

edu Guide

An educational resource published by Communications Specialties, Inc..

HDTV Standards and Practices for Digital Broadcasting

A look at the SMPTE standards that define SD, HD and Fiber Optic Signal Distribution, what the standards mean, and why they are important to you.



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edu Guide

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Introduction

This eduGuide is intended for the video professional that is starting to become involved with designing, specifying, operating or maintaining digital video broadcast and distribution systems for HDTV. For over 50 years our industry has used television technology of a primarily analog nature. True, some digital technology has been used in broadcast facilities for standard definition or NTSC and PAL systems, but its deployment has been limited and ultimately converted back to an analog signal for distribution and broadcast.

Today, HDTV is the first broadcast technology designed to be exclusively digital from image capture to display on the consumer's TV set. Many different technologies are used where the video, and audio, undergoes many transformations from start to finish. This eduGuide will help you to understand the chain of technologies used, the industry standards behind them, for both copper and fiber optic distribution, and the practices video professionals are developing for the new world of HDTV.

The Role of Technical Standards

The broadcast industry, unlike the A/V and computer industries, has historically been a proponent and practitioner of technical standards for video and audio processing and distribution. The reason is simple: interoperability. The broadcaster, and those in related professional video industries, need to be able to select the best equipment for the task at hand. Since all the equipment in a distribution or edit suite will need to process the same video and audio, there is a need to define and adhere to interface standards between the various pieces of equipment.

There are several technical standards organizations in the world that develop and promote these standards but perhaps the most noted is SMPTE. The Society of Motion Picture and Television Engineers (SMPTE) has membership and participation from individuals, broadcasters and equipment manufacturers from around the world. The expertise and experience brought to bear by this group creates a forum for developing very powerful and lasting standards.

The buyer and user of broadcast equipment is the ultimate beneficiary of this process. He can be assured that products compliant with a particular set of standards will allow video and audio signals to be communicated between them in a recognizable way without requiring additional processing or interfacing. The benefit to the user is lower design and operational costs and a wider selection of equipment to choose from for a particular application without being locked in to any one equipment manufacturer employing proprietary interfaces and protocols.

SDTV Standards for Video

We will begin our discussion of HDTV standards with a review of Standard Definition (SD) standards. It is from these SD standards that the HD standards were developed. For over 50 years, the transmission of television video and audio was done in an analog fashion. Worldwide analog standards included NTSC, PAL and SECAM with varying amounts of active scan lines, spatial timings and color encoding schemes.

A need arose to create standards for a digital representation of these analog TV systems in order to facilitate editing, recording and complex routing without degrading the original material. It was also important to insure that these new digital standards would be compatible with the analog standards to facilitate transcoding and eventual broadcast to consumers without obsolescing their TV sets.

Several standards were developed to digitally represent SD video:

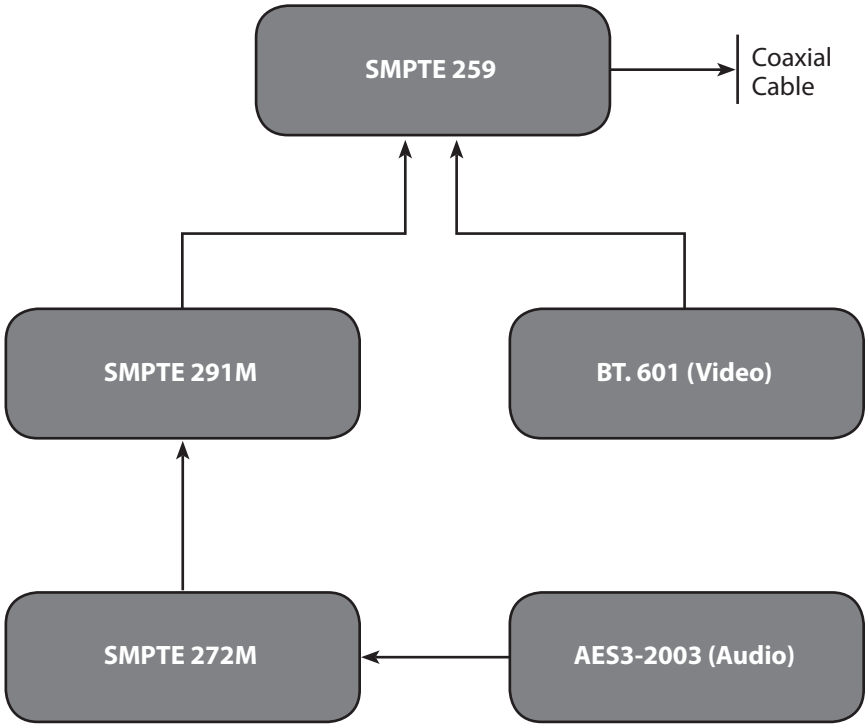
ITU-R BT.601 (a.k.a “601”): This standard defines how video luminance and color information is digitized. It defines the range of binary values for 8 and 10-bit quantization of luminance and the two color difference signals that together define the brightness, color saturation and color hue of the video. It is used to quantize both the NTSC and PAL SD timings. Luminance is sampled 720 times per horizontal line and color is sampled 360 times per line. Keep in mind that 601 only defines the spatial sampling and not any physical interface. 601 can be communicated in a bit-parallel or bit-serial manner. The latter being the most popular, which uses the SMPTE 259M standard.

SMPTE 259M-2008 (a.k.a. “SDI” or “259”): When 601 is bit-serialized and transmitted over a copper interface it is done according to the SMPTE 259M-2008 standard. SDI is the abbreviation for Serial Digital Interface. In general, the term SDI can refer to any television standard that is digitized and then serially transmitted and, up until recently, only referred to SD resolutions. However, with HDTV in more common use, we now refer to the standard definition version of SDI as SD-SDI. 259 defines important parameters of the serial digital signal such as bit jitter, data rate, rise and fall time, signal amplitude and connector impedances.

AES3-2003 (a.k.a “AES Audio”): When analog line level audio is digitized, it is done according to the AES3-2003 standard. The AES Audio standard defines the number of bits the audio is quantized into and the sampling rate of the quantization.

SMPTE 272M-2004 and 291M-2006: SMPTE 272M-20004 defines how the AES Audio bits are mapped into another standard called SMPTE 291M-2006. 291M defines how audio, ancillary data and synchronization information is encoded within the SMPTE 259M standard and other high definition and cinema standards.

How the SMPTE SDTV Standards Combine:



HDTV Standards for Video

The standards for HDTV have many roots. Early HDTV standards go back to the 1980s when HDTV was defined using analog techniques. But today, HDTV is primarily a digital technology using an array of standards for both video and audio.

Video HDTV standards define both the color gamut and spatial resolution of the image. Color gamut, the array or palette of colors that are possible and valid for a video signal, is different in HD than in SD television allowing for slightly deeper green and red hues.

ITU-R BT.709 (a.k.a. “709”): This standard defines how video luminance and color information is digitized for HDTV. It defines the range of binary values for 8, 10 and 12-bit quantization of luminance and the two color difference signals that together define the brightness, color saturation and color hue of the video. It also defines the algebraic formula matrix for converting from RGB color space into luminance and color difference signals. These formulas vary slightly from the “601” formula matrix. The actual number of samples per line will vary depending on the spatial resolution of the HD format being used.

SMPTE 274M-2008: This HD standard defines the 1920x1080 spatial resolution (image sample structure) and several frame rates for this resolution. 1920 pixels define the active number of pixels per line and 1080 lines are the active number of lines per frame. Frame rates can be either interlaced or progressive. Special consideration is given to NTSC frame rate compatibility by defining 60, 30 and 24 hertz frame rates which are divided by 1.001. This allows genlocking HD signals to NTSC references and is in common use in NTSC facilities.

