# DESIGN FAQs

## Frequently Asked Questions:

# COUPLING VIDEO AMPLIFIERS

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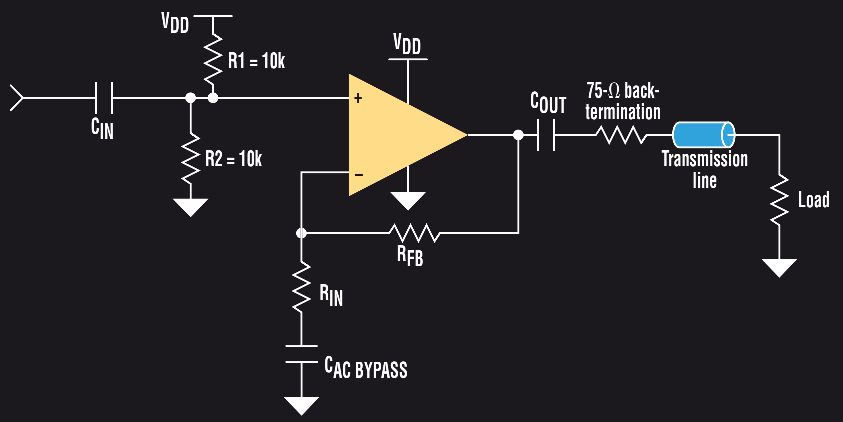
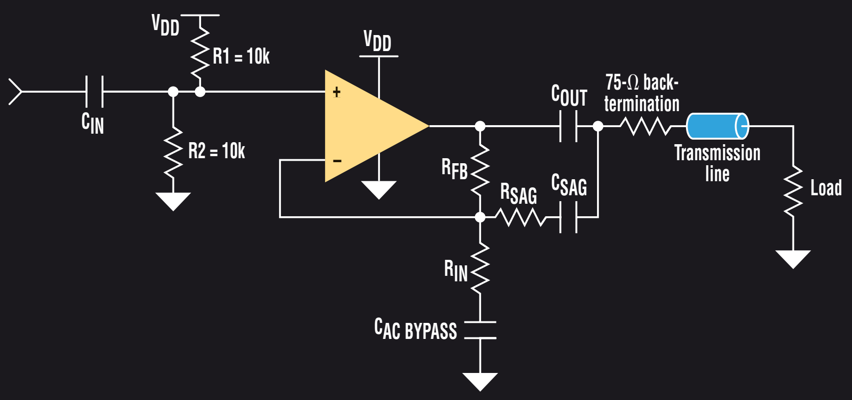
## What's the difference between ac coupling and dc coupling in video and high-speed amps?

Using capacitors on inputs and outputs, ac coupling simplifies circuit design by removing dc voltages on the transmission line and isolating ground connections between the transmit and receive systems. On the other hand, the presence of those capacitors compromises signal quality. Some systems can accommodate those compromises, while others cannot. Eliminating the cost of the output capacitor, which must be on the order of several hundred microfarads to minimize those compromises, makes dc coupling particularly attractive in high-volume, price-sensitive products. But it loses that attraction when the input signal swings positive and negative. (Think negative video-sync pulses.) That's because that complication introduces the need for an additional, negative supply to ensure an input common-voltage range that accommodates plus-and-minus signal swings.




**1. Values for input and output capacitors should be calculated based on the need to pass the lowest-frequency component of the applied signal.**




**2. Adding further frequency compensation for sag has the benefit of reducing the size of the required output capacitor at the expense of adding components. The use of dc coupling would eliminate the capacitor issue altogether.**



## How do you size an input capacitor for ac coupling?

Video signal bandwidths require capacitors large enough to pass the minimum frequency *(Fig. 1)*. In video, this is most commonly the 50- or 60-Hz vertical frame rate. Given values of 10 kΩ each for R1 and R2, a value of 0.1-µF for input capacitor $C_{IN}$ would place a pole at 318 Hz. For a 6.5-µF capacitor, $f_0$ would be 6 Hz.

## How do you size an output capacitor?

Output capacitor $C_{OUT}$ cannot be anywhere close to as small as $C_{IN}$, because the amplifier has to drive a relatively low-impedance transmission line. Passing a 50- or 60-Hz signal requires an output capacitor considerably larger than 100 µF, which is the point at which physical size and cost take a considerable upward jump. In Figure 1, the transmission line is back-terminated, so the output capacitor is working into an effective resistance of 150 Ω instead of the 5 kΩ on the input side. Although this is in parallel with the feedback network, the feedback resistors are relatively large, so their impact can be assumed to be negligible. The low impedance puts the required value of $C_{OUT}$ to pass a 60-Hz vertical sync signal at 220 µF ($f_0$ = 9.6 Hz) or higher.

## What about sag? Doesn't addressing sag also shrink the size of the required output capacitor?

Sag occurs when charge accumulates across the output coupling capacitor. In a field or line bar test signal, it manifests itself as a tilt in the video waveform from the start of the sweep to the end. On a TV monitor, sag would show up as brightness variation from side to side or from the top to the bottom of the picture. The effect may not be noticeable in low-end products, but it is definitely unacceptable in professional and broadcast equipment.

The cure for sag results in a smaller output capacitor, but at the cost of additional circuit components. Correcting for sag is based on low-frequency compensation for the high-pass filter formed by the back-terminated transmission line and the output capacitor. Figure 2 shows a sag-compensated circuit. Datasheets usually provide optimum component values. In a typical case, $R_{FB}$ might be 10 kΩ, $R_{IN}$ and $R_{SAG}$ each 1 kΩ, $C_{OUT}$ 47 µF, and $C_{SAG}$ 22 µF.

## What about dc coupling using amplifiers that can handle the common input voltage?

Many output drivers, with and without internal gain-setting resistors, can handle signals that swing above and below ground. Their drawback is that they require ±5-V supplies. That extra complexity is acceptable in professional and high-end equipment, but it's less attractive for a designer facing cost and board-space constraints. Fortunately, recent amplifiers have internal charge pumps that can generate $V_{EE}$ as much as 1.6 V below ground, resulting in a 4.9-V common input voltage range with only a single 3.3-V supply.

## What's available in dc-coupled video amplifiers?

It's a small field as yet. Two chip vendors introduced direct-coupled video amplifiers based on integrated charge pumps in mid-2005. One package provides a single amp, and the other is a triple. Both provide 6 db of gain per channel. The single integrates a six-pole Butterworth filter to perform reconstruction filtering on video inputs from a digital-to-analog converter. There are subtle differences in the way the two vendors deal with charge-pump noise, although the results are excellent in both cases. The single uses a charge pump followed by linear regulator, while the triple has a multiphase charge pump. ED Online 11046