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Feb 26, 2008

APPLICATION NOTE 4167

Cookbook for Analog Video Filtering in Camera Systems

Abstract: Analog video filtering is widely used at the output stage in video camera applications, such as CCTV, security camera, digital still cameras (DSCs), and digital video camcorders (DVCs). As products are reduced in size and power, designers are moving away from discrete solutions to more integrated, one-chip solutions. This article explains different filter amplifier configurations for several popular DACs in the video camera market. It is an easy-to-use guide for Maxim's various integrated video filter amplifiers that satisfy a wide range of video application requirements.

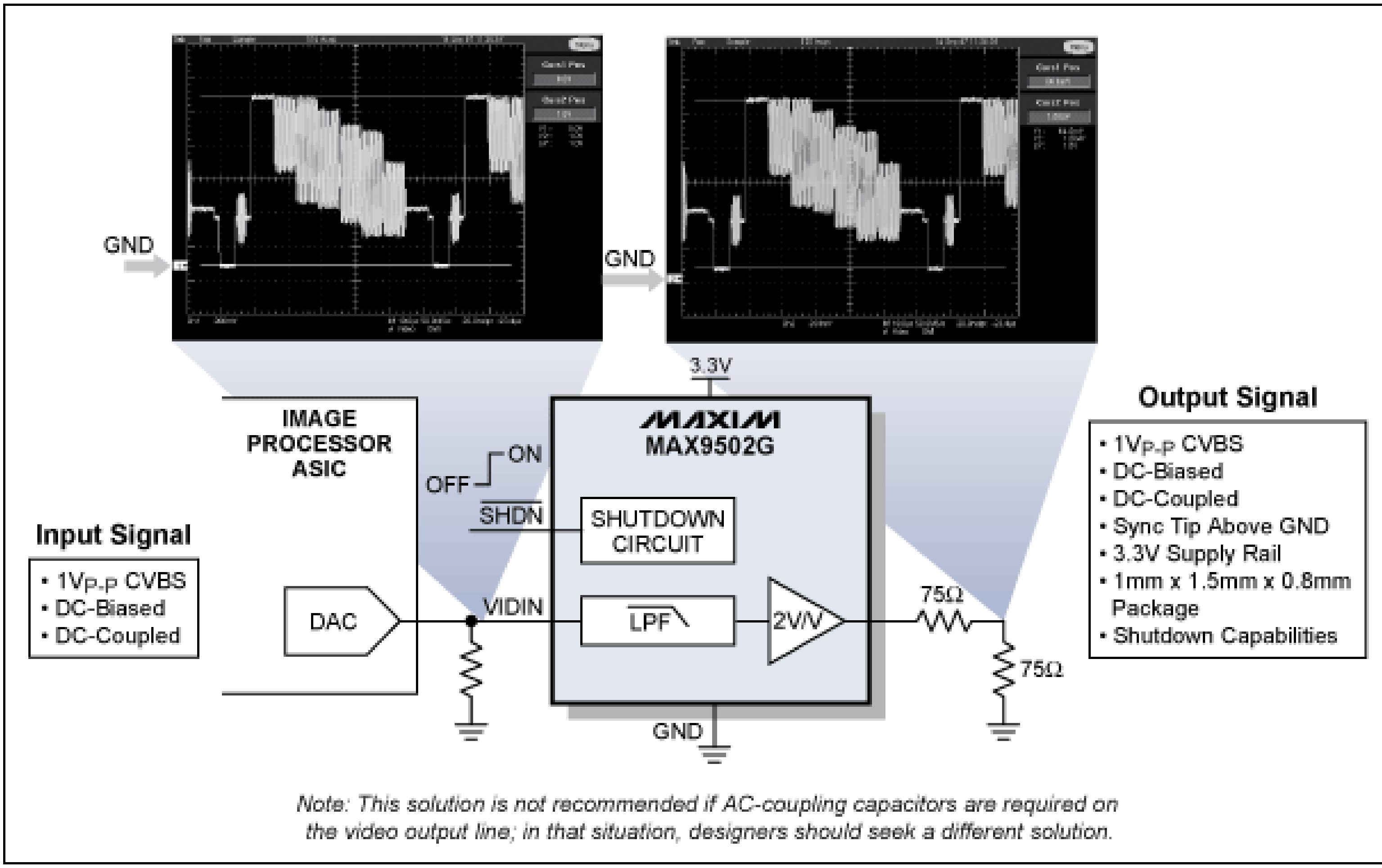
This article was also featured in Maxim's Engineering Journal, vol. 62 (PDF, 1.3MB).

In most video systems, lowpass filters are included on the video output lines of the video encoders. These filters reject high-frequency noise and smooth out the rising-/falling-edge video signals that are output from a video digital-to-analog converter (DAC). Traditionally, discrete passive filters have been used in such configurations. However, in most of today's video subsystems, an integrated filter amplifier follows the video DAC to clean up and amplify the video signal. This article details Maxim's variety of integrated video filter amplifiers that satisfy a wide range of video application requirements.

