January 1995, Rev A FN7171

Video Fader

élantec

The EL4453 is a complete fader subsystem. It variably blends two inputs together for such applications as video picture-in-picture effects.

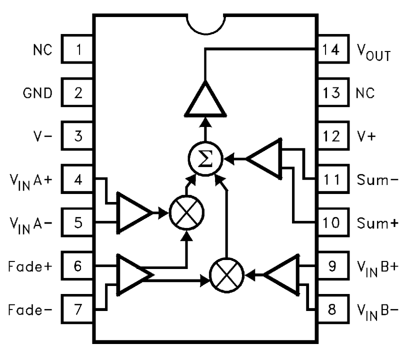
The EL4453 operates on ±5V to ±15V supplies and has an analog differential input range of ±2V. AC characteristics do not change appreciably over the supply range.

The circuit has an operational temperature of -40°C to +85°C and is packaged in 14-pin PDIP and SO-14.

The EL4453 is fabricated with Elantec's proprietary complementary bipolar process which gives excellent signal symmetry and is free from latch up.

Pinout

EL4453
(14-PIN PDIP, SO)
TOP VIEW



Features

- Complete two-input fader with output amplifier—uses no extra components
- 80MHz bandwidth
- Fast fade control speed
- Operates on ±5V to ±15V supplies
- > 60dB attenuation @ 5MHz

Applications

- Mixing two inputs
- Picture-in-picture
- Text overlay onto video
- General gain control

Ordering Information

PART NUMBER	TEMP. RANGE	PACKAGE	PKG. NO.
EL4453CN	-40°C to +85°C	14-Pin PDIP	MDP0031
EL4453CS	-40°C to +85°C	14-Pin SOIC	MDP0027

Absolute Maximum Ratings (T_A = 25°C)

V+	Positive Supply Voltage	16.5V	
V_S	V+ to V- Supply Voltage	33V	
V_{IN}	Voltage at any Input or Feedback	V+ to V-	
V_{IN}	Difference between Pairs of Inputs or Feedback	6V	
ΔI_{IN}	Current into any Input, or Feedback Pin	4mA	
I_{OUT}	Output Current	30mA	
P_D	Maximum Power Dissipation	See Curves	
T_A	Operating Temperature Range	-40°C to +85°C	
T_S	Storage Temperature Range-	60°C to +150°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

Power Supplies at ±5V, Sum+ = Sum- = 0, T_A = 25°C

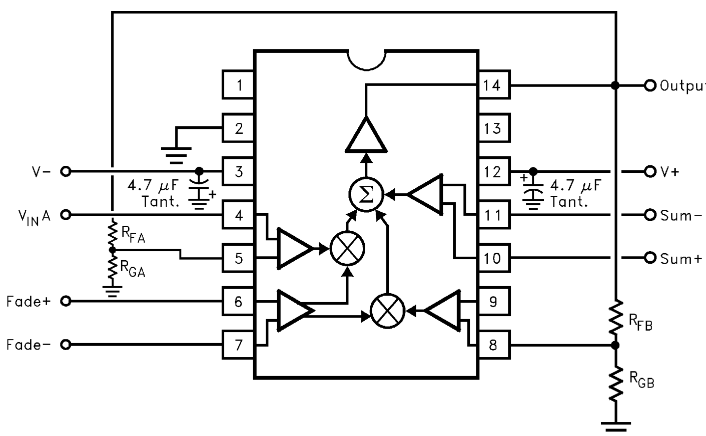
PARAMETER	DESCRIPTION		MIN	TYP	MAX	UNITS
V_{DIFF}	V_{IN}A, V_{IN}B, or Sum Differential Input Voltage	Clipping	1.8	2.0		V
		0.2% Nonlinearity		0.7		V
V_{CM}	Common-Mode Range (All Inputs; V_{DIFF} = 0)	V_S = ±5V	±2.5	±2.8		V
		V_S = ±15V	±12.5	±12.8		V
V_{OS}	A or B Input Offset Voltage				25	mV
V_{FADE}, 100%	Extrapolated Voltage for 100% Gain for V_{IN}A		0.9	1.05	1.2	V
V_{FADE}, 0%	Extrapolated Voltage for 0% Gain for V_{IN}A		-1.2	-1.15	-0.9	V
I_B	Input Bias Current (All Inputs) with all V_{IN} = 0			9	20	µA
I_{OS}	Input Offset Current between V_{IN}A+ and V_{IN}A-, V_{IN}B+ and V_{IN}B-, Fade+ and Fade-, and Sum+ and Sum-			0.2	4	µA
F_T	V_{IN}A Signal Feedthrough, V_{FADE} = -1.5V			-100	-60	dB
NL	A or B Input Nonlinearity, V_{IN} between +1V and -1V	V_{IN}A or V_{IN}B		0.2	0.5	%
		Sum Input		0.5		%
R_{IN}, Signal	Input Resistance, A, B, or Sum Input			230		kΩ
R_{IN}, Fade	Input Resistance, Fade Input			120		kΩ
CMRR	Common-Mode Rejection Ratio, V_{IN}A or V_{IN}B		70	80		dB
PSRR	Power Supply Rejection Ratio		50	70		dB
E_G	Gain Error, V_{FADE} = 1.5V	V_{IN}A or V_{IN}B	-2		+2	%
		Sum Input	-4		+4	%
V_O	Output Voltage Swing (V_{IN} = 0, V_{REF} Varied)	V_S = ±5V	±2.5	±2.8		V
		V_S = ±15V	±12.5	±12.8		V
I_{SC}	Output Short-Circuit Current		40	85		mA
I_S	Supply Current, V_S = ±15V			17	21	mA

