DigiPoints

The Digital Knowledge Handbook

Volume III, Issue 2 April 1999

Inside

History of Analog TV Signal Formats

Digital TV Defined

How Digital TV Works

Impact on Cable Systems

How Digital TV Will Affect Cable's Technical Personnel

Conclusion

Learning Just Enough to Be Dangerous: Glossary

Testing Your Knowledge

Answers to Issue 3-1 Questions

©1999 by the Society of Cable Telecommunications Engineers Inc. All rights reserved.

DigiPoints is published monthly by the Society of Cable Telecommunications Engineers, 140 Philips Road, Eaton, PA 19341-1318, 610-363-6888, April 1999, Volume III, Issue 2. Office of publication is 140 Philips Road, Exton, PA 19341-1318.
Developed by KnowledgeLink Inc.
Editor: Marvin Nelson, BCE, SCTE

Digital TV

By now you have heard about the dawning of digital television (DTV). It is heralded as the beginning of a new era, and the end of the analog world, at least from the broadcaster's point of view. One problem, however, is that the general public, and even technical people in the cable telecommunications industry, have different definitions of "Digital TV." The technology currently being publicized in the media as digital TV really consists of two parts: the digitization of program content, and a new viewing format. This issue will discuss both parts, to develop an understanding of how the viewing format works together with content digitization to create "Digital TV."

History of Analog TV Signal Formats

Television technology in the United States for the past half-century has been based on standards developed by the National Television Systems Committee (NTSC) in the 1940s. NTSC standards evolved as a combination of existing standards for motion picture and photographic images,

experiments with human perception of motion and video quality, and scanning technology, both currently available and predicted. Key elements were the ratio of image width to height (aspect ratio), the average distance between a viewer and the TV set, the possible number of lines in a scan of an image, and the method used to scan. With the available technology, the resulting video standard emerged as an analog signal that occupies 6 MHz of channel bandwidth in the RF spectrum. The resultant signal creates a television picture by interlacing two fields of 262.5 lines of video 60 times each second. The original NTSC signal only contained specifications for a black and white image.[1]

The motion picture industry has influenced television since the beginning of TV. The NTSC aspect ratio, for example, dates back to experiments by W.K.L. Dickerson in 1889 in Thomas Edison's laboratories. Dickerson's Kinescope used film that was 1-inch wide with frames 3/4-inch high. The resulting image has a 4:3 aspect ratio. This film size became the standard for both film and the motion picture industry that grew from it. Early television engineers adopted the prevalent standard, which had the advantage of being familiar to consumers from both photography and the movies. As television grew in popularity, the motion picture industry created the "wide-screen" format to gain back audiences. The wide-screen format used in motion pictures is closer to our normal field of vision. It, therefore, makes audiences feel more a part of the screen image. We will see later in this issue that one standard for High Definition TV (HDTV) is based upon the average "wide-screen" 16:9 aspect ratio.

Understanding the evolution of the scanning rate and the proposed new rates for digital TV requires understanding how TV scanning works. An image is created by scanning the object or scene to be viewed one line at a time from the top of a picture to the bottom at a predetermined scanning rate. The result, a complete picture, is called a frame. In NTSC video, the entire frame is not created with one scan. Instead, each frame is comprised of two fields that are interlaced together as odd and even lines in the frame. This two-field system was developed for at least two reasons. First, the early picture tubes had phosphors (the chemical on the inside of the tube that emits light when bombarded by the electron stream from the neck of the tube) that were unable to emit a constant level of light long enough to eliminate a flicker in the screen image. Secondly, a system was needed to create an illusion of continuous motion by repeating a succession of slightly different still images at a rate fast enough to make the motion appear smooth. The interlacing of two fields, each scanned at 60 times per second, is a way to realize the benefits of full-image repetition at 60 times per second, far above the flicker perception level.

Early designers experimented with the number of lines that would be needed to provide reasonable resolution and settled on 525 lines as the United States standard. In Europe, most of Asia, Africa, and South America, 625 lines was chosen as the PAL standard. Yet another standard, SECAM, has been used in the former Soviet Union and a few other countries. As discussed in the last issue of *DigiPoints*, only 484 of the 525 NTSC-specified lines are used for actual video or picture information.[2]

1 For those interested in a detailed derivation of the bandwidth needed for an NTSC signal, *Modern Cable Television Technology*, by Walter Ciciora, James Farmer, and David Large, p. 72, contains a description of all the factors involved in the calculations.

© SCTE

As the technology became available, color information, or chrominance, was added to the black and white (luminance) picture. In the 1960s, NTSC was updated to include color with the addition of a subcarrier. The use of this subcarrier maintained backward compatibility with a fast-growing black and white television base. However, this method of adding color was only accomplished with several compromises. The color information creates the potential for imperfections that must be dealt with. The filtering and other techniques used to reduce these imperfections can be complicated and expensive.