In video-camera applications, the most common signals that video DACs output are composite video blanking and sync (CVBS) and luminance/chrominance (Y/C) signals. The eight filter amplifier configurations detailed in **Examples 1** through **8** are composed of different combinations of the signal's DC level at the DAC output, signal amplitude, and AC- or DC-coupling of the video signal. Common power-supply rails for integrated video filters are 5V or 3.3V. However, for the applications with the lowest power requirements (Examples 6 and 7), a video filter amplifier can be powered by a 1.8V or 2.5V supply. The specific filter amplifier (MAX9509) used in these low-power examples takes advantage of Maxim's patented DirectDrive™ technology,† and delivers a $2V_{P-P}$ video signal with an internal fixed gain of 8V/V.

The following eight configurations have several common features. All outputs are measured at 75Ω loads. Thus, when the output graph shows $1V_{P-P}$, the output of the integrated filter amplifier should be $2V_{P-P}$. Also, a 75% TV NTSC color-bar signal is used as the source for all filter examples.

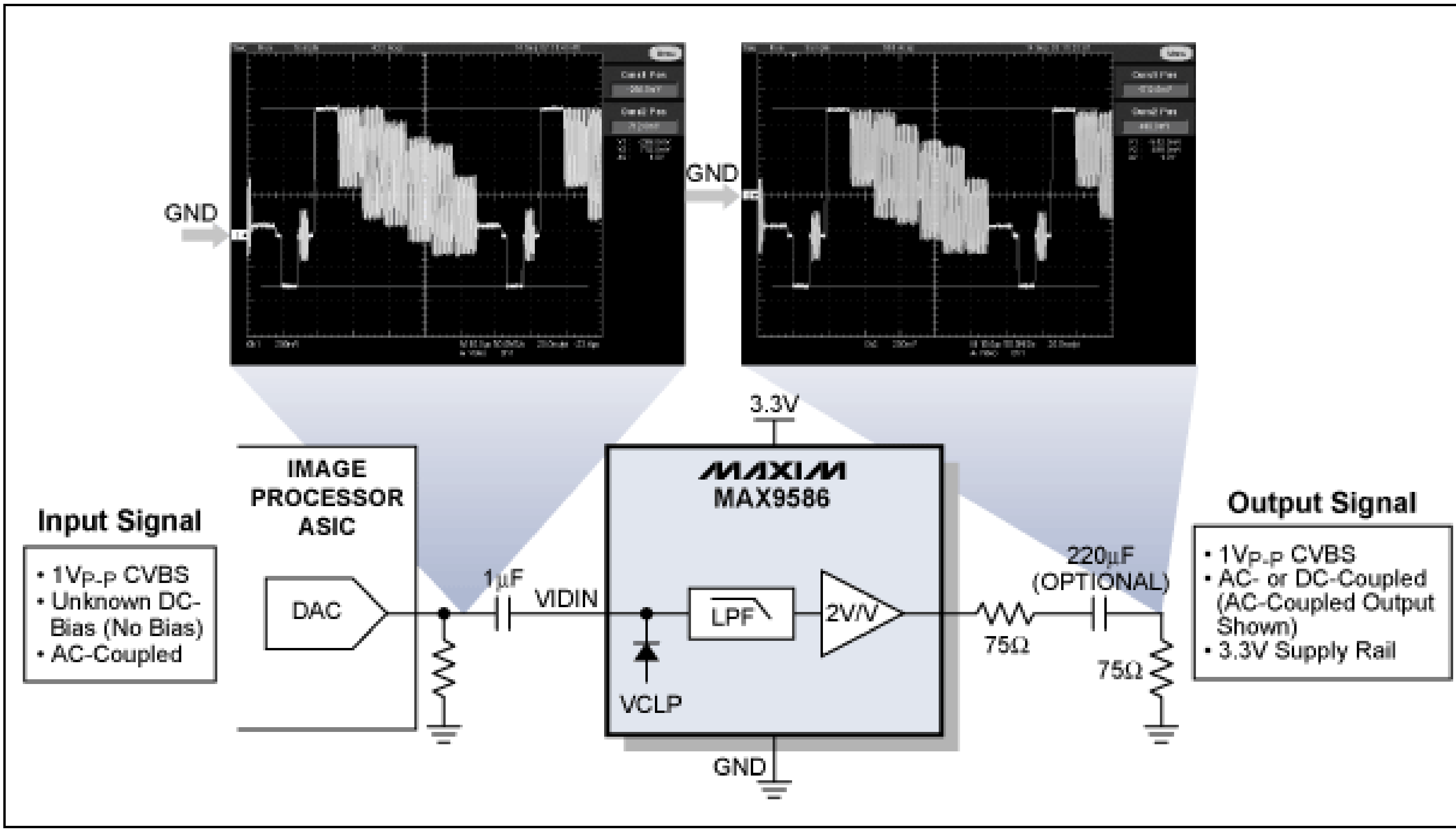
Example 1: Reconstruction Filter Connects the Video DAC to the Video Amplifier



More detailed image (PDF, 115kB)

In Example 1, the video DAC's output connects to a MAX9502G video amplifier with a reconstruction filter. The DAC's video signal output is biased so that the sync tip is near ground. The MAX9502G filters and boosts the signal, and then delivers a $2V_{P-P}$, DC-biased signal. The output of MAX9502G is also biased and its sync tip is approximately 300mV above ground. This sync-tip value changes to 150mV at the load due to the 75Ω divider setup at the output. A highly-integrated solution, the MAX9502G consumes little board area, thus saving space in most portable system designs.

