Superfast Fixed-Gain Triple Amplifiers Simplify Hi-Res Video Designs by Jon Munson

Introduction

The LT6553 and LT6554 triple video amplifiers offer 600MHz performance in a compact package, requiring no external gain-setting resistors to establish gain of 2 or unity-gain, respectively. One may wonder "Why are such super-fast amplifiers are now necessary in video designs—isn't that overkill?" The answer is a resounding no. The proliferation of high-resolution video displays, both in the professional and consumer markets has markedly increased the analog bandwidth of baseband video signals. The latest demands of video equipment are so far ahead of the last generation that the performance of the LT6553 and LT6554 is not overkill at all, but in fact mandatory.

For example, digital studio equipment for NTSC broadcast television typically uses pixel-rates around 14 million per second, while now ubiquitous XGA computer outputs (1024 x 768) routinely churn out about 80 Megapixels per second. The latest High Definition consumer formats put out a comparable 75Mpixel stream and the increasingly popular UXGA professional graphics format (1600 x 1200) generates a whopping 200Mpixel per second flow. Obviously the accurate video reproduction of these newer formats is placing exceptional demands on the frequency response of the video amplifiers involved. 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, which is 2.5 times the video pixel rate, accounting for the 2 pixels per fundamental cycle relationship. This indicates that for UXGA in particular, flat frequency response to beyond 0.5GHz is required!

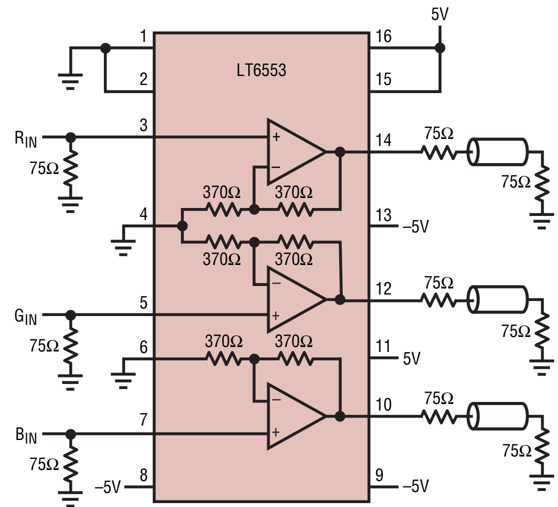

Figure 1. LT6553 RGB cable driver circuit

Easy Solution for Multi-Channel Video Applications

Baseband video generated at these higher rates is processed in either native red-green-blue (RGB) domain or encoded into "component" luma plus blue-red chroma channels (YPbPr); three channels of information in either case. With frequency response requirements extending to beyond 500MHz, amplifier layouts that require external resistors for gain setting tend to waste valuble real-estate, and frequency response and crosstalk anomalies can plague the printed circuit development process.

The LT6553 and LT6554 conveniently solve all these problems by providing internal factory-matched resistors and an efficient 3-channel flow-through layout arrangement using a compact SSOP-16 package. Figure 1 shows the typical RGB cable driver application of an LT6553, and its excellent frequency and time response plots are shown in Figures 2 and 3. Frequency markers in Figure 2 show the –0.5dB response beyond 450MHz and –3dB response at about 600MHz.

What's Inside

The LT6553 and LT6554 integrate three independent sections of circuitry that form classic current-feedback amplifier (CFA) gain blocks, all implemented on a very high-speed fabrication process. The diagram in Figure 4 shows the equivalent internal circuitry (one CFA section shown).