An in-depth discussion of how color is transmitted is beyond the scope of this document. Interested readers are encouraged to read about this topic further in *Video Engineering*, by Andrew K. Inglis and Arch C. Luther.

In the 1970s, the NTSC standard was improved further with the addition of multichannel sound, including stereo and a SAP (second audio program) channel. An additional provision for closed captioning was added to the NTSC standard in the late 1980s. In the 1980s, attempts were made to modify the standard for video improvement. However, it became too difficult to further modify NTSC, and it was decided to pursue a new standard for television in the United States. Terrestrial bandwidth is at a premium, resulting in channel assignments in geographic markets where interference from transmitters in different cities can degrade quality. Increasingly less expensive and larger screen televisions populate households, further exposing the NTSC limitations as various artifacts, such as crawling dots or fluttering lines, become more apparent.

Digital TV Defined

Digital TV has become the generic term given to digital television technology. The term has come to be associated with all new technology that is digital and video. This is not technically correct, for it should be noted that digitized video and audio have been a part of the production and editing arenas for a number of years. The need to produce and preserve very high quality recorded material has driven the need for digital media at the source. Broadcasting, however, has remained an analog technology, as has the reception of the signal by millions of analog television sets. Now an impetus similar to that experienced in the production arena is occurring in broadcasting, this time driven by the need for more subscriber-accessible features and the need for more program spectrum.

The FCC is accelerating the move toward digital TV broadcasting. In 1998, it gave UHF spectrum to broadcasters free of charge to use for transmission of digitally coded programming. In return, the broadcasters were to adhere to a timetable that phases out analog broadcasting by the year 2006. During the transition period, broadcasters are to transmit programming in both the analog and digital formats, beginning with defined major markets. After 2006, the analog

2 Another interesting historical tidbit is that NTSC TV is designed for a 5-to-1 viewing distance. That is, the picture that results from the NTSC scanning resolution has the best perceived quality when viewed at a distance five times the height of the picture.

© SCTE

spectrum is to be returned to the government for other use, leaving digital broadcasting as the only alternative.

Digital Viewing Formats

Digital broadcasts will be transmitted in either High Definition Television (HDTV), or in Standard Definition Television (SDTV) format. HDTV signals result in a resolution of approximately twice that of an analog NTSC signal in both the horizontal and vertical planes. HDTV also has an aspect ratio of 16:9, which is 30 percent wider than NTSC, and approximates the same format as wide-screen movie theaters and the human eye. The horizontal resolution is defined by the number of pixels, or digital samples, per line, and the maximum is 1,920 compared to 720 for NTSC. The frame rate, or the number of individual frames of information per second, is defined from 24 to 60 per second. Lastly, the scanning formats can exist as either progressive, as used in computer monitors, or interlaced, as in current NTSC. Various frame rates and scanning formats are necessary to accommodate the wide variety and interoperability of various media.

SDTV formats are similar to the current NTSC format, although they provide digital quality and utilize a wider range of format combinations. These include both 16:9 and 4:3 aspect ratios, and various frame and scan rates. Vertical resolution remains at 480 lines. Horizontal resolutions are either 640 or 704 pixels. There are 18 formats in all, six for HDTV and 12 for SDTV, including four for computers. Table 1 lists them all, with the shaded area identifying HDTV formats. Broadcasters must choose which format they are going to use to deliver their programming. The dilemma for consumer product manufacturers and cable operators is that their equipment must be compatible with multiple formats.

Vertical Resolution (Scanning Lines)	Horizontal Resolution (Pixels)	Aspect Ratio (H/V)	Frame Rate (Hz)	Scanning Format
1,080	1,920	16:9	60	Interlaced
1,080	1,920	16:9	30	Progressive
1,080	1,920	16:9	24	Progressive
720	1,280	16:9	60	Progressive
720	1,280	16:9	30	Progressive
720	1,280	16:9	24	Progressive
480	704	16:9	60	Interlaced
480	704	16:9	60	Progressive

© SCTE

480	704	16:9	30	Progressive
480	704	16.9	24	Progressive
480	704	4:3	60	Interlaced
480	704	4:3	60	Progressive
480	704	4:3	30	Progressive
480	640	4:3	24	Progressive
480	640	4:3	60	Interlaced
480	640	4:3	60	Progressive
480	640	4:3	30	Progressive
480	640	4:3	24	Progressive

Table 1: DTV Formats

Digital TV Parameters

The question could be asked, “Why so many formats?” To answer this question requires an expanded discussion of some terms.