Example 2: Video DAC Sends an AC-Coupled Signal to the Video Amplifier



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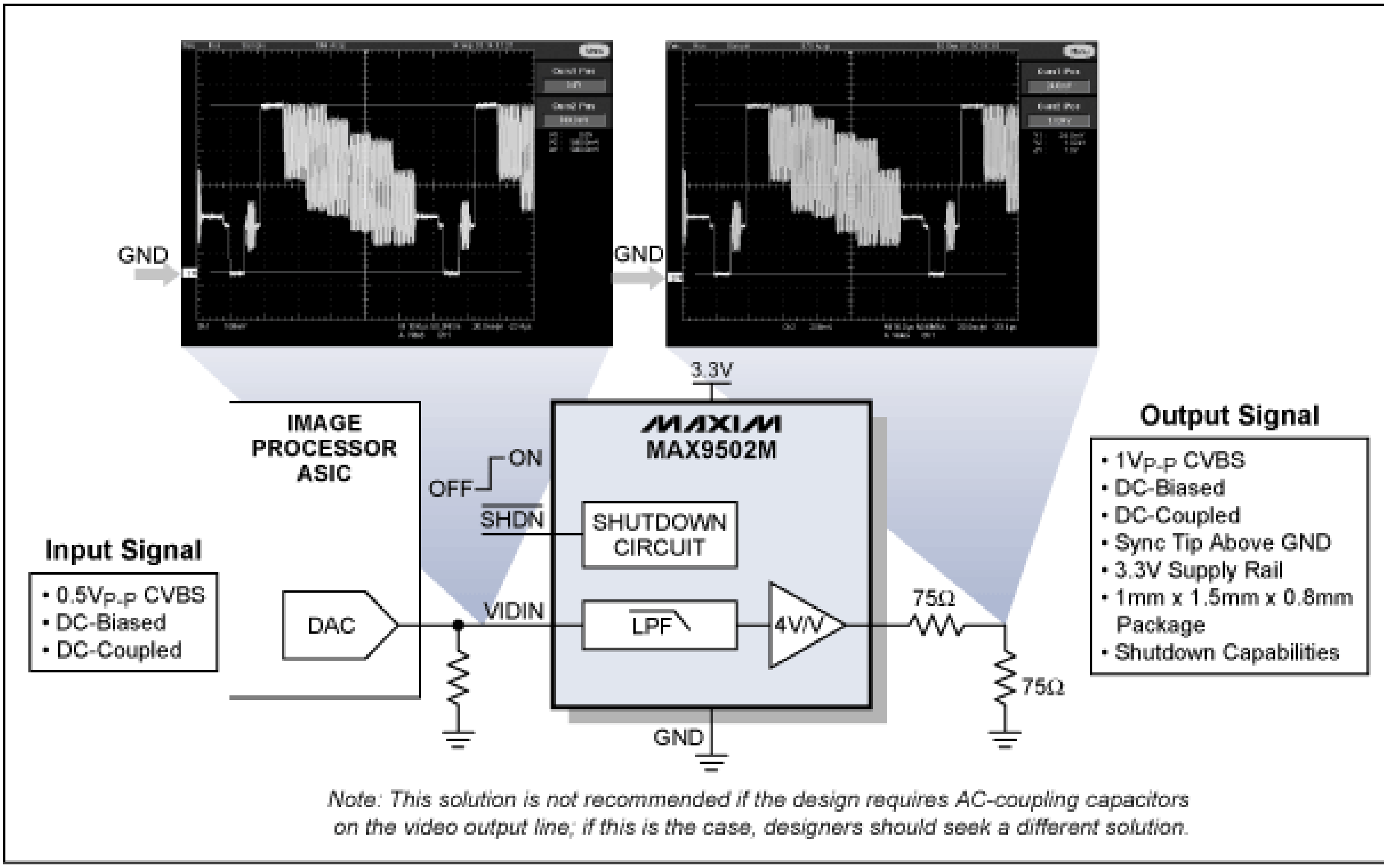
In Example 2, a video DAC delivers an AC-coupled video signal to the MAX9586 video filter amplifier. This is a good solution for single-supply applications that require the signal to be AC-coupled and the sync tip to be placed below ground. However, AC-coupling the video at the output does not put the black level at ground; instead, the black level changes as the content of the video signal changes. The MAX9586 can drive two DC-coupled video loads or a single AC-coupled 150Ω load.

