

# Triple and Quad RGB Amplifiers Deliver Full Performance on 3.3V

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## Introduction

The LT6550 and LT6551 3.3V triple and quad high speed amplifiers make it possible to create compact solutions for driving RGB and component video cables. These voltage feedback amplifiers drive either 50Ω or 75Ω double terminated cables and are preconfigured for a fixed gain of two, thus eliminating six or eight external gain setting resistors.

The industry trend of using lower supply voltages increases the demands placed on analog signal handling characteristics. For example, a 3.3V video amplifier not only requires high slew rates and fast settling times but must also have wide input and output voltage swing ranges to avoid clipping any portion of the video waveform. Current feedback amplifiers cannot be used because they lack sufficient signal swing at low supplies and they require input signal above ground.

The LT6550 and LT6551 are true voltage feedback amplifiers featuring 110MHz (−3dB) bandwidth, 340V/μs slew rate, and fast settling time, making them ideal for low voltage, high resolution, RGB Video Processing.

The LT6550 and LT6551 operate from 3V to 12.6V and are fully specified on single 3.3V and 5V supplies, the LT6550 is also fully specified on ±5V supplies. Both parts are available in compact 10-pin MSOP packages and performance is guaranteed over the industrial temperature range.

## Amplifier Characteristics

The block diagrams in Figure 1 show the differences between the LT6550 and LT6551. The LT6551 quad is designed for single supply operation with the feedback returned to ground. The LT6550 triple has a separate  $V_{EE}$  pin and can be used on either single or split supplies.

These devices feature internal feedback resistors and a flow-thru pin out,

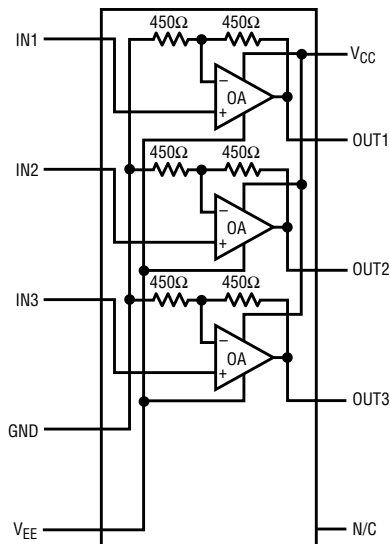


Figure 1a. LT6550 block diagram

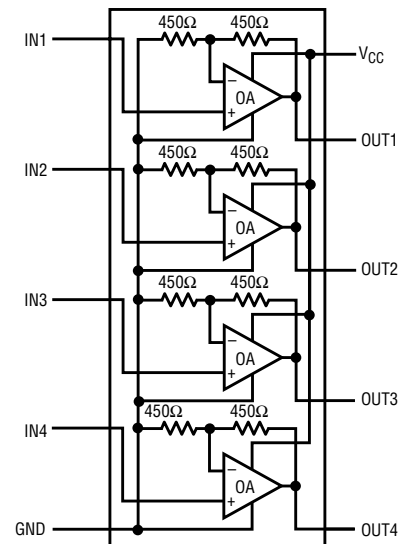


Figure 1b. LT6551 block diagram

which simplifies PC board layout and enhances performance by minimizing input to output stray capacitance. The amplifiers feature a rail-to-rail output and an input common mode range which includes ground. Figure 2 shows the output swing driving a 150Ω load vs supply voltage. On a single 3.3V supply, the input voltage range extends from ground to 1.55V and the output typically swings to within 400mV of the supply voltage while driving a 150Ω load. Table 1 summarizes the major performance specifications.