Scanning Lines

The horizontal resolution is measured in lines of scanned information. Two formats are included in the standard. One method, interlaced scanning, was described earlier. Interlaced scanning preserves bandwidth while reducing flicker. The field rate is 60 fields per second, which is double the perceptible flicker rate of approximately 30 frames per second. However, electrically, the signal only requires the bandwidth of a 30-frame-per-second scan, because even and odd fields each take one-half the scan time.

The other method is to progressively scan from the top of the frame to the bottom, each line in sequence to the next. This is the method used for computers and requires more bandwidth. It also requires a higher frame rate to reduce flicker because now there is only one field per frame. The computer industry has chosen progressive scan because it provides a better quality image for characters and still graphics than interlaced scan at the same lines of resolution. Motion, on the other hand, requires either a faster scan rate (with associated higher bandwidth requirements) or interlaced scanning to achieve a non-flickering image. In computers, higher scan rates require faster processors and more memory. Given the improvements in both processor speed and memory costs in the past few years, it should not come as a surprise that the computer industry

© SCTE

accommodates progressive scanning better than its video counterpart, which needs to contend with broadcast spectrum constraints as well as memory and storage. Improved manufacturing processes and chemical improvements with the phosphors used in picture tubes are also contributing to the movement toward more progressive scan systems.

Pixels

A pixel (picture element) is the smallest element of a picture whose properties can be defined separately from adjacent areas. A pixel can be defined in various ways depending on the actual system being discussed. For example, the number of pixels in a horizontal line of analog video is determined by the half cycle of the highest transmitted video frequency. An NTSC broadcast video signal contains approximately 152,000 pixels, and a common format of HDTV may contain as many as 1,162,000 pixels.[3]

Aspect Ratio

One of the early target applications for HDTV is to be able to bring theater-quality presentation of movies to the consumer's home viewing area. The ratio of width to height for HDTV is 16:9, or 1.78:1. This is very close to what is used for movies (1.85:1 or greater). For NTSC, the ratio is 4:3, or 1.33:1. To show a motion picture on an NTSC screen requires either cropping the right and left sides of the picture, or showing an image with black bars on the bottom and top of the screen (called "letter boxing"). Cropping removes video information from the sides of the picture and decreases the viewing experience, while letter boxing fails to use the available vertical resolution.

Frame Rate

Several frame rates are written into the standards for digital TV. The slowest is 24 frames per second and comes from the movie industry. The standard video rate is 30 frames per second, which is the carryover rate from NTSC standards. A higher rate, 60 frames per second, is used for live transmissions, where action increases the need for faster capture of more information. The frame rate is part of the perceived quality of the image. If you combine the horizontal and vertical resolutions, a higher frame rate provides new information more frequently, with interlacing providing the most frequently updated information (at twice the progressive rate).

It is possible to convert frame rates between source, transmission, and display of data. For example, movie film is shot at 24 frames per second, which by itself would cause the appearance of flicker. Movie projectors show each frame twice, making the effective frame rate 48 frames per second. When a film source is converted to a videotape at 30 frames per second, it uses a

3 Andrew F. Inglis and Arch C. Luther, *Video Engineering*, second edition.

© SCTE

technique called 3:2 pulldown. This technique repeats the first of the two interlaced fields every other film frame (see Figure 1).[4]