Example 3: Example 1 with a 0.5V$_{P-P}$, DC-Biased Signal



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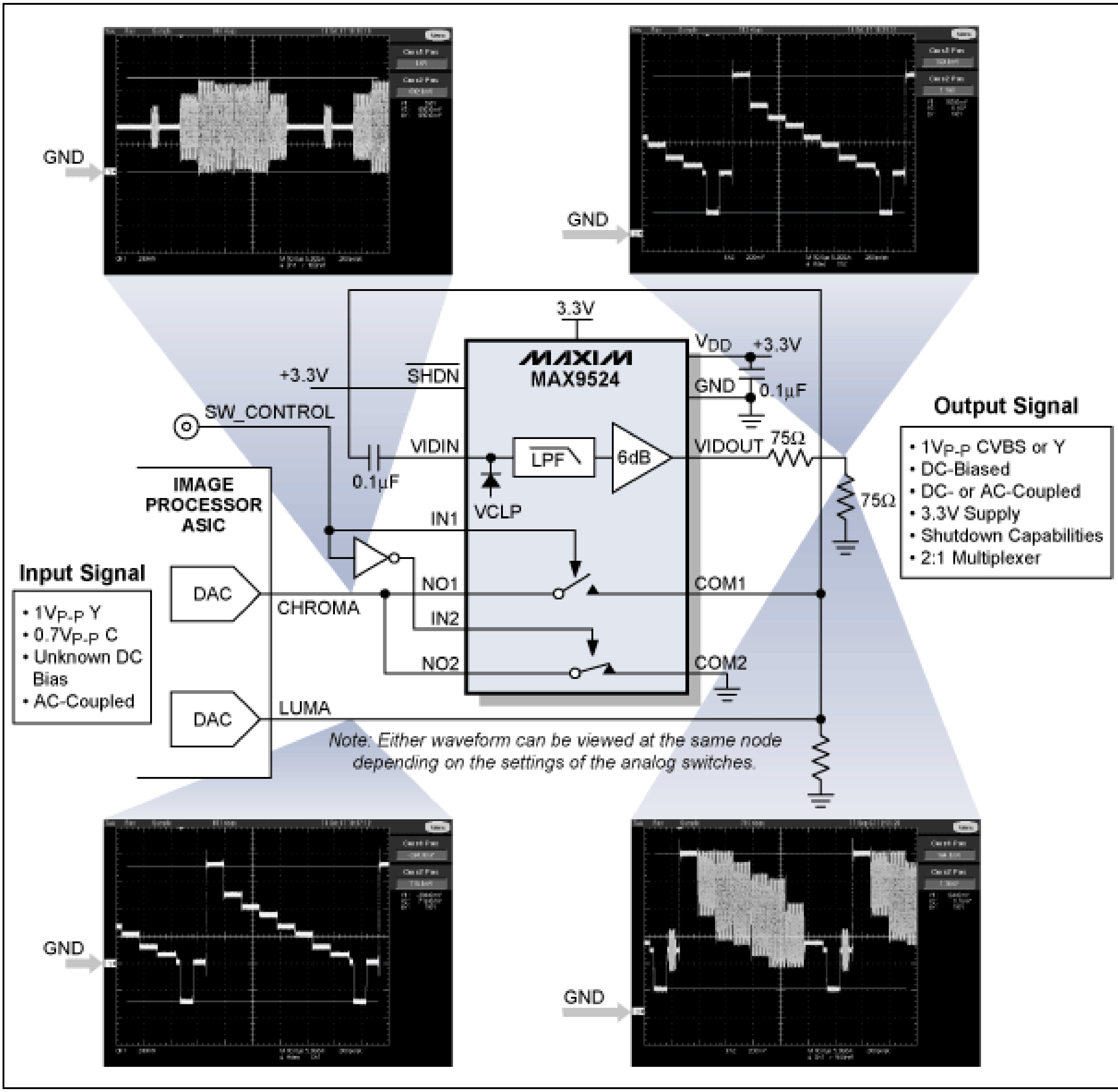
Example 3 is very similar to Example 1, except that the DAC can only output a 0.5V$_{P-P}$, DC-biased signal. The MAX9502M is the appropriate solution in this case because of its 12dB fixed gain. The video signal at the load has a DC offset and the sync tip is about 150mV above ground. Also, the video signal output from the DAC must be above ground. The MAX9502M can drive a 2V$_{P-P}$ video signal into a 150Ω load to ground.