Open-Loop DC Electrical Specifications

Power supplies at ±12V, T_A = 25°C, R_L = 500Ω, C_L = 15pF, V_{FADE} = 1.5V, Sum+ = Sum- = 0

PARAMETER	DESCRIPTION		MIN	TYP	MAX	UNITS
BW, -3dB	-3dB Small-Signal Bandwidth, V_{IN}A or V_{IN}B			80		MHz
BW, ±0.1dB	0.1dB Flatness Bandwidth, V_{IN}A or V_{IN}B			9		MHz
Peaking	Frequency Response Peaking			1.0		dB
BW, Fade	-3dB Small-Signal Bandwidth, Fade Input			80		MHz
SR	Slew Rate, V_{OUT} between -2V and +2V		TBD	380		V/µs
V_N	Input-Referred Noise Voltage Density			160		nV/Hz
F_T	Feedthrough of Faded-Out Channel, F = 3.58MHz			-63		dB
dG	Differential Gain Error, V_{OFFSET} from 0 to ±0.714V, Fade at 100%	V_{IN}A or V_{IN}B		0.05		%
		Sum Input		0.35		%
dθ	Differential Phase Error, V_{OFFSET} from 0 to ±0.71V, Fade at 100%	V_{IN}A or V_{IN}B		0.05		(°)
		Sum Input		0.1		(°)

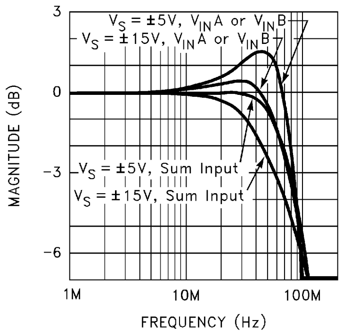
Test Circuit



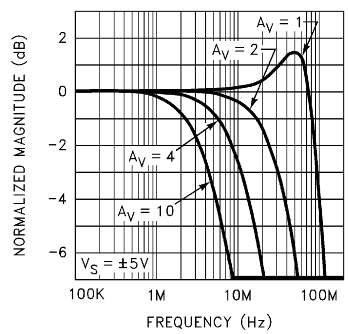
Note: For typical performance curves Sum+ = Sum- = 0, R_F = 0W, R_G = ∞, V_{FADE} = +1.5V, and C_L = 15pF, unless otherwise noted.