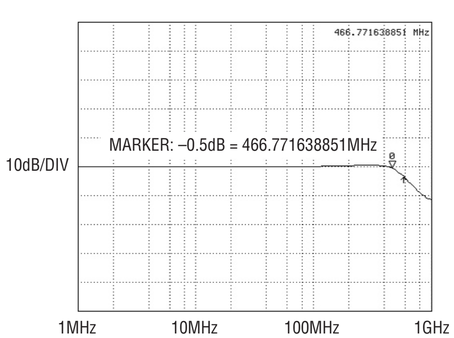

Figure 2. Wide frequency response of circuit in Figure 1

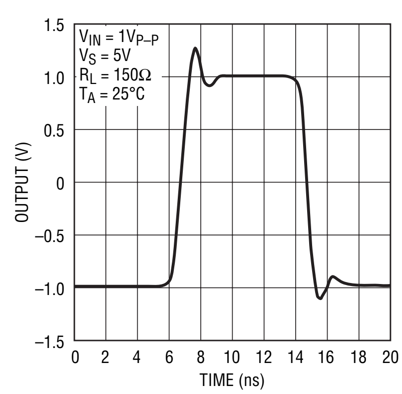

Figure 3. Fast pulse response of circuit in Figure 1

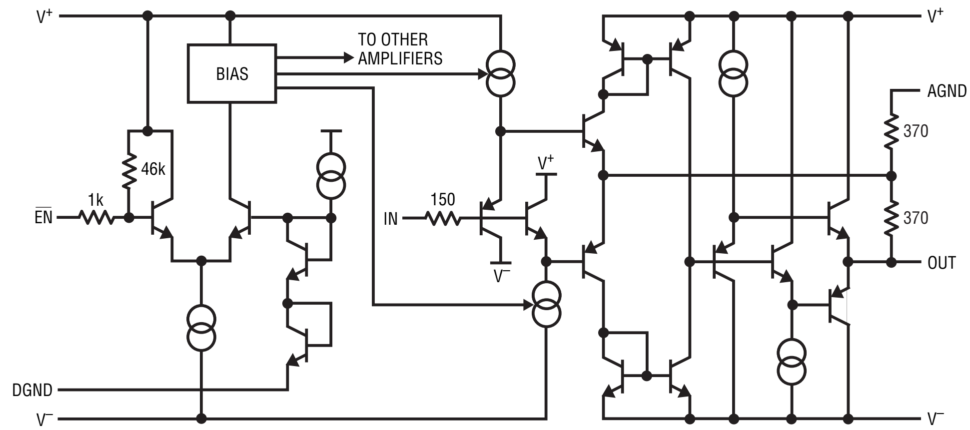

Figure 4. LT6553 & LT6554 simplified internal circuit functionality

The on-chip feedback resistors set the closed-loop gain to unity or two, depending on the part. The nominal feedback resistances are chosen to optimize the frequency response for maximal flatness under the anticipated loading conditions. The LT6553 is intended to drive back-terminated 50Ω or 75Ω cables (for effective loading of 100Ω to 150Ω respectively), while the LT6554 is useful for driving ADCs or other high impedance loads (characterized with 1kΩ as a reference loading condition).

All three CFAs have a bias control section with a power-down command input. The shutdown function includes internal pull-up resistance to provide a default disable command, which when invoked, reduces power consumption to less than 100µA for an entire three-channel part. During shutdown mode the amplifier outputs become high impedance, though in the case of the LT6553, the feedback resistor string to AGND is still present. The parts come into full-power operation when the enable input voltage is brought within 1.3V above the DGND pin. The typical on-state supply current of 8mA per amplifier provides for ample cable-drive capacity and ultra-fast slew rate performance of 2.5V per nanosecond!