Example 4: Video DAC with Only One Output Line for CVBS or Y Signals



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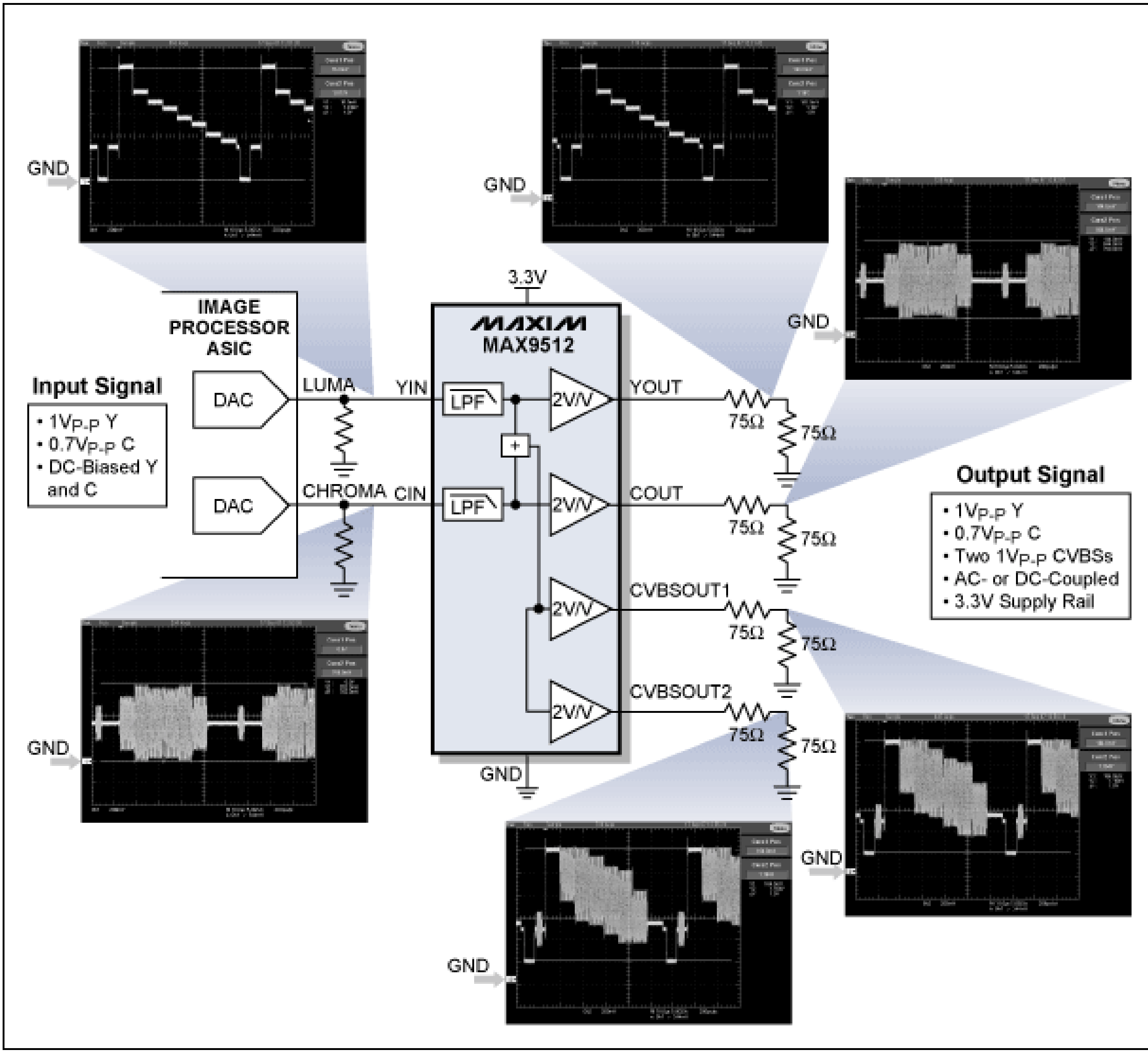
Example 4 is an interesting configuration. In certain applications, DACs provide both Y and C, but the Example 4 design has only one output line. This output should be selectable between CVBS and Y signals so that a CVBS signal can be created by using a summer (combiner) circuit. It is difficult to provide both types of signals on the same output line and switch between them at the appropriate time. This is usually done by implementing a 2:1 multiplexer on the output line. Fortunately, the MAX9524 video filter amplifier used in this example has two integrated analog single-pole switches that can be set up as a 2:1 multiplexer. This is very useful, as this single integrated chip can both select the appropriate input and filter-amplify it. The DC level is unknown because of the summation of Y and C; therefore, the video signal should be AC-coupled before the filter-amplifier. The clamp circuitry after the AC-coupling capacitor sets the bias level.

Designers should pay close attention to the combiner circuit that creates the CVBS signal. The DC offset levels of Y and C, as well as the DAC's voltage-compliance level, should be taken into careful consideration. Directly connecting Y and C, depending on the DC-bias level of each signal, could create a CVBS signal that extends beyond the DAC's voltage-compliance range.