Typical Performance Curves

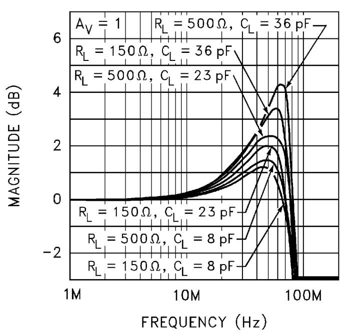
Frequency Response



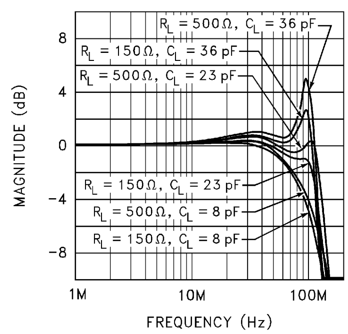
Frequency Response vs Gain



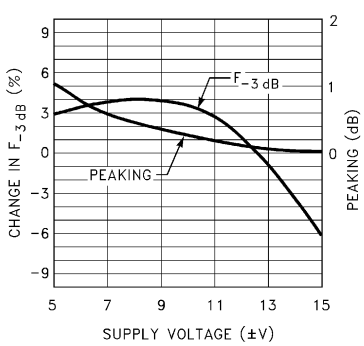
Frequency Response for Various Loads, V_S = ±5V



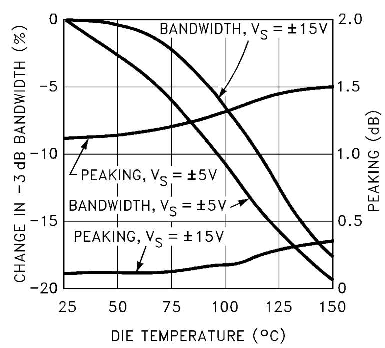
Frequency Response for Various Loads, V_S = ±15V



-3dB Bandwidth and Peaking vs Supply Voltage

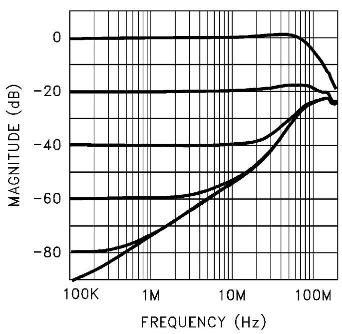


-3dB Bandwidth and Peaking vs Die Temperature

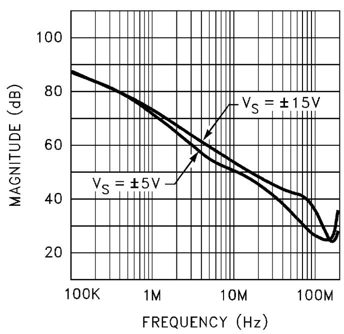


Typical Performance Curves (Continued)

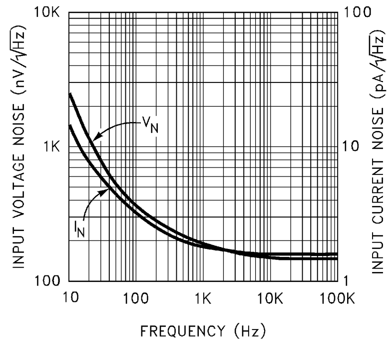
Frequency Response for Different Gains, V_S = ±5V



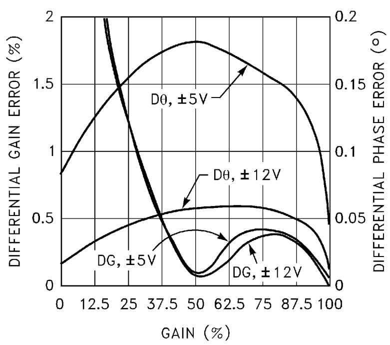
Input Common-Mode Rejection Ratio vs Frequency



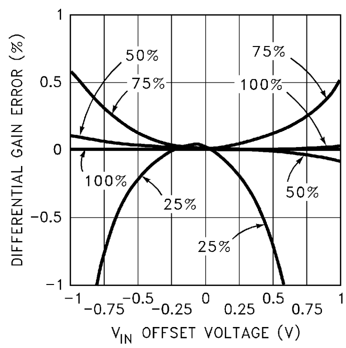
Input Voltage and Current Noise vs Frequency



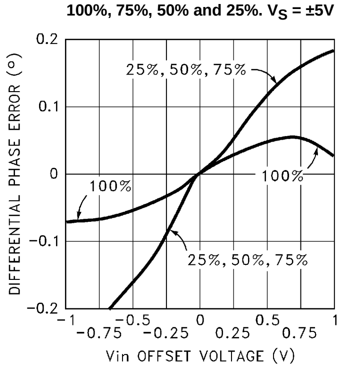
V_{IN} Differential Gain and Phase Error vs Gain



