High Definition Television (HDTV), if you have ever seen it, promises to dazzle even the most jaded home electronics fan. The picture, as many would say, is like looking through a clear glass window. The high resolution digital picture is so detailed that many will forget they are looking at a television screen. So what is HDTV? What is it all about? What are the basic facts that you must know?

In this tutorial, we cover the basics of HDTV and how it compares with Digital Television (DTV) as a whole, what programs are available in HDTV, how you could view HDTV in your own home and make recordings of HDTV programs, and what's in store in the near future.

**Digital Television, The Formats**

High Definition Television (HDTV) is actually a subset of the Digital Television (DTV) family of formats, as defined by the Advanced Television Systems Committee (ATSC). DTV uses digital data (1's and 0's) transmission of the picture and sound information, as opposed of the traditional analog signals used for what we know as analog television, devised by the National Television System Committee (NTSC). The relatively new DTV picture formats are generally characterized by the horizontal and vertical resolutions, aspect ratio, interlaced or progressive scanning, and refresh rate.

**Vertical and Horizontal Resolution**. How many pixels (picture elements) each dimension of the picture holds. For example, 480 lines of vertical resolution means there are 480 horizontal lines of information in the vertical axis. Each horizontal line consists of 640 or 704 pixels lined up.

**Aspect Ratio**. The ratio of the picture's width to height is expressed as “width:height”. For example, “4:3” aspect ratio means that the picture width is 4 units wide by 3 units high. Another way to express this aspect ratio is “1.33:1”, meaning it is 1.33 times wider than it is high. This traditional aspect ratio is commonly called “full screen”, since it fills the traditional TV screen. In contrast, “16:9” aspect ratio calls for a picture that is 16 units wide by 9 units high, or 1.78 times wider than it is high, or “1.78:1” aspect ratio. This new aspect ratio used by some DTV formats, and by all HDTV formats, is usually called “widescreen” or “16 x 9”. The widescreen format is closer to the movie aspect ratios of 1.78:1 and 2.35:1. Widescreen aspect ratios take advantage of the physiological fact that our eyes have wider horizontal field-of-view than in the vertical direction. By filling more of our natural vision,
directors and content producers can better draw us into the action. That's why movie screen have gone to the 1.78:1 and 2.35:1 aspect ratios decades ago. It's a more visually involving experience.

**Interlaced or Progressive Scanning.** The television picture can be “drawn” in one of two ways. Traditionally, the picture is drawn with two passes, one for the odd-numbered horizontal lines (first frame update), and another for the even-numbered horizontal lines (second frame update). So it takes two passes (or two frame updates) to refresh the entire picture. This is called **interlaced scanning.** An analog TV picture is completely refreshed about 30 times a second (or 30 Hz). To put it another way, the entire picture is redrawn 30 times every second, with the odd- and even-numbered lines redraw cycle repeated 30 times per second. Some of the new DTV formats call for **progressive scanning**, where the entire picture (both odd-numbered and even-numbered horizontal lines) is updated in a single pass or scan. Progressive scanning results in a brighter image with no visible TV scan lines and fewer motion artifacts (the stair-step edges that you see on moving objects). Progressive scan correlates better with the film medium, where the entire film cell is protected onto the screen one cell at a time.

**Refresh Rate.** This is the rate at which the entire picture is redrawn, expressed in number of times per second (or Hz, short for Hertz). DTV supports interlaced scanning at 30 Hz and progressive scanning at 24, 30, and 60 Hz. The 24 Hz refresh rate corresponds nicely with film projection's 24 frames per second (fps) rate.

The table below summarizes all 18 of the ATSC Digital Television formats. There are a total of six (6) HDTV formats, of which 720p/30 and 1080i/30 are the most common. Again, It is important to realize that HDTV is only a subset of the DTV standards, and so DTV is the more general term, while HDTV specifically references the six high definition formats of the 18 DTV formats. The DTV formats are most frequently referred by their horizontal lines of resolution and whether they scan in progressive or interlace (e.g., 480p, 720p, 1080i). The suffix “p” stands for progressive scan, while the suffix “i” stands for interlaced scan. Sometimes, they are further distinguished by their refresh rate, as designated with a slash (“/”), followed by the refresh rate. For example, “1080i/30” refers to 1080 horizontal lines of resolution with interlaced scanning at 30 Hz refresh rate.