Example 5: Multiple Video Outputs with a Y/C-to-CVBS Mixer



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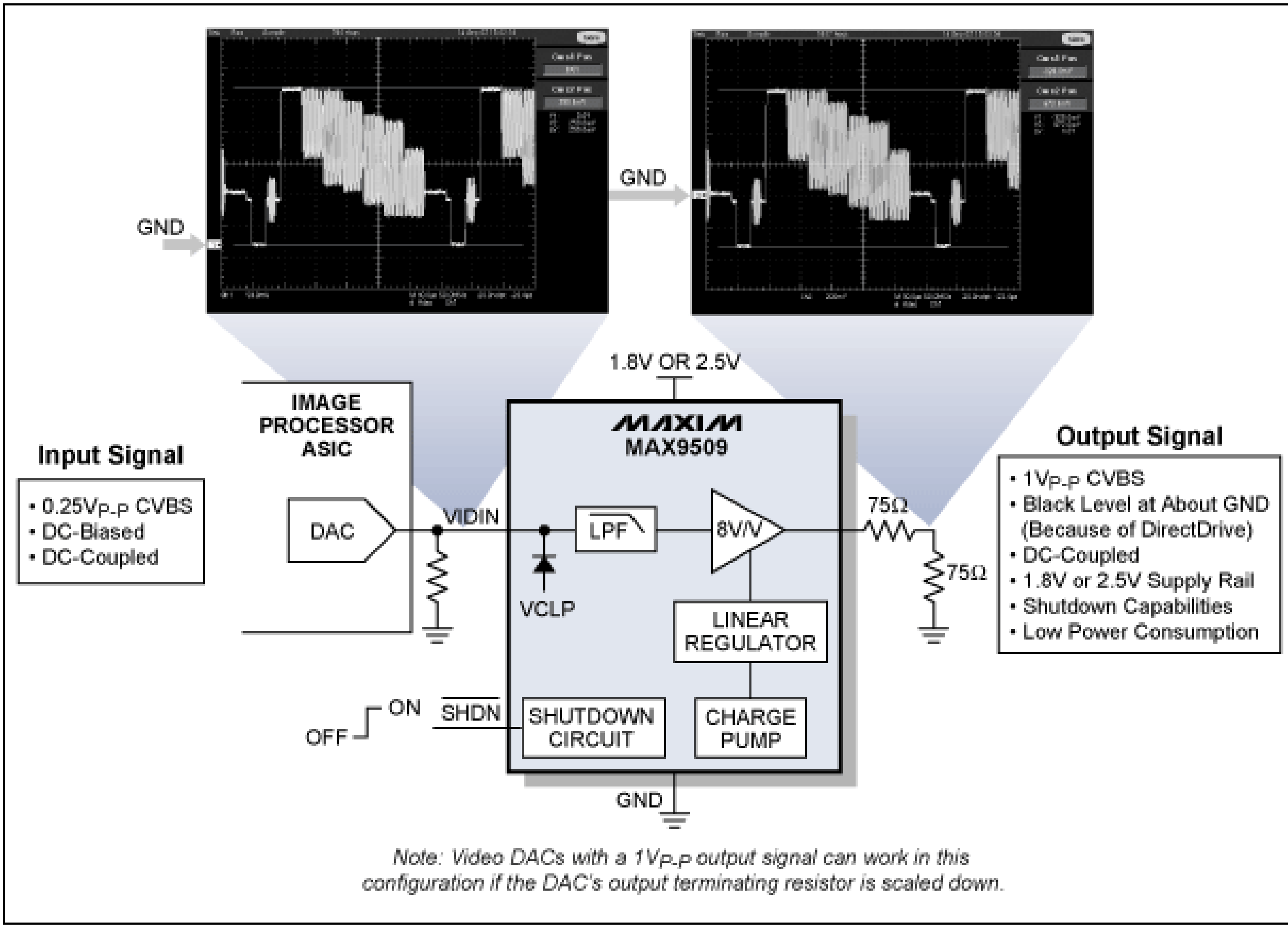
Example 5 is appropriate for designs with multiple video outputs, as the MAX9512 has four separate output channels.

This device also has a Y/C-to-CVBS mixer, which creates a composite video signal from Y and C. Each output is capable of driving two DC-coupled video loads or an AC-coupled 150Ω load. This chip also has Maxim's SmartSleep circuitry‡ (not shown) that can detect input signals or output loads and reduce power consumption by turning on/off different amplifiers accordingly. This configuration can most commonly be used to provide an S-video output, as well as two CVBS outputs.