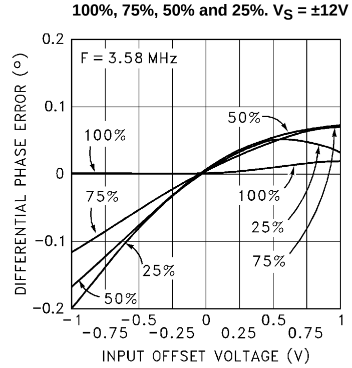
V_{IN} Differential Gain Error vs Input Offset Voltage for Gain = 100%, 75%, 50% and 25%



V_{IN} Differential Phase Error vs Input Offset Voltage for Gain = 100%, 75%, 50% and 25%. V_S = ±5V

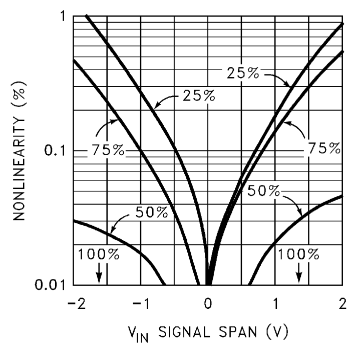


V_{IN} Differential Phase Error vs Input Offset Voltage for Gain = 100%, 75%, 50% and 25%. V_S = ±12V

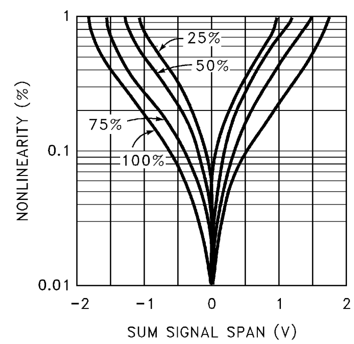


Typical Performance Curves (Continued)