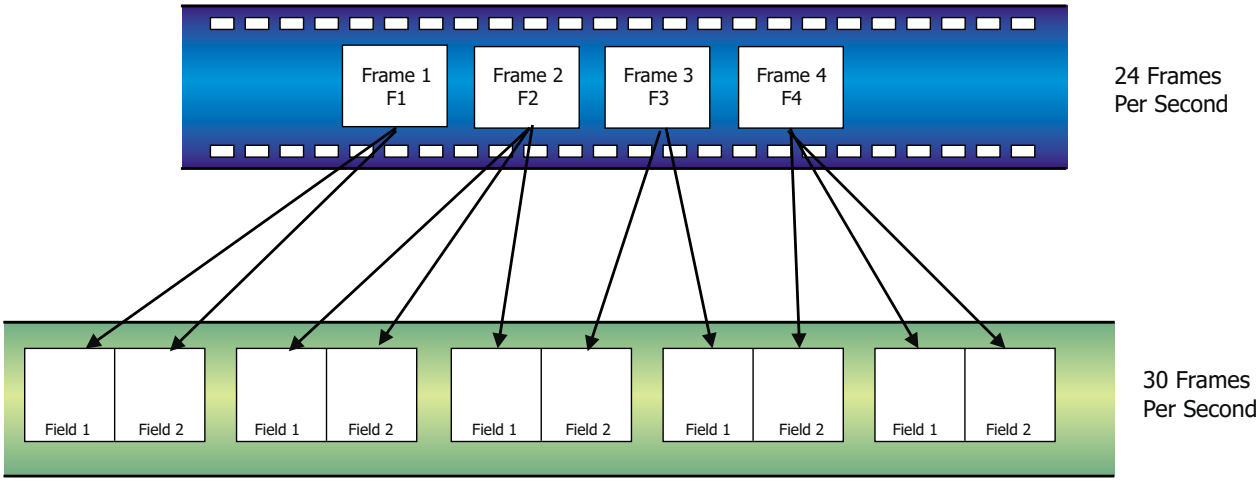

Figure 1: Telecine Conversion Process

The scan rate can also be changed from the transmitted program data. Frame stores are a way to convert programming by repeating and injecting scan lines. This is the method used to display NTSC video on 1,080-interlaced, large-screen monitors.

Audio

Audio format is another facet of DTV. Currently, NTSC broadcast only provides Multichannel Television Sound, or MTS, which allows for two channels of stereo information, and a SAP, or Second Audio Program. DTV encoding utilizes Dolby AC-3 audio compression, providing a 5.1-channel surround-sound. The “5.1” channels really are 6 separate channels, with the last channel having a narrower bandwidth. Specifically, the first five channels are the front left and right, center, and surround left and right. The 0.1 channel carries information for a very low frequency, non-directional subwoofer.

Video Signal Digitization

Digital video treats luminance and chrominance similarly to the way they are handled in analog. As with analog, there are three components or samples: one luminance and two chrominance. The way the components are converted to digital is specified by the sampling method. The most widely used digital component video sampling format is ITU-R BT.601, also known as CCIR Recommendation 601, or simply Recommendation 601. This specification evolved from a joint

4 The April 1998 issue of *Communications Technology* magazine contains an excellent article by Richard S. Prodan on progressive vs. interlaced scanning formats that discusses scanning and resolution in detail.

SMPTE/EBU task force to determine the parameters for digital component video for both 525-line, 59.94-Hz NTSC video, and 625-line, 50-Hz PAL video. Differences between NTSC and PAL are resolved in another specification for the electrical interfaces and for the data produced by the sampling (SMPTE Standard 125M for NTSC).

Recommendation 601 uses a 4:2:2 sampling structure with co-sited samples. Co-sited means that each color pixel is described by three samples, which are coincident in time. The 4 in 4:2:2 represents the multiplication by four of the subcarrier sampling frequency used in composite digital systems. In actuality, the sampling rate for luminance is 13.5 MHz. The number 4 is based on the 14.3 MHz NTSC sampling frequency that was once under consideration. Each 2 in 4:2:2 represents the 6.75 MHz sampling rate for each of the color difference signals, Cb and Cr. A lower sampling rate of the chrominance component is acceptable because of the lower color resolution of the human eye.[5]

Most digital video signals are created from analog signals by applying the three steps of analog-to-digital conversion: sample, quantize, and encode. Recommendation 601 describes an analog-to-digital conversion for a composite video signal consisting of two chrominance components and one luminance component. With 256 quantizing values and eight-bit encoding, the uncompressed bit rate requirement is 217 Mbps or more than six standard 6-MHz video channels![6] Fortunately, MPEG-2 compression can reduce that requirement substantially.

Standards

The DTV standard that is being implemented is the result of more than 12 years of research, development and negotiation. In an effort to improve the quality of broadcast television viewing, a group of individuals representing manufacturers, broadcasters and researchers came together in the Grand Alliance to develop digital HDTV systems. The Grand Alliance recommendations were then standardized by the Advanced Television Systems Committee (ATSC). The result is a viewing experience comparable to 70-mm movies and CD-quality sound. The building blocks described by the standard are:

- Video signal format and source coding, which is based on the MPEG-2 compression technology and a motion-compensated algorithm. The nominal data rate is 19 Mbps.
- Audio signal format and source coding, which uses the Dolby Digital Audio Compression (AC-3) standard and provides 5.1 channels of surround-sound using a 384 Kbps data rate. Multiple audio channels are possible for language and hearing-impaired usage.

5 More details of digital television signal processing and compression of video signals can be found in *DigiPoints: The Digital Knowledge Handbook*, Volume One, by Justin Junkus and Michael Sawyer, chapter 8. This text is available through SCTE.

6 The details of this calculation may be found in the article by Kenneth H. Metz, *Communications Technology* magazine, June 1998.

© SCTE

- Transport and Service Multiplexing, which is the packetized data transport system for combining the video, audio and data. Based on the MPEG-2 standard, packets are 188-bytes long, which includes a 184-byte payload.
- RF/Transmission subsystem, which refers to the channel coding and modulation. The standard ATSC has chosen for the transmission subsystem is 8-VSB (Vestigial Sideband) in a 6-MHz television channel.[7]
- Receiver characteristics, which will be discussed in an upcoming issue of *DigiPoints*.