Example 6: Low Power Consumption with a Black Level Nearly at Ground



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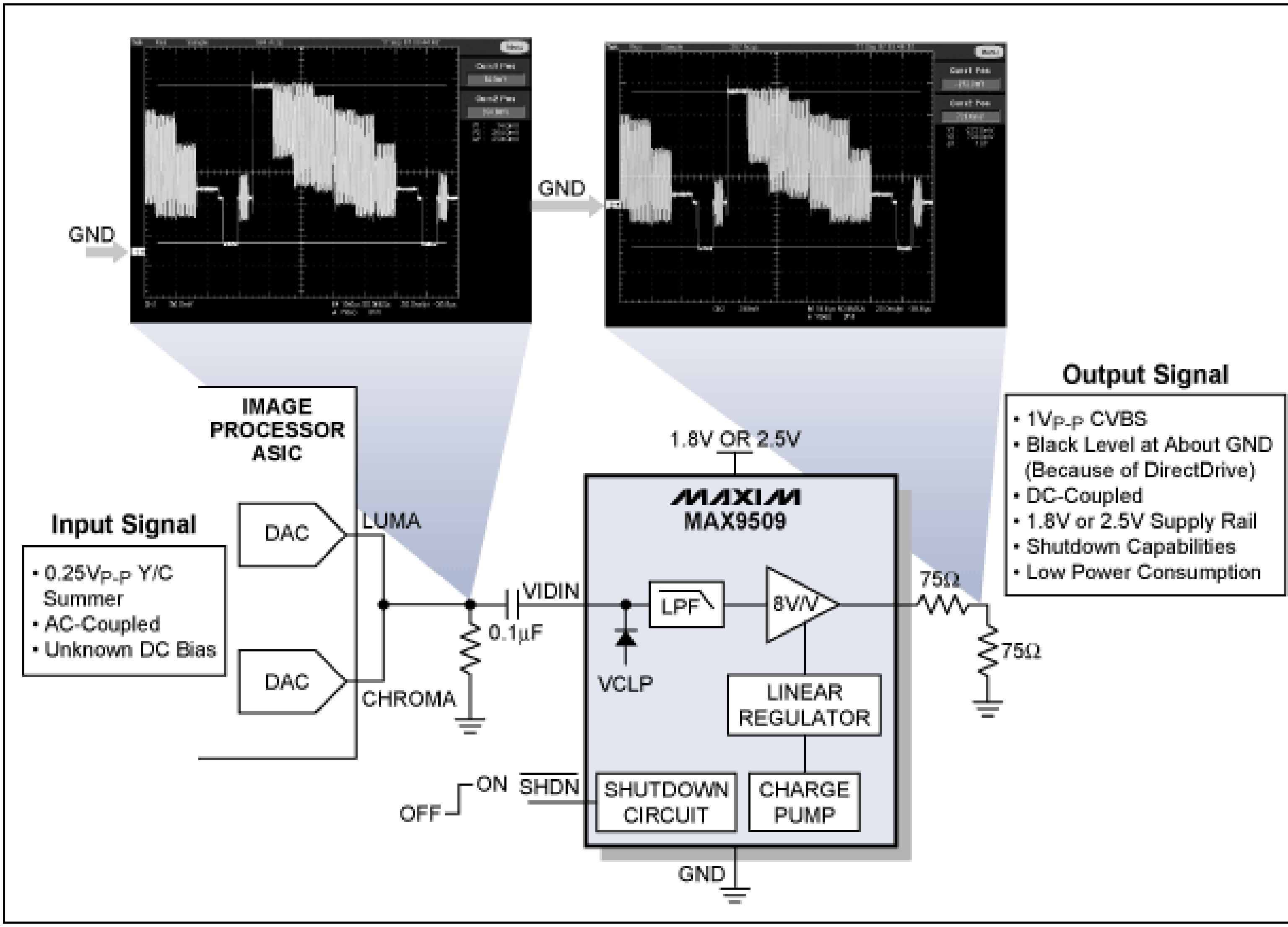
Example 6 minimizes power consumption by leveraging the MAX9509, which operates from a single 1.8V supply and consumes 11.7mW average power. Other advantages of this configuration are that the black level is almost at ground without the need for a large coupling capacitor on the output, and that the video signal is between -300mV and +700mV independent of the video signal contents. Because the amplifier has an internal fixed gain of 8V/V, the DAC output should have an amplitude of $0.25V_{P-P}$. This can easily be achieved by changing the value of the terminating resistor at the output of any type of DAC.