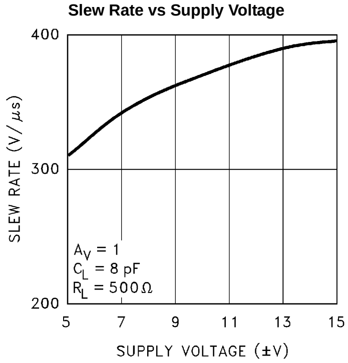
Nonlinearity vs V_{IN} Signal Span



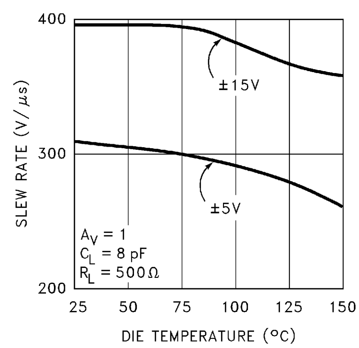
Nonlinearity vs Sum Signal Span



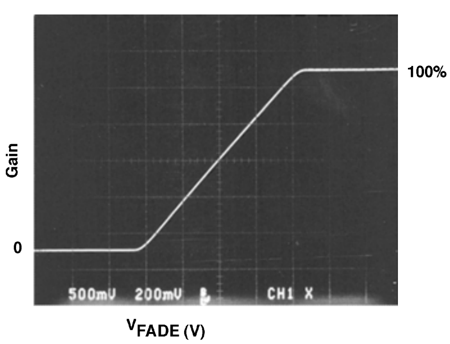
Slew Rate vs Supply Voltage



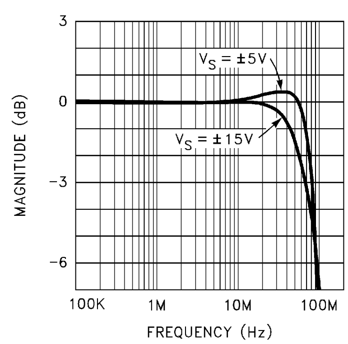
Slew Rate vs Die Temperature



V_{IN}A Gain vs V_{FADE}

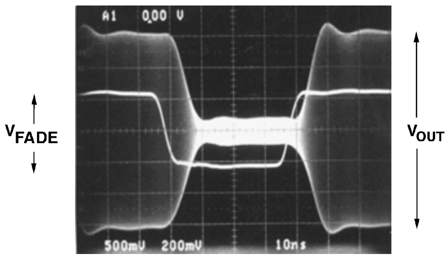


Frequency Response of Fade Input

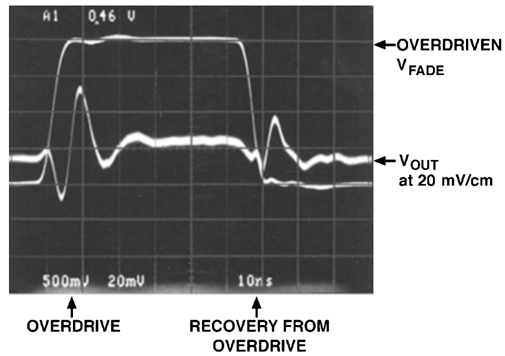


Typical Performance Curves (Continued)

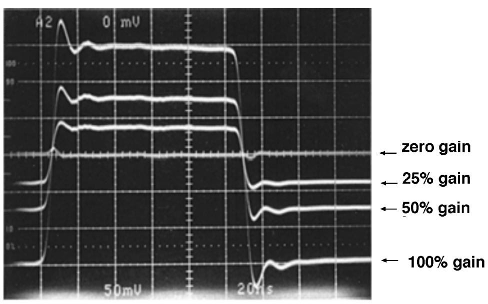
Transient Response of Fade Input Constant Signal into $V_{IN}A$



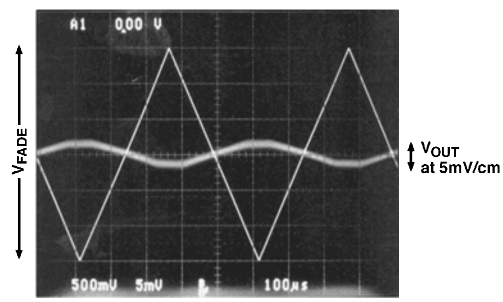
Overdrive Recovery Glitch from V_{FADE}, No Input Signal



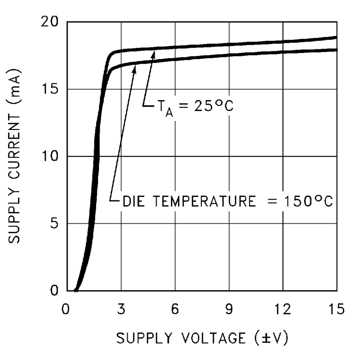
$V_{IN}A$ Transient Response for Various Gains



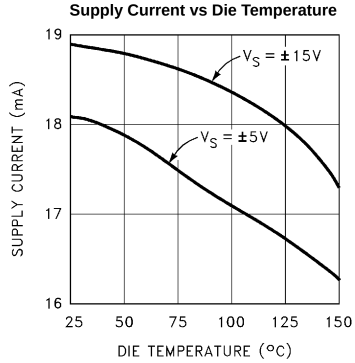
Cross-Fade Balance with $V_{IN}A = V_{IN}B = 0$



Supply Current vs Supply Voltage



Supply Current vs Die Temperature



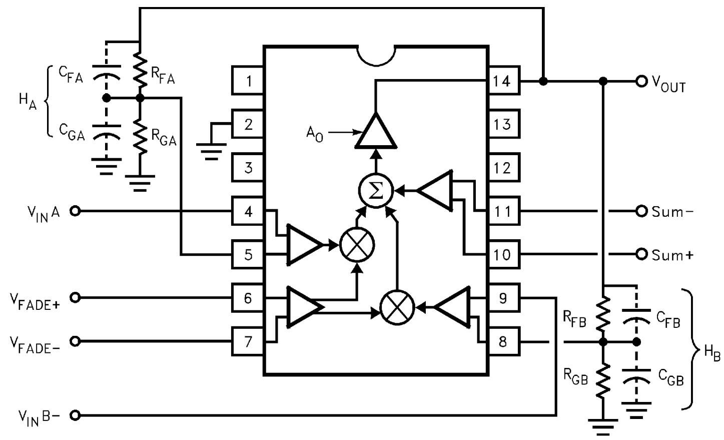


FIGURE 1.

Applications Information

The EL4453 is a complete two-quadrant fader/gain control with 80MHz bandwidth. It has four sets of inputs; a differential signal input $V_{IN}A$, a differential signal input $V_{IN}B$, a differential fade-controlling input V_{FADE}, and another differential input Sum which can be used to add in a third input at full gain. This is the general connection of the EL4453 (Figure 1).

