High-speed, 5-V amplifiers optimized for high-resolution video

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Video op amps (like the good engineers who design with them) are constantly being asked to do more with less. To enable higher video resolution, higher analog-video signal bandwidths are required, demanding ever-faster amplifier products. At the same time, designers are looking for ways to achieve these higher resolutions with lower voltages and even single-supply rails.

Fortunately, a new crop of signal-conditioning products can achieve this.

For some time now, amplifiers have been able to achieve standard-definition video and SVGA (800 x 600 pixels) on low-voltage supplies. For example, the LT6550 and LT6551 achieve 110-MHz bandwidth and 400-volt/microsecond slew rate, yet can operate on supplies as low as 3.3 V. Until recently, however, high-resolution video such as UXGA (1,600 x 1,200-pixel) required amplifiers running on supplies of 6 V or higher. This wider supply range is needed to keep from clipping the signal, because the fastest operational amplifiers typically require additional headroom.

Video signal characteristics

To better understand the increasing performance needs of video amplifiers, it helps to look a closer at the video signals involved. Digital studio equipment for NTSC broadcast television typically uses pixel rates that are around 14 million pixels (Mpixels) per second. In contrast, the common XGA computer format (1,024 x 768) operates around 80 Mpixels per second. The latest high-definition consumer formats put out a comparable 75-Mpixel stream and the increasingly popular UXGA professional graphics format (1,600 x 1,200) generates a whopping 200 Mpixels/s.

As a result, getting accurate video reproduction in these newer formats puts exceptional demands on the frequency response of video amplifiers. Specifically, pulse-amplitude waveforms like those of baseband video generally require reproduction of high-frequency content up to at least the 5th harmonic of the fundamental frequency component, or 2.5 times the video pixel rate. In other words, for UXGA resolution, a frequency response up to and beyond 500 MHz is required. Products like the LT6553 with 650-MHz bandwidth, 1,700-V/microseconds slew rate, and 6-nanosecond settling time, can hit UXGA speed and resolution, but typically need more than one 5-V supply to do so, because of the video-signal amplitude.

In NTSC and PAL video systems, 700 mV is about the difference between the maximum signal voltage and black-signal level. Another 300 mV below black level is used for the sync-signal tips that carry timing information. Typical video applications are therefore specified to have nominal 1-V P-P amplitude.

Most video amplifiers drive cables that are series-terminated (also called back-terminated) at the source, and load-terminated at the destination, with resistances equal to the cable's characteristic impedance, $Z_0$ (usually 75 $\Omega$). This configuration forms a 2:1 resistor divider in the cabling that must
be corrected in the driver amplifier by delivering 2-V_{p-p} output into an effective 2 \times Z_0 load (e.g., 150 \Omega). Driving the cable can require in excess of 13 mA, while the output is approaching the saturation limits of the amplifier output.

In AC-coupled systems, this is further complicated since the average signal voltage of the video waveform is affected by the picture content, meaning that the black level at the amplifier wanders with scene brightness. The amount of wander can be as much as 0.56 V for 1 V_{p-p} NTSC video. Assuming a gain of 2, the minimum voltage swing that the amplifier must drive is 3.12 V. In addition to the signal swing, the supply voltage must accommodate the amplifier headroom (or the difference between the maximum and minimum output swing and the supply range, specified as V_{oh} and V_{ol}), to avoid clipping the signal. Thus, we can calculate V_{Smin} = 3.12 V + V_{oh} + V_{ol}.

**A UXGA-resolution, 5-V video amplifier**

The recently released LT6557 RGB amplifier, Figure 1, achieves the goal of driving high-resolution video on a single 5-V supply, without the need for external or internal charge-pump circuits.

![Figure 1: This 5-V UXGA AC-coupled triple video driver (LT6557) is suitable for high-resolution video.](image)

It does this by achieving 500-MHz bandwidth, 2200-V/microseconds slew rate and 7-ns settling time, while offering a wide output swing that extends to 0.8 V of supply rails, Figure 2.

![Figure 2: The fast large-signal response of the device matches the needs of these faster signals.](image)

Operating from a single 5-V supply, it achieves 3.4 V of dynamic range, which is suitable for standard video. In addition, the LT6557 has a 0.1-dB gain flatness, which extends to 120 MHz, suitable for use over a wide range of video signals.

The LT6557 also uses a unique internal architecture that simplifies implementation of high-speed
video signals in single-supply applications. An internal biasing circuit allows the user to program the inputs of all three amplifiers to a desired DC bias voltage level with a single resistor. This minimizes external-component count and provides ease-of-use in AC-coupled applications, yet it can be disabled for DC-coupled applications.

Furthermore, the internal fixed gain-of-2 eliminates six external gain-setting resistors required for driving double-terminated cables. A fixed gain-of-1 version is also available for applications that do not require a gain of 2, such as when driving an A/D converter. The amps are the industry's first wideband RGB amplifiers on the market, which are capable of providing full video swing when operated from a single 5-V supply. Each of the three amplifiers has a separate power and ground pin to minimize crosstalk and simplify supply bypassing. Crosstalk performance is -80 dB at 10 MHz using 2-Vp-p inputs.

**Cable drives and muxes**

In especially cost-sensitive applications such as consumer video-playback equipment and KVMS (keyboard, video, mouse switches), the LT6559 is a basic triple current-feedback op-amp (CFA) with individual channel enables. It offers great flexibility in forming various multiplexer, cable-driver and ADC driver functions at low cost. Though the LT6559 is not a true rail-to-rail output device, it has about 3 Vp-p of available output swing from a 5-V supply, due to a high-performance output-device design. As a general-purpose CFA, the feedback resistor value (30 Ω) optimizes the frequency response. This circuit is well-suited as an output buffer/driver for following passive reconstruction filters such as for the increasingly popular 1,080p HD format (i.e. 60-MHz low-pass).

Another interesting part used in single 5-V video applications is the LT6556. High-performance multimedia video-display systems usually include a multiple-input feature, to select between a VESA-compliant, D-type PC connection and consumer component video that uses RCA-jacks.

The incoming video signal is, at most, 1 Vp-p nominal value (Y-channel, 1.5 Vp-p worst-case when AC-coupled) and the required gain is unity, matched to digitizing by an A/D converter or simple signal routing. This input-selection function is readily implemented using the LT6556 operating on 5 V. The part supports all video resolutions, including UXGA, due to its 750-MHz bandwidth and 6.5-ns settling time. For AC-coupled applications, the outputs swing up to approximately plus/minus 0.7 V from the mid-supply level, depending on picture content and signal. The part incorporates layout-friendly flow-through pinouts, crucial in these high-speed applications.

As system designers continue to reduce the number of supply voltages in their products, pressure to maximize analog performance on available +5-V logic-level supplies has led to the need for viable, low-voltage, high-performance video solutions.

**About the author**

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