Figure 3 shows a simplified schematic of one channel of the LT6551. Resistors  $R_F$  and  $R_G$  provide an internal gain of 2. (The LT6550 triple is a slight variation with the gain setting resistor,  $R_G$ , connected to a separate ground pin). The input stage consists of transistors Q1 to Q8 and resistor R1. This topology allows for high slew rates at low supply voltages. Transistors Q3 and Q4 are class AB biased as are transistors Q5 and Q6. The input stage transconductance is derived from  $1/g_m$  of these transistors and resistor R1. The input stage

drives the folded cascode degeneration resistors of PNP and NPN current mirrors, Q9 to Q12, which convert the differential signals into a single-ended output. There are back-to-back series diodes, D1 to D4, across the plus and minus inputs of each amplifier to limit the differential input voltage to  $\pm 1.4V$ .  $R_{IN}$  limits the current through these

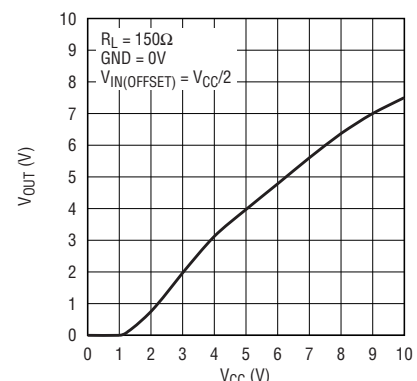
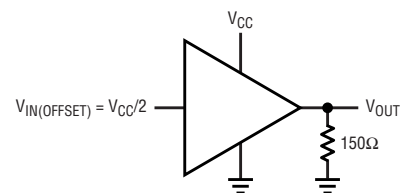
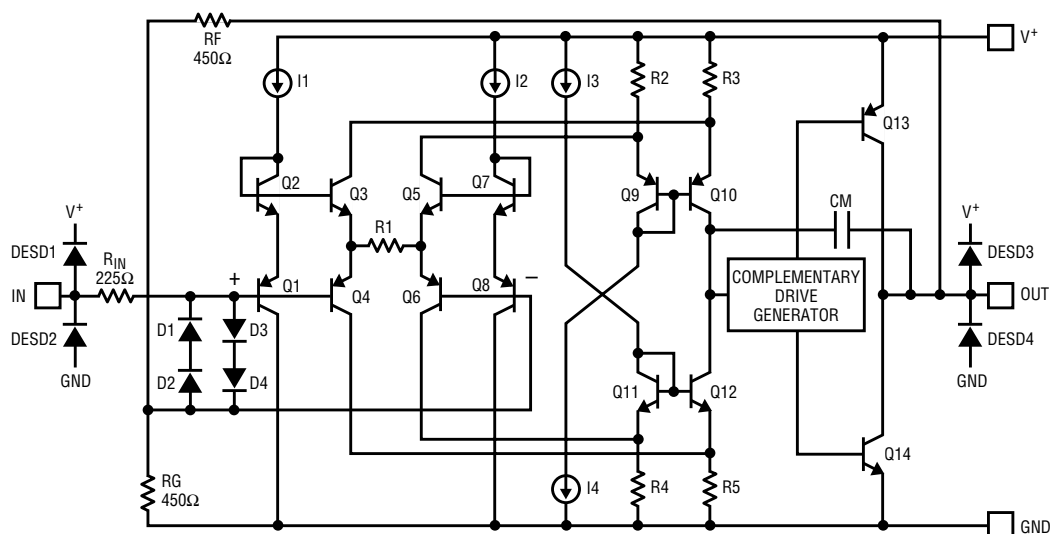


Figure 2. Output swing high vs supply voltage



**Figure 3. Simplified schematic**

diodes if the input differential voltage exceeds  $\pm 1.4\text{V}$ . The complementary drive generator supplies current to the output transistors that swing from rail-to-rail.

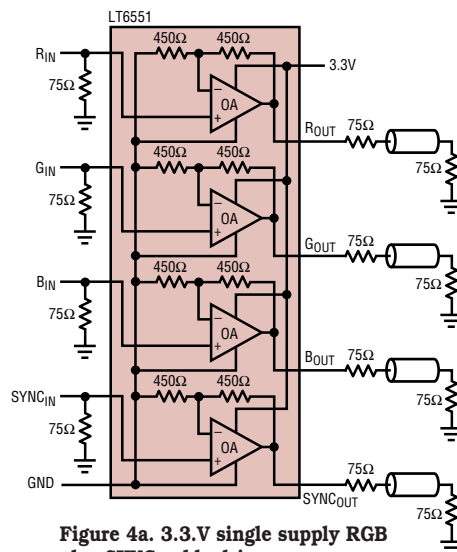
## RGB Video Applications

RGB (Red, Green, and Blue) video format requires three signals that represent the amplitudes of the respective colors plus timing signals (sync) that are sometimes combined with the green component.