The building blocks in their subsystems are shown together in Figure 2.

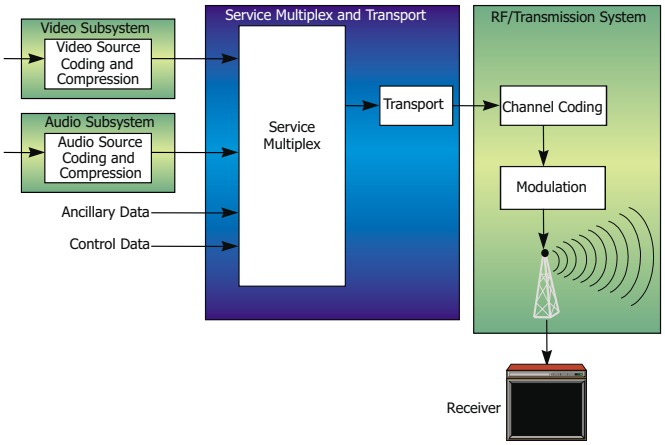

Figure 2: DTV Broadcasting Block Diagram

How Digital TV Works

Encoding

The DTV signal begins with a raw video and audio data stream. If an HDTV signal were to be transmitted uncompressed, it would require over 20 MHz to carry all the data. Since this is not possible, the signals need to be bit-reduced prior to transmission in a terrestrial system. This reduction is called compression and maintains efficiency in the transport system. The ATSC coding and compression are based on the MPEG-2 video standard, at a nominal bit rate of 19 Mbps. The compression specified in the MPEG-2 standard is very effective at encoding a high-quality signal. The basic premise behind MPEG is to code the image, transmit that frame, and then only transmit the changes to the objects instead of the whole image all over again in each subsequent frame. This is accomplished through a complex but effective use of different

7 Vestigial Sideband (VSB) is a different modulation scheme than the QPSK or QAM schemes used in cable systems. This will present several challenges to the cable telecommunications industry, especially if “must carry” rules are imposed for digital broadcast channels. Please see the sidebar entitled “Digital Modulation Methods” for a summary of VSB, how it differs from QPSK and QAM, and a short history of the choice of VSB technology for broadcast DTV.

© SCTE

types of frames to perform these roles. This process provides a very bandwidth-efficient method of sending video information, providing compression rates of greater than 50:1.[8]

The audio is encoded using Dolby Digital AC-3 audio compression at a nominal bit rate of 384 Kbps. This is the same audio encoding system that is employed in movie and home theaters. The Dolby Digital AC-3 standard will be discussed in detail in a subsequent issue of *DigiPoints*.

Multiplexing and Transport

Once encoded and compressed, the data streams are multiplexed and packetized for transport. Multiplexing allows for the combining of video, audio and auxiliary data and control information. A feature of the ATSC standard allows for a number of auxiliary data streams for future services and interactive control. This provides the capability for multiple SDTV program

Digital Modulation Methods

There are three prevalent modulation methods in use for digital TV: QAM, QPSK, and VSB. The cable telecommunications industry has chosen QAM as its standard (SCTE DVS-031). Satellite transmission of digital signals generally uses QPSK because it is less susceptible to degradation by noise introduced over the long distances involved in the satellite-terrestrial links. The broadcast industry has chosen VSB. Although all three methods are multibit modulation, the different ways that the bits are transported on the carrier signal makes each incompatible with the other. VSB stands for Vestigial Sideband. The name comes from the way the carrier signal is transmitted. Figures A and B illustrate how the term came into being.

The frequency spectrum of a modulated carrier initially contains two sidebands in a frequency distribution that is symmetric about the carrier frequency (see Figure A). Because of the symmetry, the sidebands contain redundant information. Double sideband transmission allows easy and inexpensive recovery of the modulating signal, but it wastes power and bandwidth, since both sidebands must be transmitted.

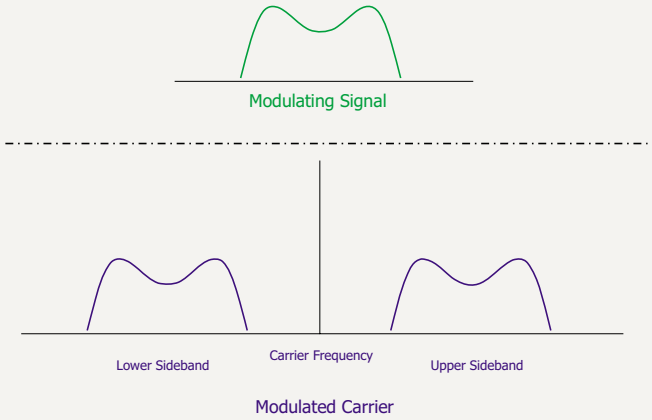

Figure A: Double Sideband

Transmitting only one of the sidebands keeps all of the information in the modulating signal and cuts both power consumption and bandwidth requirements in half. Unfortunately, the generation of such a signal is complicated and expensive.

