Past, Present, and Future

by Robert Diaz

Analog TV's days are numbered. In a few years, we will likely see an end of analog broadcasts in the major cities. Yet, the average consumer knows very little about HDTV and even HDTV salespeople don't fully understand the history and technology behind the system. Here, I will provide a brief summery of the history, the basic technology, and potential future for HDTV.

History

In the 1980s, the Japanese unveiled the Hi-Vision HDTV system. This sparked US interest in developing an HDTV system. Near the end of the 1980s to the early 1990s, the FCC (Federal Communications Commission) received many proposals for HDTV systems, but the one proposal that caught the most interest was from General Instrument Corporation. Their proposal was for an all digital system. Other companies quickly followed with their digital proposals. The problem was that all the different proposals were very good, but no one system out-shined all the others.

By 1993, the FCC realized that the best solution would be to take the top contenders and form a "grand alliance" of different companies. The idea was to take the best from each proposal and incorporate that into one unified proposal. Today, the ATSC (Advanced Television Systems Committee) oversees this process.

The original timetable (established 1996 to 1997) listed the year 2006 as the last year for analog TV. Back then, January 1, 2007, must have seemed like more than enough time to make the transition, but things don't always work as planned.

In 1999, HDTV stations started to come online in 30 major cities and, by 2002, HDTV transmissions were generally available in all the other major areas. The theory was if you build it, they will come. Well, the system was built, but buyers weren't coming and investing in HDTV in large numbers.

This put the FCC into a major bind. Demand for open frequencies was huge and — as long as there is

Table 1

Product	50% Of Products	100% Of Products
36" TVs and larger	July 1, 2004	July 1, 2005
25" to 35" TVs	July 1, 2005	July 1, 2006
13" to 24" TVs		July 1, 2007
VCRs & Other Recorders		July 1, 2007

Table 2

Aspect Ratio	Decimal	Usage / Name
4:3	1.33	Analog TV and Pre-1950 Movies
16:9	1.78	HDTV Wide Screen
37:20 (9:5)	1.85	Academy Flat (About 16.65:9)
47:20 (12:5)	2.35	Anamorphic Scope or Cinema Scope

The numbers in parenthesis are approximations of the aspect ratio.

a dual digital and analog TV system in operation — a vast amount of the radio spectrum is being tied up. A single 6 MHz TV channel can be broken into 400 narrow band FM 15 kHz voice/data channels. Bringing an end to analog TV will free up a massive amount of bandwidth, but if most of the country's TVs go blank, the fallout will be enormous.

In 2002, the FCC issued the Digital Tuner Mandate Timetable for TV Manufacturers. Manufacturers must include a digital tuner with their product (See Table 1). The TV manufacturers fought this in the courts. In the end, the FCC won and the manufacturers must now comply. Today, the FCC appears to be pushing for January 1, 2009, as the shut-off date for analog TVs. Yet it's still possible that the FCC may still pick the original shut-off date of January 1, 2007.

Even if the later date is selected, the potential outcry from consumers could be immense. Today, about 85 percent of the American public receives their TV signal via either satellite or cable. Only 15 percent of the public receives their TV signal via the broadcast system. This means that, when all analog broadcasting comes to an end January 1, 2007 or 2009, around 85 percent of the public will continue to receive TV via cable or atellite. However, the remaining 15 percent without DTV (Digital TV) reception will become a very unhappy and vocal group.

Currently, an HDTV Tuner with HDTV and standard TV outputs sells for around $300.00. The industry expects that these tuners will sell for about $200.00 in 2007 and around $100.00 in 2009. A standard definition TV will work with an HDTV tuner, but the resolution must be scaled to the resolution limit of the TV.

HDTV Standards

One of the early critical questions to be settled was the aspect ratio. Aspect ratio is the ratio of the horizontal size of the image compared to the vertical size of the image. This can be expressed as H:V or as a decimal number, where the number equals H/V. The most common aspect ratios are listed in Table 2.

The movie industry has used many aspect ratios over the years. Some of the ratios not listed above are: 1.66, 1.96, 2.20, 2.55, 2.59, 2.66, 2.75, 2.76, 2.77, and 3.00. With so many different ratios to chose from, you might assume that the task of selecting the ideal aspect ratio is impossible. However, the 16:9 ratio seemed to be the most reasonable balance between 1.33 material and 2.35 material. A full screen Academy Flat loses only four percent of the image at the edges on a 16:9 screen.

After choosing the aspect ratio, the next step was to select the resolution for HDTV. This is a good example of why decisions by committee aren't always the best. With so many people from so many different companies, everyone had their own ideas as to what should be included in the standard. The end result was not one or two, but

Table 3

Resolution (H x V)	Ratio	Scan Rates
1920 x 1080	16:9	60i, 30p, 24p
1280 x 720	16:9	60p, 30p, 24p
720 x 480*	16:9	60p, 60p, 30p, 24p
720 x 480*	4:3	60p, 60p, 30p, 24p
640 x 480	4:3	60p, 60p, 30p, 24p

If this wasn't messy enough, the scan rate can also be 1000/1001 or 60 --> 59.94, 30 ---> 29.97, 24 ---> 23.98 The 59.94 rate matches the current scan rate of color analog TV.