SMPTE 296M-2001: This HD standard defines the 1280x720 spatial resolution at various frame rates. All frame rates are progressive only. There are 1280 active pixels per line and 720 active lines per frame. Special consideration is given to NTSC frame rate compatibility by defining 60, 30 and 24 hertz frame rates which are divided by 1.001.

SMPTE 240M-1999 and 260M-1999: These two HD standards describe a HD spatial resolution consisting of 1125 total lines per frame of which 1035 lines are active. The 240M standard defines the analog representation of the signal and 260M defines the digital representation. In both cases, an interlaced frame is used with a vertical sync frequency of either 60 hertz or 60/1.001 hertz to match NTSC. Also, these use the 601 color space conversion matrix and not the 709 matrix. When the 260M analog representation is digitized according to 260M, it can be quantized into either 8 or 10 bits per pixel. There are 1920 active pixels per line.

SMPTE 292-2008 (a.k.a. “HD-SDI” or “292”): This standard defines how the signals defined by 274M, 296M and 260M are transmitted in a bit-serial

fashion at an approximate data rate of 1.5 Gbps over coaxial cable. It does not define the resolution of the video image defined in other standards, including those for audio and data embedded within the video, but rather how they are to be communicated. SMPTE 292 is just a transport stream and physical layer interface definition for coaxial cable. Please note that 292 only supports 1080i (interlaced) frames at 50, 59.94 and 60 Hertz on a single 292 interface. In order to support 1080p (progressive) frame rates 50 Hertz and above, either two 292 interfaces must be used in parallel, as defined by SMPTE 372M, or one SMPTE 424 interface can be used. 292 and 424 define important parameters of the serial digital signal such as bit jitter, data rate, rise and fall time, signal amplitude and connector impedances.

SMPTE 424M-2006: This standard defines the bit serial structure using a coaxial interface at a nominal bit rate of 3 Gbps for component digital video and other packetized data. The actual data rate used is either 2.97 Gbps or 2.97/1.001 Gbps with the later being used to synchronize to NTSC references. The significance of this standard is that it defines how 1080p at frame rates from 50 to 60 Hertz are to be transmitted over a single coaxial cable. This standard is now gaining in use instead of the 372 standard as it requires only one signal path.

Ancillary Data Packets

Audio data, format ID and time code are just some of the information types that can be accommodated within both SD and HD standards. Data for this information is inserted into the streams during the horizontal and vertical blanking times of the image raster. Here is a brief look at some of the SMPTE standards for this information:

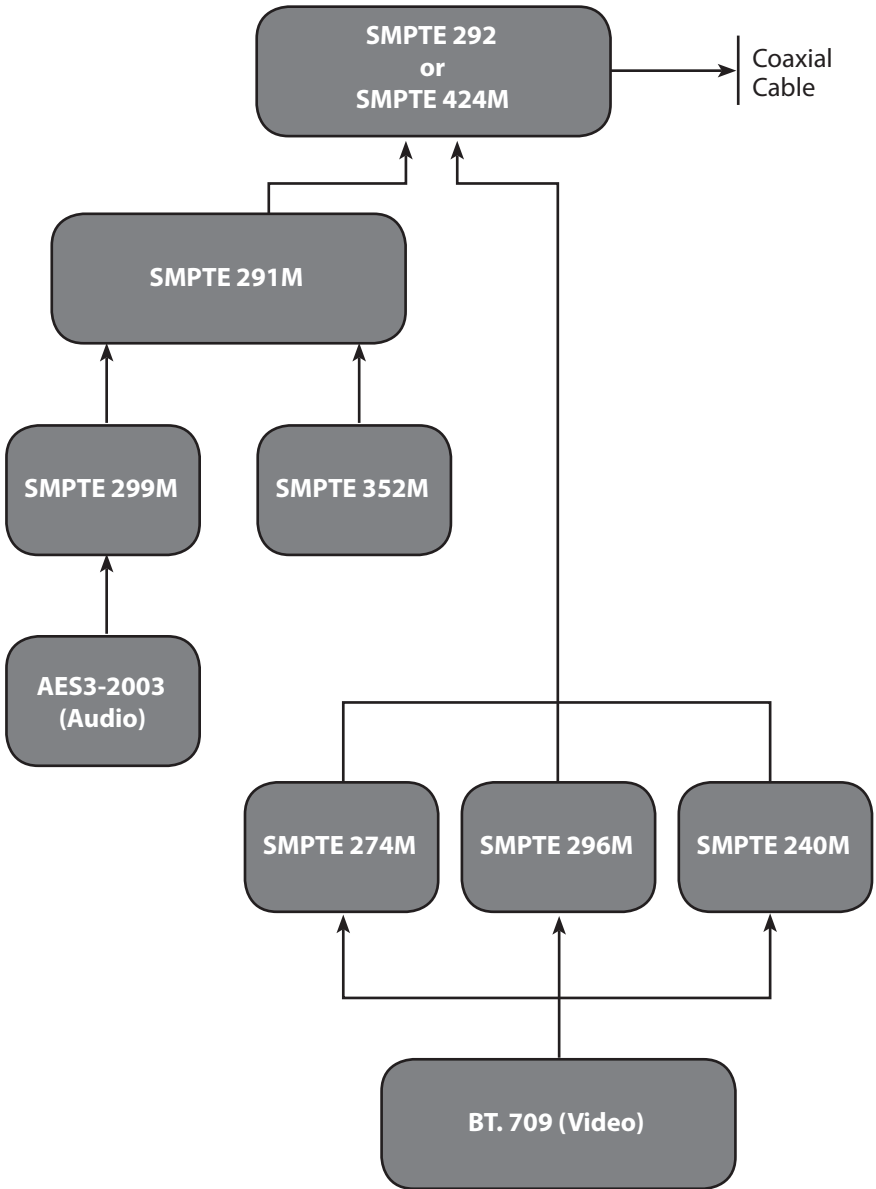
SMPTE 291M-2006: This standard describes the basic formatting structure of an ancillary data space for insertion into 259 and 292. The ancillary data packets that can occupy this data space can contain audio, data, time code, program ID information or other data. Think of 291 as a basket into which we can place various information for transport. The 291 basket can then be carried by various means, such as 259 and 292.

SMPTE 299-2009: This standard describes how 24-bit AES audio is mapped into the 291 data space for use with a 292 HD-SDI signal. Audio channels are transmitted in groups of four up to a maximum of 16 audio channels. A 48 kbps sample rate is used. Using this standard with 292 is often referred to as “embedded audio”.

SMPTE 352M-2002: This standard defines the video payload identifier information. It is a 4-byte identifier that may be added to 291 to identify the video signal being transmitted in 259 or 292.

The chart on the following page shows how these standards combine:

How the SMPTE HDTV Standards Combine:



Fiber Optic Transport of 3G/HD/SD-SDI

It is becoming increasingly necessary and economically feasible to transport 3G/HD/SD-SDI signals over fiber instead of coaxial cable. The reasons are m0ds were used to define how SDI signals were to be transported over fiber. Now, there is one standard to define the many aspects and parameters of the fiber optic interface for the transmission and reception of SDI over fiber.

SMPTE 297-2006: This standard defines the fiber optic interface for the transmission and reception of SDI signals at various data rates:

SMPTE 259M:	143 through 360 Mbps
SMPTE 344M:	540 Mbps
SMPTE 292:	1.485 and 1.485/1.001 Gbps
SMPTE 424M:	2.97 and 2.97/1.001 Gbps

SMPTE 297-2006 defines many parameters of the optical interface for both a transmitting and receiving device with a fiber optic interface. The input to a fiber Transmitter can be any one of the SMPTE coaxial-based standards indicated above. On the Receiver, the output will be of the same coaxial interface type of the Transmitter. The significance of the new 297 standard is that it allows for interoperability between fiber optic devices from different manufacturers that comply with the standard. Historically, fiber optic interfaces for the transmission of video and audio used proprietary protocols and optical interfaces which required that both the Transmitter and Receiver be purchased from the same manufacturer. When using devices that are compliant with the new 297 standard this is no longer required.