The gain of the feedback dividers are H_A and H_B, and $0 \le H \le 1$. The transfer function of the part is:

$V_{OUT} = A_O \times [((V_{IN}A+) - H_A \times V_{OUT}) \times (1 + (V_{FADE}+) - (V_{FADE}-)) / 2 + ((V_{IN}B+) - H_B \times V_{OUT}) \times (1 - (V_{FADE}+) + (V_{FADE}-)) / 2 + (Sum+) - (Sum-))]$,

with $-1 \le (V_{FADE}+)-(V_{FADE}-) \le +1$ numerically.

A_O is the open-loop gain of the amplifier, and is about 600. The large value of A_O drives:

$((V_{IN}A+) - H_A \times V_{OUT}) \times (1 + (V_{FADE}+) - (V_{FADE}-)) / 2 + ((V_{IN}B+) - H_B \times V_{OUT}) \times (1- (V_{FADE}+) + (V_{FADE}-)) / 2 + (Sum+) - (Sum-)) \rightarrow 0$.

Rearranging and substituting:

$$V_{OUT} = \frac{F \times V_{IN}A + \bar{F} \times V_{IN}B + Sum}{F \times H_A + \bar{F} \times H_B}$$

Where $F = (1 + (V_{FADE+}) - (V_{FADE-}))/2$

$\bar{F} = (1 - (V_{FADE+}) + (V_{FADE-}))/2$

and $Sum = (Sum+) - (Sum-)$

In the above equations, F represents the fade amount, with F = 1 giving 100% gain on $V_{IN}A$ but 0% for $V_{IN}B$; F = 0 giving 0% gain for $V_{IN}A$ but 100% to $V_{IN}B$. $\bar{F}$ is 1 - F, the complement of the fade gain. When F = 1,

$$V_{OUT} = \frac{V_{IN}A + Sum}{H_A}$$

and the amplifier passes $V_{IN}A$ and Sum with a gain of $1/H_A$. Similarly, for F = 0,

$$V_{OUT} = \frac{V_{IN}B + Sum}{H_A}$$

and the gains vary linearly between fade extremes.

The EL4453 is stable for a direct connection between V_{OUT} and $V_{IN}A$- or $V_{IN}B$-, yielding a gain of +1. The feedback divider may be used for higher output gain, although with the traditional loss of bandwidth. It is important to keep the feedback divider's impedances low so that stray capacitance does not diminish the feedback loop's phase margin. The pole caused by the parallel impedance of the feedback resistors and stray capacitance should be at least 150MHz; typical strays of 3pF thus require a feedback impedance of 360Ω or less. Alternatively, a small capacitor across R_F can be used to create more of a frequency-compensated divider. The value of the capacitor should scale with the parasitic capacitance at the FB input. It is also practical to place small capacitors across both the feedback resistors (whose values maintain the desired gain) to swamp out parasitics. For instance, two 10pF capacitors across equal divider resistors for a gain of two will dominate parasitic effects and allow a higher divider resistance. Either input channel can be set up for inverting gain using traditional feedback resistor connections.

At 100% gain, an input stage operates just like an op-amp's input, and the gain error is very low, around -0.2%. Furthermore, nonlinearities are vastly improved since the gain core sees only small error signals, not full inputs. Unfortunately, distortions increase at lower fade gains for a given input channel.

The Sum pins can be used to inject an additional input signal, but it is not as linear as the V_{IN} paths. The gain error is also not as good as the main inputs, being about 1%. Both sum pins should be grounded if they are not to be used.

Fade-Control Characteristics

The quantity V_{FADE} in the above equations is bounded as $-1 \le V_{FADE} \le 1$, even though the externally applied voltages often exceed this range. Actually, the gain transfer function around -1V and +1V is "soft", that is, the gain does not clip abruptly below the 0%-V_{FADE} voltage or above the 100%–V_{FADE} level. An overdrive of 0.3V must be applied to V_{FADE} to obtain truly 0% or 100%. Because the 0% = or 100%-V_{FADE} levels cannot be precisely determined, they are extrapolated from two points measured inside the slope of the gain transfer curve. Generally, an applied V_{FADE} range of -1.5V to +1.5V will assure the full span of numerical $-1 \le V_{FADE} \le 1$ and $0 \le F \le 1$.