Example 7: Y, C, and CVBS Signals from One Output



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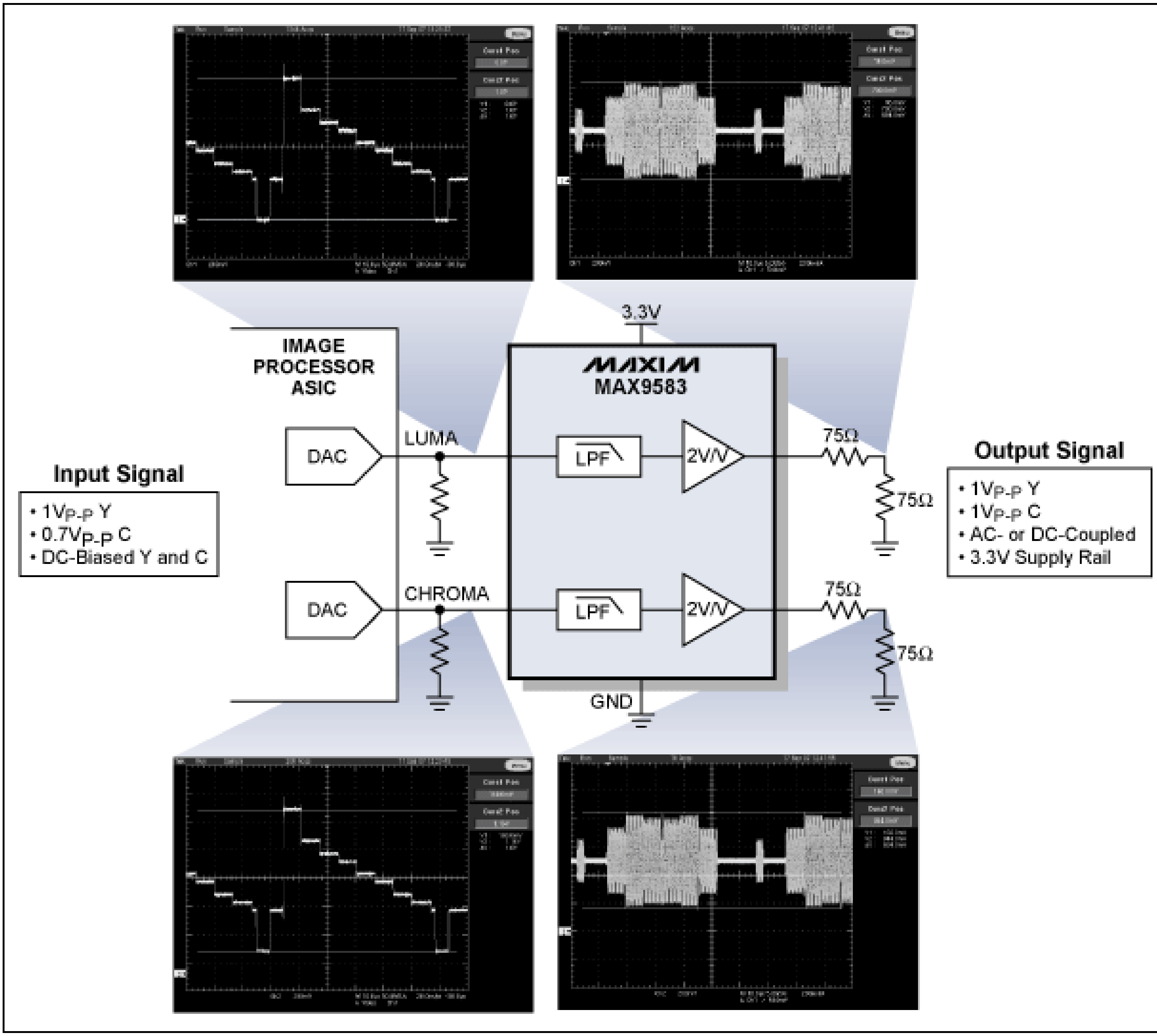
For certain applications, only Y and C signals are available on the DAC's output, but the system must still deliver a CVBS signal. In such situations, a common solution is to use a combiner circuit to create the desired output signal. This common solution is similar to the combiner circuit in Example 4, but because the amplitude of the desired CVBS is only $0.25V_{P-P}$, meeting voltage compliance levels is probable. If the DAC normally outputs $1V_{P-P}$, an amplitude of $0.25V_{P-P}$ can easily be achieved by changing the value of terminating resistor at the DAC.

Example 7 demonstrates the appropriate filtering-amplifying solution for a very low-power application. The designer can obtain the appropriate amplitude ($0.25V_{P-P}$) by scaling down the terminating resistor at the DAC output. Because the DC bias level can be unknown (depending on the signals and combiner circuit), the signal should be AC-coupled into the MAX9509. A sync-tip clamp level-shifts the signal appropriately at the input. Because of the filter-amplifier's DirectDrive capabilities, the black level at the amplifier's output is sitting approximately at ground. This eliminates the need for large coupling capacitors on the output. The MAX9509 can, therefore, drive a $2V_{P-P}$ video signal into a 150Ω load.

Example 8: Two Video Output Signals with No DC Offset



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For applications that require two video output signals (such as S-video), the MAX9583 two-channel video filter amplifier provides the compact solution seen in Example 8. The MAX9583 has an internal fixed gain of 2V/V and, therefore, is suited for DACs with a $1V_{P-P}$ output. The output of this device can be AC-coupled to a 150Ω load or two DC-coupled video loads. AC-coupling of the video signal eliminates any DC offset, and the black level changes as the video content changes.

Conclusion

This article focuses on most of the common configurations seen in today's video-camera applications. CVBS and Y/C are by far the most common output signals in such applications. Rarely, on some of the higher end equipment, one might see a YPbPr output whether the video signal is standard definition (SD) or high definition (HD). Though this article does not discuss these rare applications, designers should be aware that there are integrated solutions available.

†U.S. Patent #7,061,327.
‡Patent pending

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