Advances in Video Encoders

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Foreword to the reader: Video technology uses many special terms that may be unfamiliar to those not in the field. We've provided a 32-page glossary *(Application Note 548, in PDF, 112 KB) to help readers who want to understand video terminology. It may be helpful to print out a copy to have on hand as a reference. A printed version of the glossary may also be ordered from* Literature Distribution.

Introduction

Digital video signals from sources such as MPEG codecs must be appropriately encoded and converted to analog before they can be displayed by analog TVs and VCRs. In general, encoding means to convert from one format or signal to another. For video encoders, this means converting from 4:2:2 YCrCb digital video data into YUV, RGB, or CVBS analog video signals. YCrCb is a component digital signal, where Y is the luminance signal, which contains the black-and-white signal information, Cr is red minus the luminance (R-Y), and Cb is blue minus the luminance (B-Y). YUV is a scaled version of YCrCb. This scaling is necessary prior to combining the YUV signals into composite video, so that it will be contained within the amplitude limits of signal-processing and recording equipment. This YUV signal should not be confused with the *analog* YUV inputs found on high-end TVs. CVBS (Color, Video, Blank, and Sync) is a composite analog signal. In this format, a single analog video signal includes information on sync, color, and luminance. Composite signals are used in standard TVs and VCRs. The component formats provide a sharper picture with less noise than a composite signal because the modulation required to produce the CVBS signal is eliminated.

The ADV719x family (Figure 1) is a new generation of video encoders. They provide all of the features of other members of ADI's video encoder family, plus 4× oversampling, digital noise reduction (DNR), gamma correction and, in the ADV7194, Xtended-10™ technology (see below). A key feature of the ADV719x is the ability to input progressive scan signals in 3 × 10-bit 4:2:2 YCrCb format. On-board DACs convert these signals into an analog YPrPb format that can be viewed on a progressive scan monitor.

4× Oversampling: In A/D converters, oversampling means using a sampling rate that is higher than the Nyquist rate, that is, sampling at a rate more than twice that of the highest frequency of the incoming signal. For a D/A converter, oversampling is actually an interpolation process, accomplished by computing the average value between consecutive samples.

Video data is clocked into the ADV719x at a 13.5-MHz rate. It is first interpolated up to 27 MHz, and interpolated again up to 54 MHz. The video data is then sent to the six 10-bit DACs. The interpolation process allows a given signal quality to be reached using less-expensive components with looser tolerances. In this case, interpolation allows the use of reconstruction filters with a gentler roll-off slope. This, in turn, means less-complex filter designs and lower cost. Phase nonlinearity and passband ripple are less likely to cause problems. Interpolation also allows the resolution of converters to be extended. In an ideal system, if the bandwidth of the signal is doubled, the same amount of information can be conveyed down a channel with an SNR of 6 dB or less. Therefore, raising the sampling rate allows the word length in each sample to be reduced without information loss.

Figure 2 shows the reconstruction filter requirements when 2× oversampling and 4× oversampling are used.

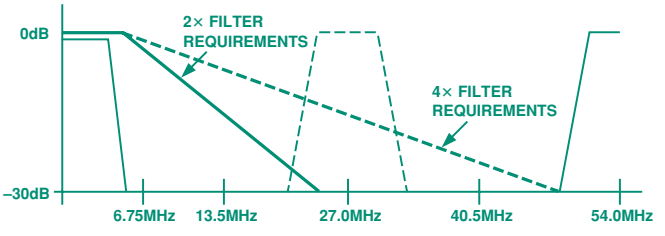

Figure 2. Low-pass filter requirement with 2× and 4× oversampling.