The fade control has a small-signal bandwidth equal to the V_{IN} channel bandwidth, and overload recovery resolves in about 20ns.

Input Connections

The input transistors can be driven from resistive and capacitive sources, but are capable of oscillation when presented with an inductive input. It takes about 80nH of series inductance to make the inputs actually oscillate, equivalent to four inches of unshielded wiring or about six inches of unterminated input transmission line. The oscillation has a characteristic frequency of 500MHz. Often placing one's finger (via a metal probe) or an oscilloscope probe on the input will kill the oscillation. Normal high frequency construction obviates any such problems, where the input source is reasonably close to the fader input. If this is not possible, one can insert series resistors of around 51Ω to de-Q the inputs.

Signal Amplitudes

Signal input common-mode voltage must be between (V-) + 2.5V and (V+) - 2.5V to ensure linearity. Additionally, the differential voltage on any input stage must be limited to ±6V to prevent damage. The differential signal range is ±2V in the EL4453. The input range is substantially constant with temperature.

The Ground Pin

The ground pin draws only 6µA maximum DC current, and may be biased anywhere between (V-) +2.5V and (V+) - 3.5V. The ground pin is connected to the IC's substrate and frequency compensation components. It serves as a shield within the IC and enhances input stage CMRR and channel-to-channel isolation over frequency, and if connected to a potential other than ground, it must be bypassed.

Power Supplies

The EL4453 works well on any supplies from ±3V to ±15V. The supplies may be of different voltages as long as the requirements of the GND pin are observed (see the Ground Pin section for a discussion). The supplies should be bypassed close to the device with short leads. 4.7µF tantalum capacitors are very good, and no smaller bypasses need be placed in parallel. Capacitors as small as 0.01µF can be used if small load currents flow.

Singe-polarity supplies, such as +12V with +5V can be used, where the ground pin is connected to +5V and V- to ground. The inputs and outputs will have to have their levels shifted above ground to accommodate the lack of negative supply.

The dissipation of the fader increases with power supply voltage, and this must be compatible with the package chosen. This is a close estimate for the dissipation of a circuit:

$$P_D = 2 \times V_S, max \times V_S + (V_S - V_O) \times V_O / R_{PAR}$$

where

I_S, max is the maximum supply current

V_S is the ± supply voltage (assumed equal)

V_O is the output voltage

R_{PAR} is the parallel of all resistors loading the output

For instance, the EL4453 draws a maximum of 21 mA. With light loading, $R_{PAR} \to \infty$ and the dissipation with ±5V supplies is 210mW. The maximum supply voltage that the device can run on for a given P_D and the other parameters is:

$$V_S, max = (P_D + V_O^2 / R_{PAR}) / (2 I_S + V_O / R_{PAR})$$

The maximum dissipation a package can offer is:

$$P_D, max = (T_D, max - T_A, max) / \theta_{JA}$$

where

T_D, max is the maximum die temperature, 150°C for reliability, less to retain optimum electrical performance

T_A, max is the ambient temperature, 70°C for commercial and 85°C for industrial range

θ_{JA} is the thermal resistance of the mounted package, obtained from datasheet dissipation curves

The more difficult case is the SO-14 package. With a maximum die temperature of 150°C and a maximum ambient temperature of 70°C, the 80°C temperature rise and package thermal resistance of 110°/W gives a dissipation of 636mW at 85°C.

This allows ±15V operation over the commercial temperature range, but higher ambient temperature or output loading may require lower supply voltages.

Output Loading

The output stage of the EL4453 is very powerful. It typically can source 80mA and sink 120mA. Of course, this is too much current to sustain and the part will eventually be destroyed by excessive dissipation or by metal traces on the die opening. The metal traces are completely reliable while delivering the 30mA continuous output given in the Absolute

Maximum Ratings table in this data sheet, or higher purely transient currents.

Gain changes only 0.2% from no load to 100Ω load. Heavy resistive loading will degrade frequency response and video distortion for loads < 100Ω.

Capacitive loads will cause peaking in the frequency response. If capacitive loads must be driven, a small-valued series resistor can be used to isolate it. 12Ω to 51Ω should suffice. A 22Ω series resistor will limit peaking to 2.5dB with even a 220pF load.