Advanced Digital Video Encoders

CCIR-601 YCrCb to NTSC/PAL: studio quality digital video at consumer video prices

by Bill Slattery

The ADV7175/ADV7176* digital video encoders convert digital video data into standard analog baseband (NTSC/PAL) television signals. These low-cost, high-performance devices encode digital YUV (CCIR-601/656—4:2:2) and square pixel component video; and they can drive EuroSCART (RGB), S-Video (Y/C) and YUV analog video signals, as well as supporting closed-captioning and Teletext. The AD7175 also includes Macrovision® antitaping (license required from Macrovision, Inc.) The digital input section interfaces gluelessly to all standard MPEG (1 & 2) Decoders. Applications encompass TV settop boxes, VideoCD, DVD, Internet/Network Computers, Web TVs and Multimedia PC Video, as well as professional broadcast/studio video equipment. Packaging in a tiny 44-Lead PQFP. Prices (10,000) start at $7.59.

Digital video: Television signals are, in the main, transmitted in standard analog format; the signal is received over an outdoor or indoor antenna, or over a cable distribution system that may have a local analog settop box to enable pay-TV channels. This system, based on the composite analog NTSC (North America, Japan) and PAL (Europe) formats, has existed for 40 years or more and has served consumers quite well worldwide. Recently, however, television broadcasting has undergone revolutionary changes. Intent on permitting existing equipment and program material to continue in use, broadcasters have had to maintain backward compatibility of the existing format but transmit and distribute it with digital processing. Analogous to the evolution from black-and-white TV to color TV, this change will allow complete backward compatibility and transparency for both program makers and television viewers. Only the medium of delivery has changed.

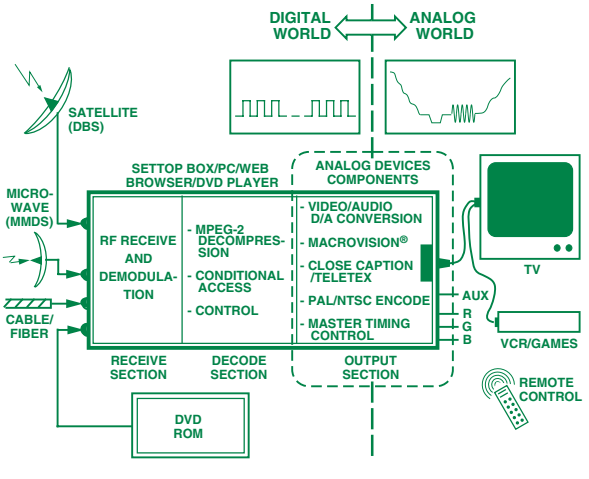

Figure 1. In home digital video architectures, the encoder is key, whatever the source.

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This digital revolution offers a new and very significant feature to viewers. The ability to compress the digital video data means that a great many more viewing channels become available to the consumer using a standard TV set. Up to six channels can now be transmitted in the bandwidth that was previously required for just one. In addition to more channels, the signal quality available in a digital system results in vastly improved displayed pictures.

Figure 1 shows the array of reception options that the home viewer has in the digital video world, including DBS (direct-broadcast satellite), digital cable (coaxial, fiberoptic, etc.) and what is oxymoronically termed wireless cable—in essence, a microwave line-of-sight distribution system, known also as MMDS (multipoint microwave distribution system). The major broadcasting networks have plans to introduce a digital version of the traditional antenna-based transmission system. Besides video broadcasts, the viewer may have local video sources, such as video CD, game console or, indeed, the emerging DVD format.

The received digitally coded TV signal must first be converted back to the traditional NTSC or PAL signal, capable of being understood by the standard TV. The settop box, or integrated receiver decoder (IRD), which interfaces (bridges the gap) between analog and digital worlds, implements these functions:

- Receive and demodulate digital signal (QAM/QPSK receiver)
- Decompress the digital data (MPEG-2 Decoder)
- Convert the digital data into standard TV Signal (NTSC/PAL digital video encoder).