Digital Noise Reduction: Noise is generally visible as "snow," or small dots that make the picture look fuzzy, and can be caused by bad transmission or low-quality equipment. Noise is more visible

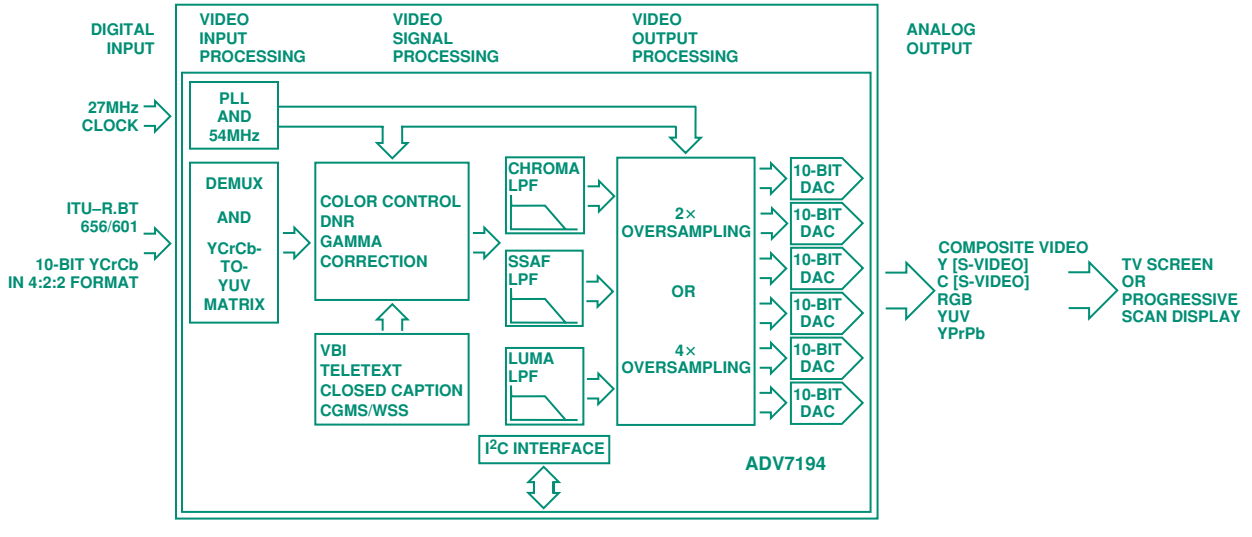

Figure 1. Functional block diagram of the ADV7194.

on pictures with significant high frequency content; that is, pictures that contain lots of detail and color. The digital noise reduction (DNR) used on the ADV719x effectively reduces noise in the picture, and also has the ability to reduce noise that results from the MPEG compression. MPEG compression splits the video data contained in one frame into compressed blocks of 8 × 8 pixels. Several of these blocks make up a field. The border areas of these blocks cause noise to be visible on the TV picture, which makes it generally less sharp. This type of signal degradation is typical of MPEG compression. In the ADV719x family of video encoders, the amount of noise reduction applied to the transition areas is programmable.

Video noise characteristically combines high frequencies and low amplitudes. The ADV719x makes use of this fact by analyzing the incoming signal for its high-frequency, low-amplitude content. This noise signal is then subtracted from the original signal, resulting in improved picture quality. Depending upon the noise requirements, the user can program a threshold value that determines the amount of noise attenuation applied.

Additionally, programming allows high-frequency signals to be enhanced. When received, high-frequency signals with high amplitudes are assumed to be valid data. Applying a programmable gain to these signals and adding them to the original signal results in an improvement in picture sharpness.

Figure 3 shows a simulation of an input signal (light trace) and the resulting output signal (heavy trace) when digital noise reduction is applied.

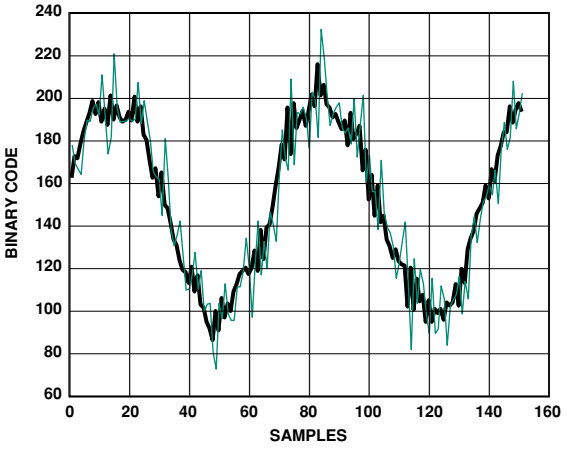

Figure 3. Effect of digital noise reduction. Heavy trace is output waveform.