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**Summary of the 18 Digital Television formats, including 6 HDTV formats**
Standard Definition Television (SDTV) consists of the first DTV format of 480i/30. It is equivalent to interlaced video output of DVD-Video in 4:3 aspect ratio. This format is used for when bandwidth is a bigger consideration than absolute picture quality. SDTV uses a data rate of about 4-7 Mbps, so three to six SDTV channels can be cramped into the same bandwidth as a HDTV channel.

Enhanced Definition Television (EDTV) is a step up from SDTV, but not quite as good as HDTV. EDTV consists of some 11 formats as shown in the above table. The vertical resolution is limited to 480 lines, but horizontal resolution varies 640 to 704 vertical lines. It encompasses both 4:3 and 16:9 aspect ratios, a number of refresh rates, and both interlaced and progressive scanning. EDTV is used when better picture quality is desired, but without the full bandwidth of HDTV.

High Definition Television (HDTV) uses a data rate of 25 - 27 Mbps for the best possible picture. All HDTV formats are in 16:9 aspect ratio. The 720 vertical resolution only uses progressive scanning, but at various refresh rates. The highest resolution is commonly used in interlaced scanning mode (1080i), due to limitations of current broadcast and consumer equipment. But the format includes 1080p, to accommodate future growth as imaging and display technologies catches up. HDTV is used for premium programming when picture quality is of utmost priority, and bandwidth is less of a concern. This includes select prime time shows, major sporting events, and premium movies.
At its highest resolution, HDTV offers 2,116,800 pixels (picture elements). This is over a six-fold improvement in picture detail of standard definition television which only has 307,200 pixels. Color resolution is also improved by a factor of two. All of the DTV formats use MPEG-2 as the video compression standard, just like DVD-Video. MPEG-2 is a flexible video encoding algorithm and scales up nicely for the higher resolutions of DTV. With digital transmission, there are no analog transmission artifacts and degradations such as snow due to weak signal, double images or ghosting due to multi-path interference of large buildings and structures, and sparkles due to noise from a vacuum cleaner.

The Audio Format

Not only does DTV bring us a near-perfect picture, but included in the DTV formats is digital audio as well. Dolby Digital is the standard digital audio encoding format for all DTV formats. Many of you know Dolby Digital for its multi-channel surround sound capability from DVD-Video. What some of you may not realize is that Dolby Digital is more flexible than just a 5.1-channel surround sound format. Dolby Digital is actually a scalable digital audio encoding algorithm that supports 1.0-channel (mono) and 2.0-channel (stereo, with optional Dolby Pro-Logic/Pro-Logic II) when the original programming only has a mono or stereo soundtrack. Dolby Digital only uses as much data as it needs to encode these 1.0-channel and 2.0-channel audio soundtracks. Home theater fans will realize of course that Dolby Digital can scale up to “6.1” extended surround sound as in Dolby Digital EX. If you are not familiar with surround sound, be sure to read our Surround Sound Tutorial and Home Theater Receiver Buying Guide for more information.

Delivery

Just like analog TV, Digital Television and HDTV can be delivered in one of four ways:

- Over-the-air broadcasts
- Broadcast satellite
- Terrestrial cable
- Pre-recorded media

Over-the-Air (OTA) Broadcasts. Many local broadcasters in large cities and metropolitan areas have already started broadcasting Digital Television and HDTV over the airwaves. Yes, this is old rabbit-ear indoor antenna (and unsightly roof-top outdoor antenna) approach to receiving television signals. What you will need is an roof-top HDTV antenna (if your neighborhood and city code allow for it) or an indoor HDTV antenna to pull in these signals.
You will also need an integrated DTV (with a DTV receiver built-in) or a DTV receiver and a DTV monitor (also known as “DTV-ready television”). Alternatively, you can use a DTV receiver and your existing analog TV, but you won’t be able to see DTV and HDTV in its native high resolution formats. In this case, the DTV receiver will down-convert the high resolution DTV signal, scaling it down to a lower resolution that your analog TV can handle. You will get the clear, noise-free digital picture benefits of DTV programming, but you won’t see the much-improved high resolution picture due to limitations of your existing analog TV. (This in fact fact how many consumers will transition to DTV when analog TV broadcasting stops. More on this later.)