MUXing Without Switches

RGB and YPbPr video signals are commonly multiplexed (selections made on an occasional basis) to reduce I/O connector count or otherwise re-use various high-value video signal-processing sections when selecting various modes of operation in the end use of the product. This has often been accomplished with the use of FET switches and buffer amps to route the various video channel signals, but can alternatively be performed by use of the power-down functionality included in the LT6553 and LT6554. Figure 5 shows an example circuit using LT6554 units cross-controlled to allow a single video path to be enabled at any particular time. This might be the situation at the input side of a video display or AV receiver

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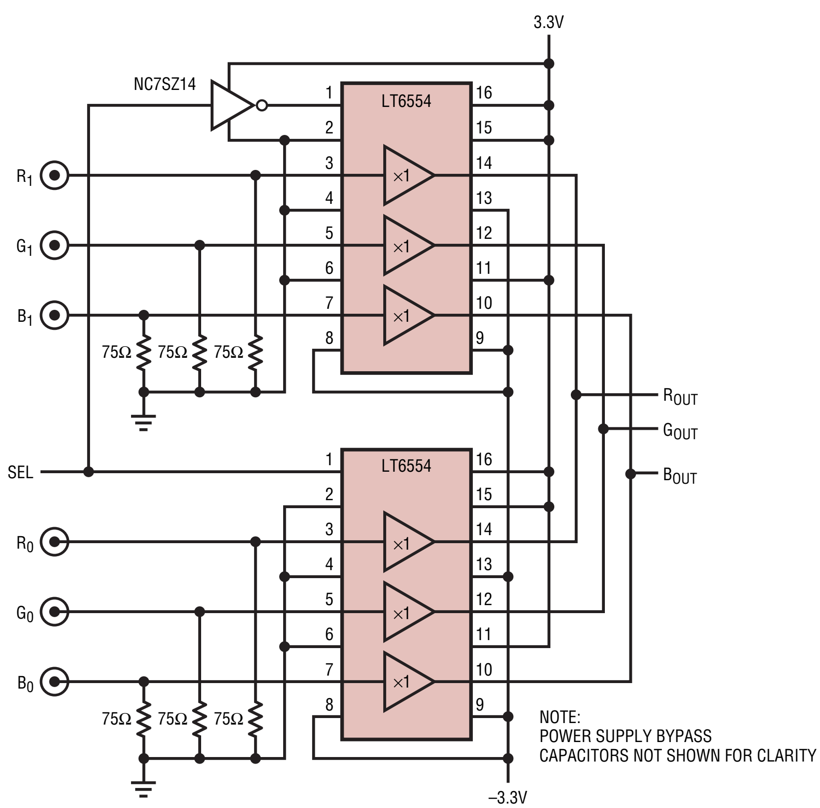

Figure 5. Video input multiplexer using LT6554 shutdown feature

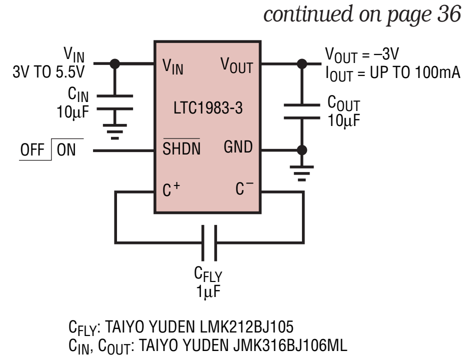

Figure 6. Generating a local –3V supply with 4 tiny components

Figure 6 shows a solution with an optimization to provide a wide asymmetric common-mode range (–12V to 73V) as might be encountered in an automotive environment. The amplifier is biased from just a single +5V power supply. The asymmetry of the common-mode window is controlled by the applied V_{REF} voltage, provided here by a versatile LT6650 resistor-programmable reference (see article in this issue: 'Tiny, Resistor-Programmable, µPower 0.4V to 18V Voltage Reference'). The LT1990 is shown strapped to produce a gain of ten and outputs a bidirectional signal referenced around V_{REF}. The excellent CMRR of the LT1990 keeps output ripple from the H-bridge PWM activity at a low level so that simple filtering (not shown) can accurately recover the desired low-frequency motor current information.

Conclusion

These three new amplifiers are so versatile and easy to use, it is possible to stock one of them and use it for many varied applications. No external components are needed to achieve hundreds of gains in non-inverting, inverting, difference and attenuator configurations. Just strap the pins and go. It's a great way to reduce inventory, ease manufacturing, and simplify a bill of materials.