This last function is implemented by the ADV7175/ADV7176. In addition to performing the basic D/A conversion, the device also encodes the component YUV data into the analog composite (CVBS) or S-Video (Y/C) signals for standard analog TVs.

Multimedia PC application: The ADV7175/ADV7176 are also ideally suited for video editing on PCs. *Analog Dialogue* 30-2 (1996) introduced the ADV601 integrated Wavelet Video Codec; combined with the ADV7175/ADV7176 and a video decoder, it provides a complete, low-cost video-capture/editing system on a PC. Like the interface to MPEG encoders, it needs no additional glue logic.

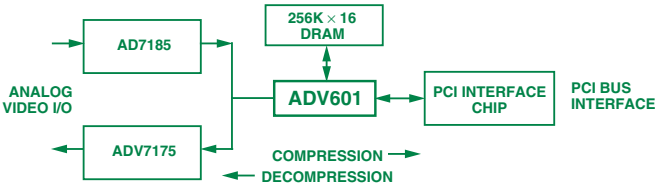
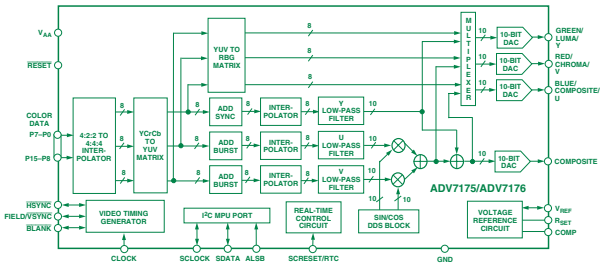


Figure 2. Encoder provides analog output of decompressed video in PC application.

Advanced NTSC/PAL digital encoder: The ADV7175/ADV7176 has been developed in close cooperation with digital video end customers. The resulting parts integrate all the required functionality and features, plus the optimum level of performance at the price levels demanded in the consumer electronics industry.

Beyond four 10-bit DACs, the encoder incorporates our DDS (direct digital synthesis) technology with a 32-bit-wide accumulator to accurately regenerate the color sub-carrier. An extensive input port translates the digital input samples of 4:2:2 YCrCb data into the appropriate luma (Y) and chroma (UV) video signals. A two-wire, I^2C-compatible port allows all functions to be programmed.



The output circuitry enables the part to support the ubiquitous standard composite video formats as well as the increasingly popular performance S-Video (Y/C) video mode. The four outputs mean that the part can simultaneously drive a variety of combinations of CVBS and S-Video. For example:

	Simultaneous composite video and SVHS		SCART format	Professional studio
	Option 1	**Option 2**	**Option 3**	**Option 4**
DAC A	CVBS	Y	CVBS	—
DAC B	CVBS	CVBS	B	U
DAC C	C	C	R	V
DAC D	Y	CVBS	G	Y

For the European market, in which the SCART connector format has become a requirement, the ADV7175/ADV7176 is capable of driving R,G,B & CVBS outputs simultaneously (see Option 3).

The input port enables the device to process industry-standard, CCIR-601 (D1) video data configured in accordance with CCIR-656. The port can be configured for the traditional 16-bit YUV format or the more modern 8-bit format. The associated timing signals of FIELD/VSYNC, HSYNC and BLANK, and the part's ability to operate in a variety of master and slave configurations, means a glueless interface (no additional logic—see Figure 4) between the device and its driving source (e.g., MPEG decoders).

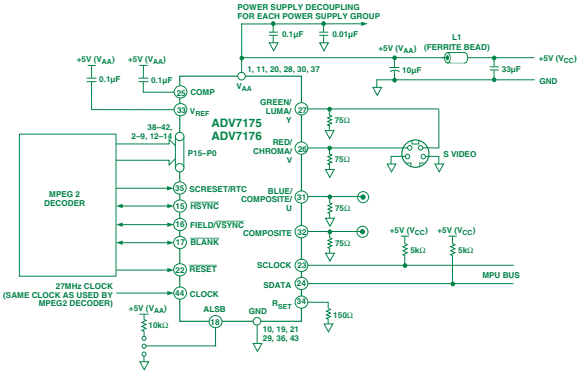


Figure 4. Connection to MPEG decoder.