8 MPEG compression is discussed in detail in *DigiPoints: The Digital Knowledge Handbook*, Volume One.

sources within one transmission stream.

This capability may be used for multicasting or datacasting. Multicasting allows several standard definition television channels to be broadcast in the 6-MHz spectrum allocated for a single video channel.[9] Broadcasters may use this capability to present programming alternatives for their viewers without the requirement that they switch channels. This provides the potential for increasing the viewing audience for any given channel. Datacasting allows data associated with programming to be transmitted on the same channel frequency. An example is the statistics associated with players in a football game.

The 6-MHz channel bandwidth restricts the number of programs or data that can be simultaneously transmitted with a digital signal. The number of programs depends on the

Vestigial Sideband transmission is a compromise that filters out all but a small part (vestige) of the lower sideband and leaves the upper sideband intact (see Figure B). With this technique, the power requirement is reduced, and a signal that would have required almost 9 MHz of spectrum for double sideband transmission can be carried in a 6-MHz spectrum.

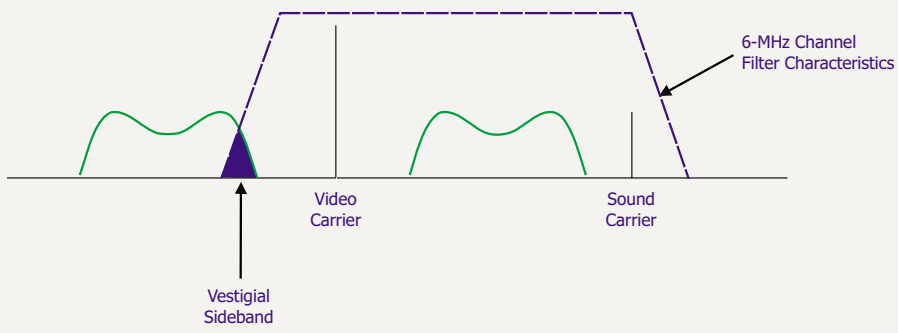

Figure B: VSB Carrier and Sidebands within 6-MHz Spectrum

VSB was chosen by the broadcasters for their off-air signal modulation because it provides a better solution to co-channel interference between multiple digital television signals, between digital TV and NTSC, and between NTSC and digital.

Unfortunately, recovery of both phase and amplitude information in a carrier requires both sidebands. With VSB, therefore, a digital signal can only use changes of amplitude to represent appropriate digital symbols (combinations of binary numbers such as 00, 01, 10, etc.). QAM, because it retains both sidebands, can use both frequency and phase to represent similar symbols.

The solution when going from one method to the other is usually to demodulate and then remodulate in the required format. Obviously, this involves investment in a second modulation system. For applications that can be shared between several customers, such as going from a satellite feed to a cable HFC distribution system, the cost per subscriber can be allocated across all the subscriber base, resulting in a relatively small cost per subscriber. For applications that are unique to one subscriber, such as receiving both off-air digital and cable digital signals, the cost per subscriber can be substantial. Effectively, the customer is buying two systems to receive all signals.

9 For more information on how this is done, see *DigiPoints*, Volume 2, Issue 5.

© SCTE

modulation method, the bit rate of the digital signal, and the compression method applied to the digital signal. Table 2 indicates the digital capacity of a 6-MHz channel with various modulation schemes.

Compressed Program Rate	QPSK (9 Mbps)	16 QAM (18 Mbps)	64 QAM (27 Mbps)
9	1	2	3
6	1	3	4
4	2	4	6
3	3	6	9
2	4	9	13
1.5	6	12	18

Source: *Communications Technology,* June 1998, p. 168

Table 2: Compressed Digital Programs per 6-MHz Channel

The actual bit rate of a digitally coded video program depends on the amount of action in the video, the frame rate, and the scanning format. High-action video, such as live sporting events, requires more bandwidth, even with compression, than "talking head" news. High Definition TV, with up to 1,080 interlaced scan lines, will require more bandwidth than 480-line interlaced. As shown in Table 2, the number of bits that can be squeezed into a 6-MHz channel also depends on the modulation method. Six programs per 6-MHz channel has been demonstrated, and as many as 24 programs per 6-MHz channel has been proposed.

RF/Transmission

The multiplexed packets are modulated for terrestrial transmission via an eight-level vestigial sideband (VSB) process. The signal originates as a four-level AM-VSB signal and, by the use of trellis coding, is converted to eight levels. The addition of a scrambling[10] sequence to this signal flattens the spectrum. A pilot carrier is then added 310 KHz from the lower band edge.