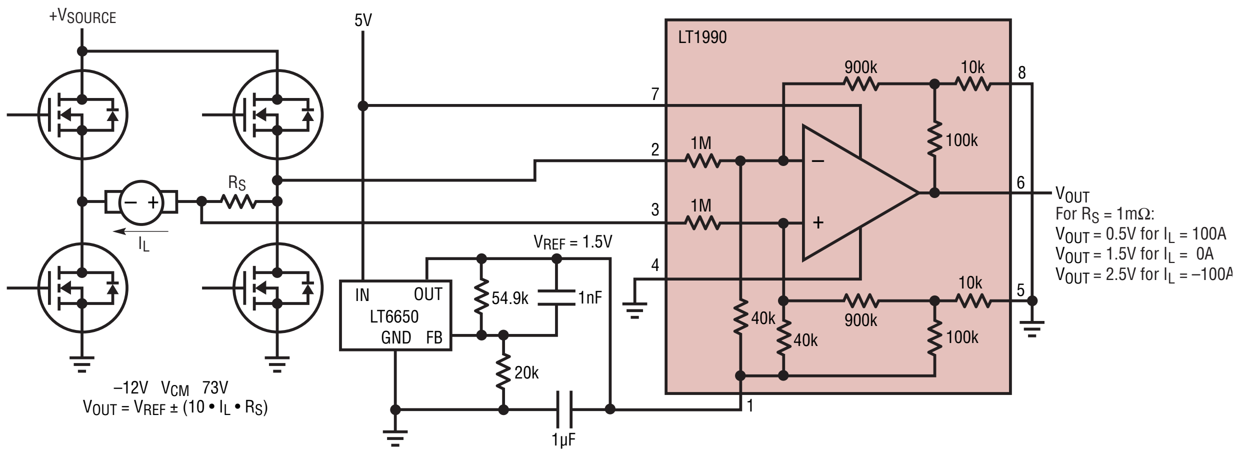

Figure 6. Sensing current in a bidirectional full bridge motor

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that requires selecting between a set of RGB or component video sources. A similar circuit using LT6553s provides a means of output selection as might be the case in a video recorder where switching between live feed and playback would be needed.

Operating With the Right Power Supplies

The LT6553 and LT6554 require a total power supply of at least 4.5V, but depending on the input and output swings required, may need more to avoid clipping the signal. The LT6554, having unity gain, makes the analysis simple—the output swing is about $(V^+ – V^-) – 2.5V$ and only governed by the output saturation voltages. This means a total supply of 5V is adequate for standard video ($1V_{P-P}$). For the LT6553, extra allowance is required for load-driving, so the output swing is $(V^+ – V^-) – 3.8V$. This means a total supply of about 6V is required for the output to swing $2V_{P-P}$, as when driving cables. For best dynamic range along with reasonable power consumption, a good choice of supplies would be ±3V for the LT6554 and 5V/–3V for the LT6553. Since many systems today lack a negative supply rail, a small LTC1983-3 solution can be used to generate a simple –3V rail for local use, as shown in Figure 6. The LTC1983-3 solution is more cost effective and performs better than AC-coupling techniques that might otherwise be employed.

Demo Circuits Available

Demonstration boards that use the LT6553 and LT6554 are available to simplify evaluation of these parts. To evaluate the LT6553 ask for DC714A or DC743A. DC714A is a DC-coupled circuit that is intended for split supply operation. DC743A includes biasing and AC-coupling components with the LT6553 in a single supply configuration. DC794A is identical to the DC714A except it has the LT6554 installed. All three of these demo circuits have high-quality 75Ω BNC connections for best performance and include a calibration trace to allow connector effects to be removed from network analyzer sweeps of the amplifier under evaluation. The demo circuits also illustrate high-frequency layout practices that are important to realizing the most performance from these super-fast parts.