The ADV7175/ADV7176 is the industry's most comprehensively specified part in terms of functionality, features and performance. Its differential gain (0.8%) and –phase (0.8°) specs are suitable to benefit consumer video applications, and to provide professional studio and broadcasters with a low-cost, highly integrated video encoder. For the benefit of professionals, the part is configurable to output their usual analog YUV format.

Video quality: Performance features also include on-board color enhancements technology, including 2× oversampling, luma low-pass filters, and notch chroma filtering. Oversampling (2 × 13.5 MHz) reduces the requirements on any external low-pass filtering by shifting the out-of-band signals up the spectrum, permitting a lower-order external filter. Figure 5 shows a vectorscope plot of the device output. The proximity of the vertices to the centers of the square boxes, and the linearity of the lines between the vertices, illustrate the device's performance, including the ability to reproduce the required color output values.

Additional features: Also supported are other key functions, programmed via the 2-wire serial (I^2C-compatible) MPU Port.

- *Square Pixel:* in addition to the standard CCIR-601 pixels, square pixel mode is needed to ensure correct aspect ratio when displaying computer-generated images, using a standard TV screen as a computer monitor.

Required sampling frequency	Format	Pixels/line
13.5 MHz	CCIR601 (NTSC/PAL)	720
12.27 MHz	NTSC Square Pixel	640
14.75 MHz	PAL Square Pixel	768

- *Genlock/RTC:* Enables coherent synchronization between two color sub-carrier frequencies of simultaneously displayed video signals (necessary to maintain backward compatibility for simultaneously transmitted traditional analog TV signals)
- *On-board color bar generator:* For system test/diagnostics
- *Programmable luma delay* (for CVBS signal to RF tuner)
- *Closed captioning:* Legal requirement to provide support to display subtitles on television programming
- *VBI (Vertical blanking interval) passthrough:* The VBI consists of transmitted lines with no video information. Not only is it used to transmit teletext data, closed caption data and test/control bits; this portion of the video signal is also being deployed to deliver Internet or Web Page data to the TV viewer
- *Programmable frequency and phase:* Ensures that all terrestrial variants of PAL and NTSC can be configured.

Thermally enhanced packaging: Fitting such functionality into a tiny 44-lead PQFP package demands advanced techniques in both chip and package design. The device is specified, worst case, to drive full video outputs from all four DACs without needing external buffering. Advanced current switching techniques, which minimize dissipation during the display of low brightness scenes, coupled with a patented thermal-coastline lead-frame design within the package, ensure that the complete functionality of the part is made available to the user in all environmental conditions. Additional programming, allowing the selective turning off and on of each of the 4 DACs, offers yet more configuration options to minimize total power consumption.

Though specified to run from 5-V supplies, measured data shows that it will satisfy the video specs with negligible degradation at 3.3 V. The ADV7175/76 is available from stock. An evaluation board can also be ordered. Device prices (10,000) start at $7.59.

The ADV7175 was developed in Limerick, Ireland, by a cross-functional team led by Joe Canning, Colin Prendergast, and John Purcell. A

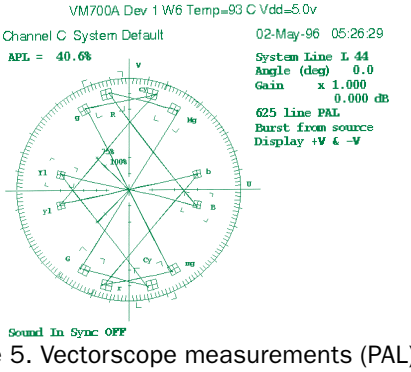


Figure 5. Vectorscope measurements (PAL).