

## New Low Cost Differential Input Video Amplifiers Simplify Designs and Improve Performance – Design Note 55

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The LT1190 is a family of high speed amplifiers optimized for video performance on  $\pm 5V$  or single +5V supplies. The family includes three voltage feedback op amps and two video difference amplifiers. All amplifiers slew at  $450V/\mu s$ , and deliver  $\pm 50mA$  output current for driving cables. The LT1193 video difference amplifier features uncommitted high input impedance (+) and (-) inputs, and can be used in differential or single-ended configurations. In addition, the LT1193 has an adjustable gain of two or greater, with a -3dB bandwidth of 80MHz.

### Wideband Voltage Controlled Amplifier

The LT1193 video difference amplifier combined with an MC1496 balanced modulator make a low cost 50MHz Voltage Controlled Amplifier (VCA), shown in Figure 1. The input signal of the MC1496 at pin 1 is multiplied by the Control Voltage on pin 10, and appears as a differential output current at pins 6 and 12. The LT1193 acts to level shift the differential signal and convert it to a single-ended output. Resistor  $R_B$  is used to set the bias current in the MC1496 to 1mA in each  $200\Omega R_L$ , while  $R_{CM}$  is used to shift the differential output into the common mode range of the LT1193. Resistors  $R_1$

through  $R_4$  bias the MC1496 inputs so that the Control Voltage  $V_C$  can be referenced to 0V. Positive  $V_C$  causes positive gain; negative  $V_C$  gives a phase inverter on ( $-A_V$ ), while 0V on  $V_C$  gives maximum attenuation (within the  $V_{OS}$  of the MC1496 control inputs). The value of  $R_e$  is chosen by knowing the maximum input signal:

$$R_e = (V_{IN \text{ max}})/1mA$$

For the example shown the maximum input signal is 100mV peak, therefore,  $R_e = 100\Omega$ . At this maximum input signal there is significant distortion from the  $r_e$  modulation of the input pair. Linearity can be improved by increasing  $R_e$  at the expense of gain. The maximum voltage gain of the VCA is:

$$\frac{V_O}{V_I} = (A_V \text{ of LT1193}) \left( \frac{2R_L}{R_e + 2r_e} \right)$$

$$V_O/V_{IN} = 2(2 \times 200)/(100 + 52) = 5.26 = 14.4dB$$

Figures 2 and 3, show the frequency response and harmonic distortion of the VCA.

The voltage gain of the VCA can be increased at the expense of bandwidth by changing the value of load