The Fiber Optic Transmitter: SMPTE 297-2006 defines many parameters for the optical output of the Transmitter. Among the most important are:

Optical Connector: The LC connector is the preferred connector with a PC polish to the tip of the connector. Other connector types are optional but as a practical matter, the Broadcast industry is embracing the LC connector.

Optical Power Output: The standard recognizes that fiber will be used for various transmission distances and classifies Transmitter optical power into Low-power, Medium-power and High-power categories. Low-power Transmitters must support both single mode and multimode fiber types whereas Medium and High power Transmitters need only support single mode fiber. The maximum and minimum Transmitter output power is specified for each category.

Transmitter Product Labeling: Because transmitters and receivers from different manufacturers that comply with this standard can be interfaced to each other, a standardized product labeling scheme is defined within SMPTE 297. The labeling scheme defines the power category of the transmitter, the polish of the connector, the SMPTE coaxial interface standards supported and the optical wavelength of the output. It should be noted that a SMPTE 297-

2006 Transmitter need not support all possible data rates.

The Fiber Optic Receiver: SMPTE 297-2006 also defines the optical properties for the input to the Receiver.

Optical Connector: The LC connector is the preferred connector with a PC polish to the tip of the connector. Other connector types are optional but as a practical matter, the industry is embracing the LC connector.

Supported Data Rates: A compliant Receiver can support any or all of the data rates specified by the four electrical interface standards cited above.

Optical Receive Power: The standard specifies the minimum optical input power a compliant receiver must support for the various data rates. A receiver can be more sensitive, that is capable of accepting a weaker optical signal, than the standard specifies. Also, the standard states the minimum optical power that a receiver must accept before going into saturation (overload). Note that this is independent of the wavelength and fiber cable type used.

Receiver Product Labeling: The labeling scheme for the Receiver indicates the type of polish used on the input fiber connector, the SMPTE coaxial standards supported and the range of wavelengths supported at the optical input.

Optical System Specifications: In addition to specifying the Transmitter and Receiver interfaces individually, SMPTE 297-2006 gives guidance on how a compliant Transmitter and Receiver should work as a system pair. Among the parameters specified are:

The minimum optical loss budget allowed based on the fiber type used, the power rating of the Transmitter and the operating wavelength of the Transmitter.

The minimum expected transmitter distance is also specified based on the same parameters. However, it should be noted that depending on exactly how the fiber cable is installed, i.e. how many splices and patch panels are used, the minimum transmitting distance may not be achieved even though the optical loss budget is not exceeded. This is especially true when multimode fiber is used as optical dispersion in the fiber will result in very poor bandwidth.

Although not stated in the SMPTE standard, it has been the experience of CSI to recommend the use of single mode fiber for SDI transmission of video signals. This ensures minimum optical signal loss, maximum transmission distance compared to multimode fiber and the ability to multiplex multiple optical signals onto one fiber with ease.

How the SMPTE Transport Standards Combine for a Fiber Optic Interface

Other issues in the eduGuide Series

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Examines how transmitting digitally over fiber are accomplished, the phenomenal results it achieves, and how cost-effective it is.

Fiber Optic Cables, Connectors and Integration

Learn how easy it is to terminate and fabricate your own fiber optic cables, what types of fiber and fiber jackets are available and how to design and integrate a fiber optic system.

Scan Converters Buyer's Guide

Everything you need to evaluate and decide on the perfect Scan Converter.

Video Scaling

A comprehensive overview of the technology, how it works and when to use this technology effectively.

Advanced Video Scaling

Easy explanations of Inverse 3:2 Pulldown, Anamorphic Scaling and Other Confusing Concepts.

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About Communications Specialties, Inc.