Gamma Correction: Gamma is the exponent applied to a signal voltage in an approximation of the nonlinear transfer function of a display device (e.g., a cathode-ray tube screen). Gamma = 1.0 would produce a perfectly linear plot, i.e., the output as a linear function of the input. In CRTs the intensity of light produced on the screen of a CRT is a nonlinear function of the voltage applied at the input, with a typical gamma value of 2.3 to 2.6.

Gamma correction, a process of compensating for this nonlinearity, is necessary for reproducing good color with the correct intensity in order to meet standards for picture appearance on a given screen.

The nonlinearity of the CRT should also be considered if an image is to be coded in such a way as to make maximum perceptual use of a limited number of bits per pixel and to minimize the visibility of noise. If uncompensated, the nonlinearity would create errors known as contouring or banding. These are visible on simple pictures having large areas of smoothly varying shades. This is effectively the same as the visible distortion caused by quantization error introduced at low levels of modulation.

Display devices, such as liquid crystal displays (LCDs) and CRTs, have differing nonlinearity characteristics. The ADV719x allows the user to program gamma values so that appropriate compensation curves can be applied to the incoming signal. Gamma correction in the display device is especially useful in cases where the video source doesn't provide a gamma-corrected signal.

Figure 4 shows responses of the gamma correction circuit to a linear ramp signal for several values of gamma.

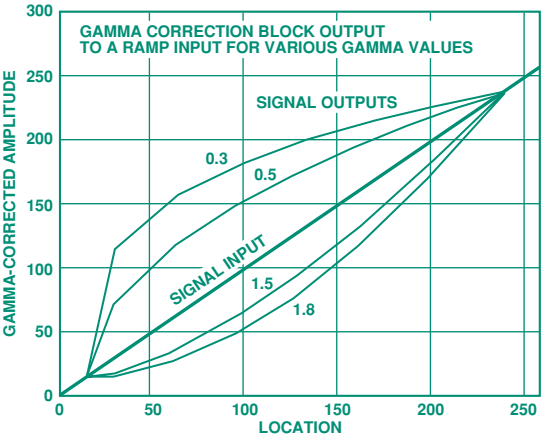

Figure 4. Gamma correction curves.

Xtended-10 Technology: Many video encoders, including the ADV7175/ADV7176, ADV7175A/ADV7176A, ADV7177/ADV7178, ADV7170/ADV7171, and ADV7172/ADV7173, allow for data to be input in 8-bit format, processed at 8 or 10 bits, and output to 10-bit DACs. With Xtended-10 technology, the ADV7194 allows data to be input in 10-bit format, processed at 10 bits, and output to six 10-bit DACs. The 10-bit processing available in the ADV7194 is of especial value in professional video applications.

THE ADV719x FAMILY

The ADV719x image processing facilities are unsurpassed. The user has control over brightness, color, contrast, chroma, and luma, as well as delay and programmable adjustment of sync pulsewidth and position. There are seven programmable luma filters, seven programmable chroma filters, and an extended SSAF™ filter with 12 programmable responses.

The ADV719x also provides features such as TTX, CGMS, Macrovision, master/slave timing modes, VBI (vertical blanking interval) programming, and closed captioning.

The technical performance of the ADV719x is outstanding, resulting in excellent signal quality. Errors in differential gain and phase are 0.2% and 0.4°, respectively. SNR of up to 75 dB can be achieved.

The AD719x runs on a single +5-V, +3.3-V, or +3-V supply. The ADV7190 is packaged in a 64-lead LQFP. The ADV7192 and ADV7194 are packaged in 80-lead LQFPs.

Evaluation boards are available. The user simply connects the board to the TV monitor when used with internal color bars, or a YCrCb signal source can be used. A PC running Windows® 95/98 is required. User-friendly software is provided.