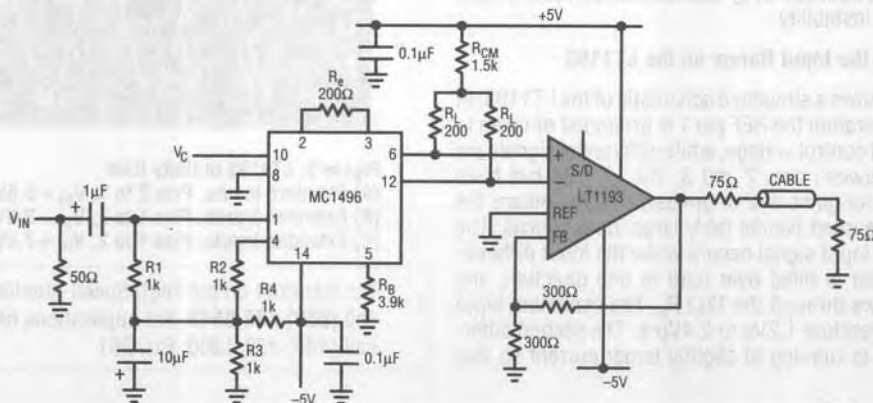


Figure 1. Low Cost 50MHz Voltage Controlled Amplifier

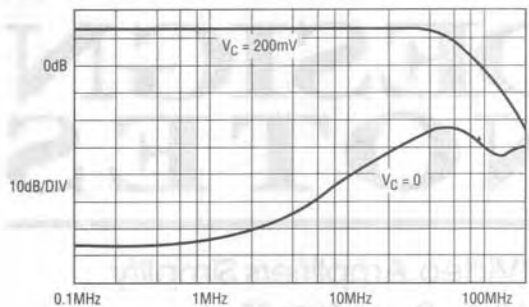


Figure 2. Gain and Attenuation of VCA

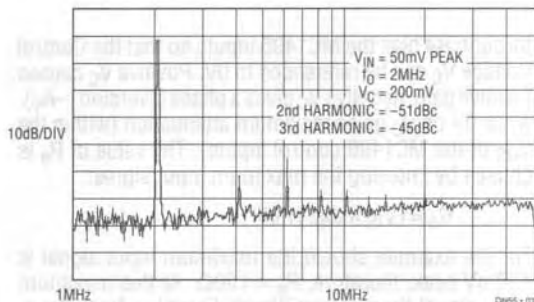


Figure 3. VCA Output Spectrum

resistors  $R_L$ . Shorting  $R_{CM}$  and increasing  $R_L$  to 2k will increase the maximum gain by 20dB and the -3dB bandwidth will drop to approximately 10MHz.

The LT1193 has a shutdown feature that reduces its power dissipation to only 15mW and forces a three-state output. The three-state output occurs when pin 5 is taken to  $V^-$ . The high  $Z$  state, dominated by the impedance of the feedback network, is useful for multiplexing several amplifiers on the same cable. The impedance of the feedback resistors should not be raised above 1k $\Omega$  because stray capacitance on the (-) input can cause instability.

### Extending the Input Range on the LT1193

Figure 4 shows a simplified schematic of the LT1193. In normal operation the REF pin 1 is grounded or taken to a DC offset control voltage, while differential signals are applied between pins 2 and 3. The LT1193 has been optimized for gains of 2 or greater, and this means the input stage must handle fairly large input signals. The maximum input signal occurs when the input differential amplifier is tilted over hard in one direction, and 1.2mA flows through the 1k $\Omega$   $R_e$ . The maximum input swing is therefore 1.2Vp or 2.4Vp-p. The second differential pair is running at slightly larger current so that

when the first input stage limits, the second stage remains biased to maintain the feedback.

Occasionally it is necessary to handle signals larger than 2.4Vp-p at the input. The LT1193 input stage can be tricked to handle up to 4.8Vp-p. To do this, it is necessary to ground pin 3 and apply the differential input signal between pin 1 and 2. The input signal is now applied across two 1k resistors in series. Since the input signal is applied to both input pairs, the first pair will run out of bias current before the second pair, causing the amplifier to go open loop. This effect is shown in Figure 5 for the amplifier operating in a closed loop gain of 1. The LT1193 has a unity gain phase margin of only 40 degrees, so when operating at unity gain, care must be taken to avoid instability.

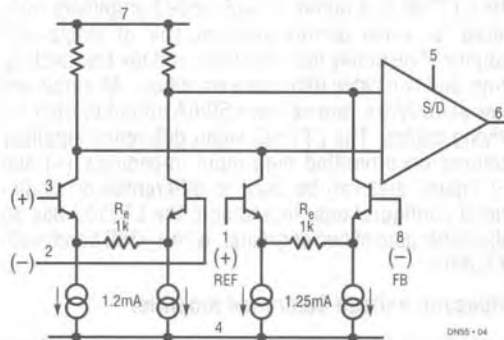


Figure 4. LT1193 Simplified Schematic

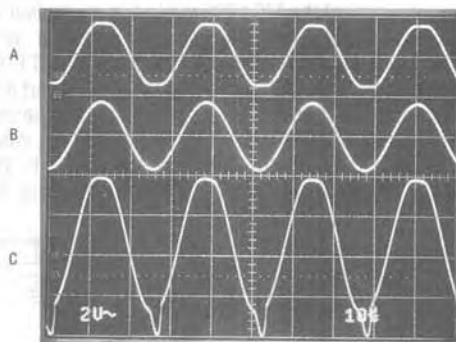


Figure 5. LT1193 in Unity Gain

- (A) Standard Inputs, Pins 2 to 3,  $V_{IN} = 3.6V_{p-p}$
- (B) Extended Inputs, Pins 1 to 2,  $V_{IN} = 3.6V_{p-p}$
- (C) Extended Inputs, Pins 1 to 2,  $V_{IN} = 7.0V_{p-p}$

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