Communications Specialties, Inc. (CSI) is an award-winning, Long Island based company that manufactures and sells a variety of products for the distribution, conversion or transmission of television and computer video signals, including fiber optic transmission systems, scan converters and video scalers.

The company was founded in 1983 by veterans of the broadcast industry. Since then, CSI has managed to consistently design innovative products that are used worldwide by Fortune 500 Companies and Government Agencies in a variety of markets such as Broadcast, Professional A/V, Videoconferencing, Education, Home Theater, Security, ITS, Industrial Monitoring, Digital Signage, Government/Military and more!

The **Pure Digital Fiberlink**[®] line offers an extensive and affordable family of fiber optic transmission systems for the Professional A/V marketplace and includes several ground-breaking products for the transmission of high-resolution RGB signals. Systems for point-to-point and point-to-multipoint signal distribution make these products highly desirable for any Pro A/V applications.

Our premier product line, the **Scan Do**[®] family of computer to video scan converters, has redefined industry standards in computer video to NTSC/PAL technology with unsurpassed performance in its price range. All models support high resolutions and refresh rates and are VGA and Mac[®] compatible. The feature-rich and versatile Scan Do family offers the widest range of scan converters on the market.

The award-winning, **Deuce**[®] video scalers convert NTSC and PAL to high-resolution, non-interlaced video and offer a far superior and affordable alternative to line doubling and quadrupling. The new generation of Deuce products offer a wide range of non-interlaced resolutions and refresh rates for every application, from professional A/V installations to home theater, including a model designed especially for use with HDTV displays.

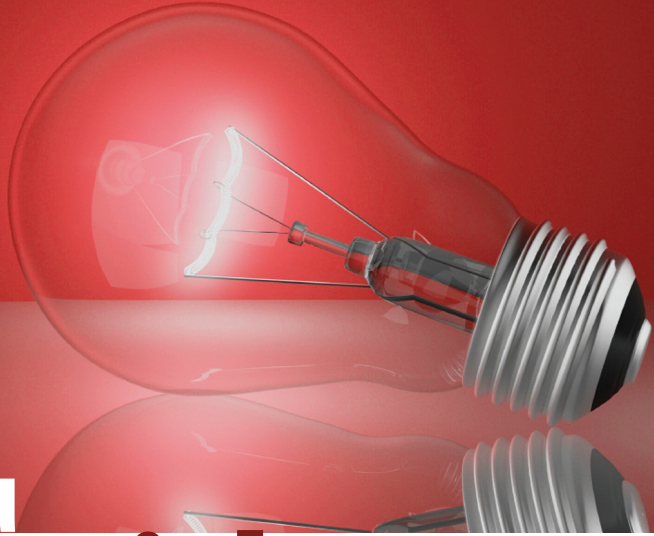
In addition, CSI manufactures a comprehensive selection of distribution amplifiers, VGA monitor, keyboard and mouse extenders and accessories for our entire product line.

Communications Specialties and its products have been the recipient of numerous industry awards. In 2005, the Pure Digital Fiberlink® 7220 Series for high-resolution RGB and Stereo Audio was honored as one of the AV industry's best technological innovations of the year by receiving a "rAVE Radical Product of the Year" award as "Best New Analog Signal Processing Product". The rAVE email newsletter is published by professional audiovisual industry veterans and is read industry-wide.

Among CSI's many other awards are AV Video Magazine's Platinum Award (given to Scan Do® Ultra and Deuce®) and the Video Systems' Vanguard Award (given to Deuce).

The company is headquartered in the United States on Long Island, New York, with Sales Offices in Florida, Indiana and Virginia. Research, development, design, engineering, manufacturing and customer support operations are performed at the New York headquarters. Other locations include Communications Specialties Pte Ltd (CSPL) - a wholly owned subsidiary office in Singapore that provides support to distributors in the Far East and Pacific Rim.

Our in-house sales department handles complete product-line sales directly to end-users as well as to an international network of representatives and resellers. All of our products are backed by an exceptional warranty.



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