10 Scrambling, when used in digital systems, refers to a method to ensure a good mix of 1s and 0s. It is not a reference to a signal security system.

Receiver

On the receiving end, the decoding process restores the video, audio and data. It demodulates, decompresses, demuxes and decodes packets into raw data streams. If the termination point for a digital broadcast signal is a cable TV headend, a conversion from 8-VSB to 64-QAM is necessary before transport over the HFC plant. At the viewer location, the current state of the art requires separate set-top boxes for viewing broadcast digital and cable digital signals, because of the different modulation methods used by each system (VSB for broadcast, and QPSK or QAM for cable).

The ideal digital decoder/receiver needs to process both VSB and QAM modulated signals. Also, it should be able to convert both frame and scan rates to the format needed by the display. If, or when, this ideal box may become a reality is anybody's guess. Hopefully one day it will be integrated into the TV or VCR.

Impact on Cable Systems

The Cable Headend

Currently the digital video evolution is underway in a number of headends with the addition of digitally encoded programming received via satellite distribution. The modulation technique used for transmission is usually QPSK. *DigiPoints* Volume 2, Issue 5 discussed digital systems in detail.

There is a great deal of debate in the industry concerning the best method of providing cable distribution of off-air digital broadcasts. The options for off-air signal distribution from the headend now are:

- place a VSB-modulated signal in the same 6-MHz frequency slot on which it is received,
- demodulate an off-air VSB signal and remodulate it to QAM for distribution, or
- somehow carry a VSB signal unchanged on a carrier using QAM modulation.

Contractual obligations which reserve channel space may preclude the first and second alternatives, even if there were set-top converters capable of processing both VSB and QAM signals. The last alternative would require the development of a new signal processor.

In the Home

As discussed earlier, the ideal converter would process both VSB- and QAM-modulated signals. It would also need to receive NTSC analog signals and decipher various forms of scrambling or encryption. Also, it should be able to convert both frame and scan rates to the format needed by the display. Such a device does not yet exist, however. To further complicate home configurations, the multiple sources of digital content, such as DVD players, VCRs, etc., each

© SCTE

have their own interfaces to the TV and to other devices. IEEE is developing Specification 1394, known as "FireWire," which will include a standard bus and interconnection for digital devices attached to a set-top converter.[11] The market, however, is demanding field delivery of digital television before 1394 is implemented, so in the interim, there will be multiple devices and interfaces in the field.

How Digital TV Will Affect Cable's Technical Personnel

Previous issues of *DigiPoints* have already discussed this point in great detail, mostly in terms of the need for increased training in digital theory and testing. Obviously, the distribution plant must be ready for digital deployment.

Addition of new digital channels in the UHF spectrum presents particular challenges in terms of adjacent channel interference. A recent technical bulletin[12] indicates UHF traps and bandpass filters are only partially effective in solving interference problems, and the bulletin points out also that lower and upper sideband splatter can pass through a signal processor's IF amplifier, appearing as impulse noise. The report suggests that cable engineers will need to consider alternate solutions involving the use of radiation pattern nulls directed toward undesired digital TV transmitters. Antenna design theory continues to be an important facet of cable's digital future.

Converters and their interfaces will present many challenges as digital television evolves. With multiple combinations of digital sources in the home, technical personnel will need to understand the differences in formats, as well as the appropriate wiring between devices. The consumer will look to the cable company's technical personnel as the "experts" who will need to be able to explain why certain connections and combinations are possible or not, and to successfully implement those which are possible. Likewise, customer support personnel will need to understand these interconnections and formats to assist customers who may add or change their own configurations, or inadvertently disconnect wiring. Those of us who have a few years experience recall the early days of the purported "cable-ready" TVs and VCRs. Customers were confused when their new "cable-ready" sets couldn't receive all of the cable programming. The multiple standards, formats and delivery strategies for digital TV will present a new set of challenges for our customers that will be even more complex than the cable-ready problems we have faced in the past.

11 SCTE has approved two corresponding standards that cover the Home Digital Network Interface with copyright protection (SCTE DVS-194) and without copyright protection (SCTE DVS-195).

12 The *Biro Technical Bulletins*, HDTV edition, Steven I. Biro Inc., January 1999, available through Steven I. Biro Inc., Box 2175, Princeton, New Jersey 08543.

© SCTE

Conclusion

Digital TV includes perceptions and technologies. The high cost of DTV to both the broadcaster and the consumer is sure to slow the adoption of the technology. But much of the recorded media today is already converted (or could be converted) to an MPEG-2 format. Providing the subscriber with solutions to the more varied equipment interconnects will prove to be an opportunity to embrace what is sure to be an evolutionary technology — digital TV.

