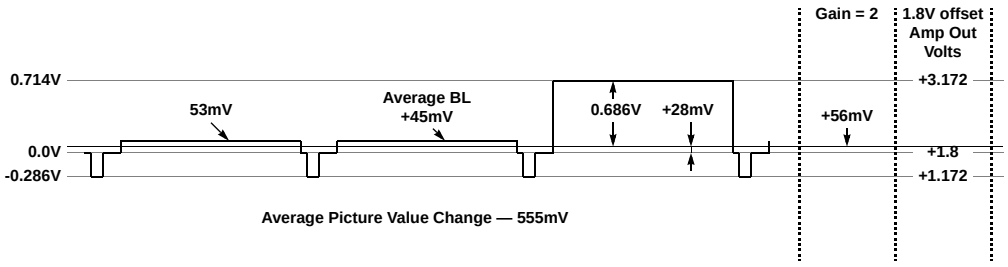



**FIGURE 3. BLACK LEVEL VIDEO**

range requirement 25% and the output offset is shifted to 2.1V you can take a gain of 1.5 and have a standard NTSC 1V at the 75Ω load.

A simple transistor, capacitor and resistor sync tip clamp may be used when the input is already AC coupled to set the sync tip to ground. This gives the input a fixed DC level and can be used like a direct coupled input. The clamp uses a PNP transistor with the collector at ground and the base has a 200kΩ resistor to 5V. The emitter connects to the amplifier input and a capacitor from the video input. The clamp functions as an inverted Beta current source for input bias current with plus inputs and a clamp to ground for minus inputs. The $R_A$ and $R_B$ resistors are removed for the clamp option (*Figure 4*).

### *Printed Circuit Layout*

The EL2110 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. Pin 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.

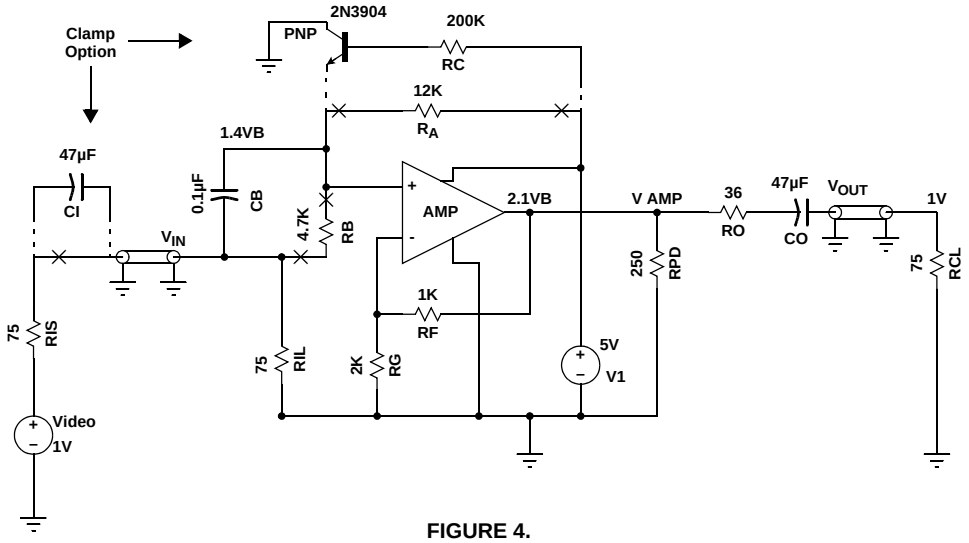



**FIGURE 4.**