Fact: More than 861 stations offer over-the-air DTV broadcasts, and 60 percent of Americans are in areas where there at least five stations broadcasting in DTV, as of May 2003.

Broadcast Satellite. Broadcast satellite providers such as Dish Network and DirecTV were relatively quick to provide HDTV channels. If you already have broadcast satellite equipment, you may still need to upgrade your satellite dish to a dual-LNB model (so it can receive from both the HDTV satellite and the “regular service” satellite). You will also need to upgrade your satellite set-top box so that it can decode the high resolution HDTV signals. Check with your satellite service provider for the specifics. (Note that “digital satellite TV” is not the same as DTV. It is simply the NTSC analog TV signals, transmitted in digital form via satellite, then converted back to analog TV signal for display on your TV set. These “digital satellite TV” signals do not provide any of the true 18 DTV formats, as explained above.)

- **Dish Network**: To receive HDTV programming, look for the *Model 6000U series* HDTV broadcast satellite receiver and a *dish antenna pointed at 61.5 or 148 orbital locations*.
- **DirecTV**: To receive HDTV programming, look for the *DirecTV High-Definition Receiver* and a *18”x24” DirecTV Multi-Satellite dish antenna with a Sat-C kit* or an *18”x20” DirecTV Multi-Satellite dish antenna (Triple-LNB)*.

Terrestrial Cable. For some time, cable TV companies were reluctant to upgrade their infrastructure to provide HDTV. In response to the Federal Communications Commission’s (FCC) strong urging, some terrestrial cable TV provides (e.g., Time Warner Cable) have begun to roll out HDTV channels. With cable TV delivery, you may need a different set-top box, a “QAM-capable” DTV cable receiver, to decode the DTV signals. (QAM stands for Quadrature Amplitude Modulation. Simply put, this is the modulation used to transmit DTV via cable TV. It differs from the 8-VSB modulation used in over-the-air broadcasts of DTV. 8-VSB stands for 8-level Vestigial Sideband.) Some of the newer integrated DTVs incorporate a built-in “QAM-capable” DTV decoder for terrestrial cable, in addition to the 8-VSB DTV decoder for over-the-air reception. The early integrated DTVs only have the latter for over-the-air reception.
of DTV, and require an additional set-top box for decoding cable delivered DTV programming. Check with your local cable TV provider to see if and when DTV programming will be available. (Note that “digital cable” is not the same as DTV. It is simply the NTSC analog TV signals, transmitted in digital form via upgrade cable equipment, then converted back to analog TV signal for display on your TV set. These “digital cable” signals do not provide any of the true 18 DTV formats, as explained above.)

Pre-Recorded Media. Today, you can view pre-recorded HDTV movies in 1080i on Digital-VHS video tapes using the D-Theater copy protection feature. So far, only DreamWorks, Fox, Universal, and Artisan have embraced this format and released a handful of movies in D-Theater. Read more about this in Digital-VHS and D-Theater Overview.

What’s on HDTV? A Question of Content

So what programming is available on DTV, and particularly in HDTV? After all, “content is king” is the mantra of the broadcasting world. Though many networks are national, the availability of these HDTV networks depends a lot on where you live. Here is the information we have compiled. Click on the web links for additional information (links open in a new web browser window).

Major national broadcasting networks:

- **ABC** is the only network to broadcast HDTV in the 720p format. ABC HDTV programming include prime time shows such as “Alias”, “The Practice”, “NYPD Blue”, “My Wife and Kids”, “MD’s”, and “The Drew Carey Show”, as well as network world-premiere movies such as “Gladiator”, “Charlie’s Angels”, “The Green Mile”, and “E.T. The Extra-Terrestrial”. Click here to check if your local ABC-affiliated channel provides over-the-air HDTV broadcasts.