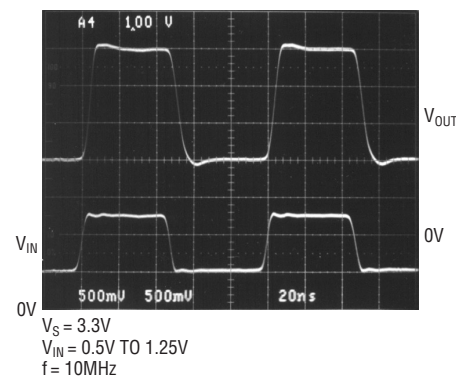
With video amplifiers driving double terminated 50 $\Omega$  or 75 $\Omega$  cables, the video output taken from the far end of the cable is 6dB lower than the output of the amplifier. For this reason these video amplifiers are configured for a closed loop gain of +2. The black

(lowest output for all three colors) to white (highest) voltage range for each

of the respective RGB channels is approximately 700mV, sync pulses are typically 300mV lower then the black level resulting in a total voltage range of 1.0V. This means that for DC-



**Figure 4a. 3.3.V single supply RGB plus SYNC cable driver**



**Figure 4b. Output step response**

**Table 1. Typical performance specifications ( $T_A = 25^\circ\text{C}$ )**

Parameter	Conditions	Typical Values@3.3V/0V	Typical Values@ 5V/0V
–3dB Bandwidth	$R_L = 150\Omega$	90MHz	110MHz
0.25dB Gain Flatness	$R_L = 150\Omega$	30MHz	30MHz
Output Voltage Swing High	$R_L = 150\Omega$	2.5V Minimum	3.5V Minimum
Output Voltage Swing Low	$I_{SINK} = 10mA$	200mV Maximum	200mV Maximum
Slew Rate	$R_L = 150\Omega$	250V/ $\mu s$	340V/ $\mu s$
Settling Time to 3%	$V_{OUT} = 1.5V$ step, $R_L = 150\Omega$	20ns	20ns
Channel Separation	Between all Channels at 10MHz	–60dB	–60dB
Differential Gain	$R_L = 150$	0.09%	0.05%
Differential Phase	$R_L = 150$	0.09°	0.05°
Supply Current per Channel		8.5mA	9.5mA

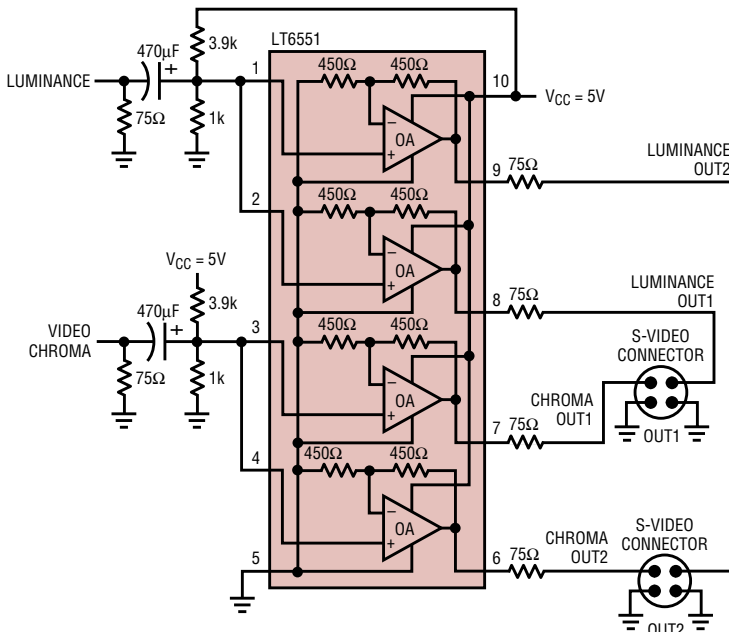


Figure 5. S-video splitter

Figure 5 shows an AC-coupled luma and chroma channel video cable driver that provides dual Y and C output ports. Operating from a single 5V supply, the LT6551 provides a guaranteed output swing of 3.3V, with the bias point established by the input resistor network shown. The chroma signal is a color subcarrier signal with no picture content offset, so it is readily accommodated with the same biasing scheme.