* The 720 x 480 resolution is also written as 704 x 480, which represents the active pixels.

In 60p Progressive, all the lines in the image are scanned 60 times per second.

In 60i Interlaced, the image is scanned 60 times per second, but all of the odd lines are scanned in the first pass and then all the even lines are scanned in the second pass. It takes two passes to fully scan the image.

For Additional Information

A wealth of information, links, and resources about DTV — **www.dtv.gov**
Online version of TV Technology Magazine — **www.tvtechnology.com**
DTV Resources — **www.checkhd.com**
National Association of Broadcasters — **www.nab.org**
HDTV Public Notice — **www.myfreehdtv.org**
Digital TV Information — **www.digitaltvzone.com**
Determine what antenna to use — **www.antennaweb.org**

18 different standards. The standards fall into five different resolution/ratio groups (Table 3).

Broadcasters are not required to transmit in every possible resolution and frame rate, but a TV receiver must be able to display all 18 of these possible resolutions and frame rates. Many HDTV sets have a fixed native resolution and convert the incoming signal to its native resolution and frame rate.

As a very general rule of thumb, for normal viewing distances of 10 to 12 feet, 1,280 x 720 is good enough for a 60-inch screen or smaller and 720 x 480 or 640 x 480 is good enough for a 34-inch or 32-inch screen. Keep in mind that this is only a general rule and what's good enough for one person may not be good enough for another.

A 1,920 x 1,080 pixel image at 30p or 60i generates about 995 Mb/second of uncompressed video data. Even the lowest resolution — 640 x 480 — and the lowest frame rate — 24p — generates about 118 Mb/second. This is more data than our 19.39 Mb/second DTV transmitters can handle.

The solution is to use data compression to reduce the amount of information. Try to imagine a single frame of video placed onto a giant Excel spreadsheet where each cell represents a single pixel. As we look over the numbers, certain patterns will appear. By using a shorthand notation to describe these patterns, we would come up with a reasonable summary of what all the cells should contain. The shorthand notation won't produce an exact reproduction of all the data in all the cells, but should be a reasonably close approximation to the original data.

Video is more than a single frame; the other video frames that follow should be close to the data in our key frame. If we record only a summary of the differences between frames, the amount of data recorded is reduced. This is a simplified explanation to how MPEG-II works, but the main thing to remember is that the final image is close enough to the original that few notice the minor differences.

Transmission Standard

The FCC chose 8-VSB — Eight Level Vestigial Sideband — as the system to transmit the digital data. In Europe, they use COFDM — Coded Orthogonal Frequency Division Multiplexing. The 8-VSB uses a single carrier frequency with all the data sent in a high speed serial stream on that carrier. COFDM uses hundreds of carrier frequencies to transmit the data in a parallel fashion. With COFDM, each carrier transmits the data slower; since there are so many in parallel, the data rate would be about 18.7 Mb/second; which is close to the 8-VSP's rate.

In the late 1990s, Sinclair Broadcast Group began a major push to promote COFDM as the standard for broadcast rather than 8-VSB. COFDM is less sensitive to multi-path or ghosting and has an optional mode that is slower, but more robust and could be received indoors; 8-VSB lacked a robust mode and could not be received indoors. Like many things in the engineering world, it turned out to be a trade-off. COFDM is more sensitive to impulse noise from motors and electrical arching and — in terms of transmitter power — does not do as well as 8-VSB. In the end, the FCC rejected Sinclair's request to use COFDM.

Since that time, major improvements occurred in each generation of 8-VSB receivers. The fifth and latest generation 8-VSB receivers incorporate powerful digital signal processing that can handle a multi-path signal as strong as the direct signal. In April 2004, the ATSC group approved E-VSB (Enhanced VSB) as an optional mode of transmission. In the future, broadcasters will incorporate a low resolution — but highly robust — signal for weak signal conditions along with the standard high definition signal. The beauty of E-VSB is that the additional mode does not render all the older 8-VSB receivers obsolete. The older receivers just ignore the robust signal and receive the standard signal.

The Future

HDTV prices continue to fall and are expected to drop even more in coming years. Still, the future isn't perfect for everyone. The broadcast flag raises all sorts of issues with the consumers' future abilities to record programs for later viewing or keep a personal library of their favorite shows.

Despite the dark clouds that some would like to focus on, HDTV opens the door to new and exciting possibilities for the future. For those who missed the 5 or 6 P.M. news, ABC is now broadcasting a news show on the second channel in their HDTV data stream. Likewise, if your favorite program is interrupted by something, you may be able to see it on one of the alternate channels. Some stations — like PBS — broadcast four different programs at once. Who knows what other ideas will be possible in the future? The future of TV is coming, stay tuned ... NV

About the Author

Bob Diaz teaches electronics and computer technology at El Camino College in Torrance, CA. He has always been interested in video and has followed the HDTV development closely for the past two decades.