© SCTE

Learning Just Enough to Be Dangerous: Glossary

Aspect ratio — In a TV picture, the ratio of width to height.

ATSC — Advanced Television Systems Committee.

Cb — One of two color difference signals. Cb is red minus luminance.

Chrominance — The color component of a television signal.

Cr — One of two color difference signals. Cr is blue minus luminance.

Datacasting — Transmission of broadcast data on a virtual channel within the same 6-MHz channel allocation as a video signal.

Dolby AC-3 — The digital audio standard specified for cable and broadcast TV in the United States.

Flicker — The perceived lack of continuous motion in a moving picture that has been constructed from frames of still pictures.

Grand Alliance — The consortium of companies that created the specifications for digital television.

HDTV — High Definition Television. The term used to describe television pictures with vertical resolution of 720 lines and above, and horizontal resolution of 1280 lines and above, with a 16:9 aspect ratio.

Interlaced scan — Television scanning method that consists of two fields per frame, with a frame created from alternate lines of each field.

Luminance — The brightness component of a television signal. See also the definition for Y.

Multicasting — Transmission of multiple programs within the 6-MHz spectrum reserved for a single TV channel.

NTSC — National Television System Committee.

PAL — Phase Alternating Line. The European standard for analog television in which the color carrier phase definition changes in alternate scan lines.

Pixel — Picture Element, also known as a pel. The smallest unit of color information on a television screen.

© SCTE

Progressive scan — Television scanning method that traces a screen picture one line after the next.

Recommendation 601 — ITU specification for digitization of a color television signal.

SDTV — Standard Definition Television.

SMPTE — Society of Motion Picture and Television Engineers.

VSB — Vestigial Sideband. Type of modulation used by broadcast digital television. Vestigial refers to the partially filtered carrier sideband.

Y — Luminance component of a color TV signal. The Y component is a weighted sum of green, blue, and red color components and indicates the brightness level.

© SCTE

Testing Your Knowledge

1. What are some differences between the NTSC television signal and the European PAL television signal?

2. What are the two parts of digital TV technology?

3. What is the distinguishing characteristic of Standard Definition TV?

4. What is the advantage of interlaced scan over progressive scan?

5. Give two examples of video format conversion.

6. What are the five building blocks of the ATSC digital TV standard?

7. What makes VSB different than QAM?

Answers to Issue 3-1 Questions

1. What was the first use for data transmitted as part of a television signal?

   Closed Captioning for the hearing-impaired was the first use for data transmitted as part of the TV signal.

2. What is the difference between "push" and "pull" interactive applications?

   In "push" applications, the same data is broadcast to many receivers, where it may or may not be used depending on whether or not it is "open." For "pull" applications, the data server is responding to a particular request, and data is transmitted to a particular receiver.

3. What are the obstacles to implementing Interactive TV via DBS?

   The distance associated with geostationary satellites (44,474 miles total signal path) introduces an unavoidable amount of delay (latency) for a two-way system. However, "push" interactive services are unaffected since the server does not need a return channel.

4. What is the maximum amount of data that can be carried via an NTSC television signal?

   Using the North American Basic Teletext Specification to transmit data on every line in the television raster scan, the maximum amount of data is 5.727272 Mbps. If this were to be combined with the system designed by the EnCamera Sciences Corporation, which can deliver a total of 4.5 Mbps and does not use the VBI, the total would be 5.727272 Mbps + 4.5 Mbps = 10.227272 Mbps.

© SCTE

5. What are the main subsystems in the WorldGate Headend Server?

   The two main subsystems of the WorldGate Headend Server are the Television Integrated Client Server (TICS) and the Television Online Communications Server (TOCS).

6. What are the main subsystems in the Wink Interactive TV system?

   The main subsystems of the Wink Interactive TV system include the Wink Studio , the Wink Broadcast Server , the Wink Response Server and a Wink-enabled TV set-top box.

7. What is Channel Hyperlinking?

   Channel Hyperlinking is a system that joins TV programming content to an Internet site via a database that is maintained by the North American Channel Hyperlinking Organization (NACHO). It allows television viewers to move directly between television programming and internet websites.

8. What industry groups are contributing to Interactive TV standards?

   The Advanced Television Enhancement Forum (ATVEF) includes, as members: CableLabs, CNN, DirecTV Inc., Discovery Communications Inc. (DCI), The Walt Disney Company, Intel Corporation, Microsoft Corporation/WebTV Networks Inc., NBC Multimedia Inc., Network Computer Inc. (NCI), NDTC Technology, Public Broadcasting Service (PBS), Sony Corporation, Tribune Company and Warner Bros.

© SCTE