### Buffered RGB to Color-Difference Matrix

High performance consumer products require generation of  $Y_P P_R$  luminance and chrominance component signals, often from standard RGB source content. The  $Y_P P_R$  format has a luma signal and two weighted color difference signals at baseband. Even with their fixed internal gain resistors, two LT6550s connected as shown in Figure 6 easily implement the required conversion matrix equations (also shown in Figure 6). To perform the conversion, the input to the Y channel of the second LT6550 is a simple weighted sum of the 2x amplified RGB signals from the first LT6550, creating a signal of 2Y. The Y channel output in the second LT6550 is fed back to its feedback resistor common pin. This configuration implicitly performs the required Y subtraction function for both of the color difference channels and sets the Y channel output stage to the required unity gain.

The necessary scaling of the color-difference signals is performed passively by their respective output termination resistor networks. Since this circuit naturally produces bi-polar color difference signals ( $\pm 0.35V$  at the cable load), the simplest implementation is to power the circuit with  $\pm 3.3V$  split supplies. With an available output swing of about 5.6V for this supply configuration, the circuit handles video with composite syncs and various DC offsets without difficulty. Since the Y channel normally needs to incorporate sync, either all of the RGB signals can have sync included or a 1.8mA gated current-sink can be

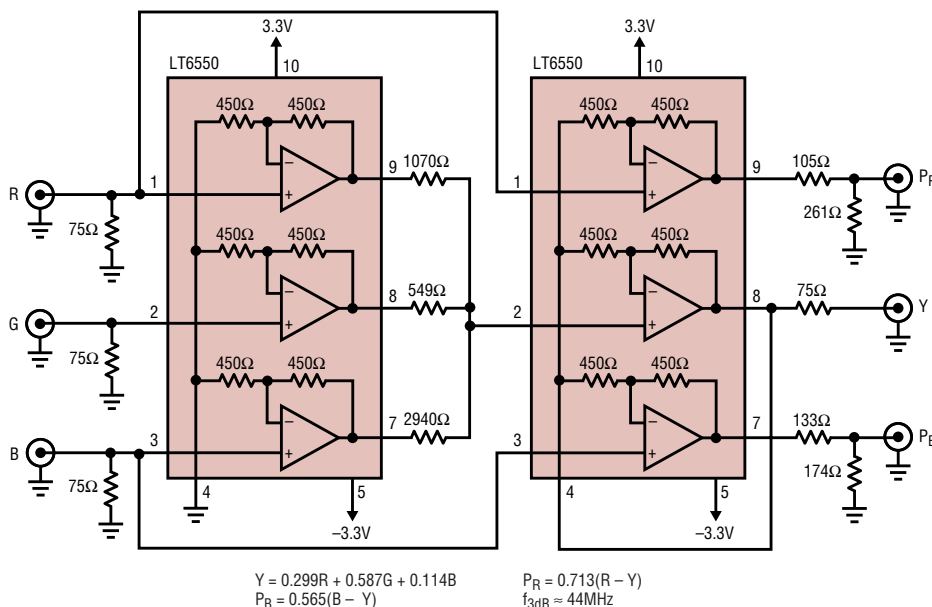


Figure 6. Buffered RGB to color-difference matrix

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*LT6550 and LT6551, continued from page 15*

introduced to the Y signal summing node to add sync.

## **Conclusion**

The LT6550 and LT6551 triple and quad voltage feedback amplifiers are well suited for use in a variety of video applications. Their high slew

rates, fast settling time, and wide input and output ranges make them an excellent choice for 3.3V RGB applications. 

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