- **CBS** feature HDTV broadcasts in 1080i for most of its prime time program, including shows such as “CSI: Crime Scene Investigation”, “CSI: Miami”, “JAG”, “The Guardian”, “Everybody Loves Raymond”, “The King of Queens”, and “Touched by an Angel”. CBS also offers HDTV broadcast for major sporting events such as the NCAA Playoffs and even a day-time soap opera “The Young and the Restless”. Click here to check if your local CBS-affiliated channel is currently broadcasting HDTV over-the-air.

- **NBC** also broadcasts HDTV in the 1080i format. Prime time shows such as “ER”, “Frasier”, “Law & Order”, “Law & Order: Criminal Intent”, “Law & Order: Special Victims Unit”, “The Tonight Show with Jay Leno”, “In-Laws”, “Hidden Hills”, and occasionally feature films and made-for-TV movies are broadcasted in HDTV. Click here to check if your local NBC-affiliated channel is currently broadcasting HDTV over-the-air.
• **Fox** broadcasts DTV in what they call “Fox Widescreen High Resolution TV”. As if terminology wasn’t difficult enough in today’s world, Fox actually broadcast in one of the **EDTV** formats, specifically the 480 × 704 in progressive scan 16:9 widescreen format (480p/30, see format #11 in the table above). The picture quality is comparable to a “enhanced for 16:9 widescreen TV” DVD-Video in progressive scan mode, but not quite as good as HDTV. Fox DTV programming includes shows such as “Ally McBeal” and “Dark Angel”.

• **PBS** broadcasts in HDTV and “Widescreen Standard Definition” (similar to Fox’s 480p/30, format #11). Its programming includes specials and series such as “Nova”, “National Geographic Special”, “Nature”, “Smart Travel”, and “Great Performances”. PBS also broadcasts an HDTV demo loop.

• For a complete listing of of local TV stations broadcasting in HDTV, click here.

**Major national premium networks (available from cable or broadcast satellite providers):**

• **HDNet** is the premiere premium network specializing in 1080i HDTV programming, as its name implies. This premium channel is included for DirecTV subscribers. **HDNet** features live sports such as NHL, USOC, CART auto racing, college and pro basketball, football, tennis, boxing, and horse racing. It even features world news with its HDNet World Report programming. **HDNet Movies** is another channel, providing movies in HDTV from Warner Bros. and independent studios, as well as made-for-TV movies and short features.

• **HBO HDTV** broadcasts movies in HDTV and is available on the DirecTV and Dish Network broadcast satellite systems.

• **Showtime HDTV** broadcasts movies in HDTV and is available on the DirecTV and Dish Network broadcast satellite systems.

• **Discovery HD Theater** offers select Discover Channel program in HDTV. This channel is available on the Dish Network.

**Major satellite providers with premium/optional HDTV channels:**

• **Dish Network** offers the following channels in HDTV: Discovery HD Theater, HBO HDTV, Showtime HDTV and CBS HD. To sign up for HDTV programming on the **DISH Network**, click here.

• **DirecTV** offers the following channels in high definition: **HDNet**, HBO HDTV, Showtime HDTV, and a High Definition Pay-Per-View channel. To sign up for HDTV on **DirecTV**, click here.

**Analog to Digital Television Transition**
When the Federal Communications Commission (FCC) auctioned the airwaves that would serve as Digital Television broadcasts back in the mid-1990s, the goal was for the United States to “fully” transition to new ATSC DTV standard by the year 2006. At such a time, Congress would take back the airwaves originally allocated to NTSC analog television and re-allocate it for other purposes. (Not everyone is aware of this fact.) Analog television signals would cease to be broadcasted over-the-air, and everyone in the United States would watch Digital Television signals.

_Analog television signals would cease to be broadcasted over-the-air, and everyone in the United States would watch Digital Television signals._

To make the huge number of existing analog televisions forward compatible with the DTV signals, manufacturers would make set-top boxes (STB), much like the set-top boxes that you may have today from your cable TV or satellite TV provider, that down-convert the DTV signal to an analog television signal so you would be able to drive your existing analog TVs with a signal that it is able to display. The down-conversion process takes the higher resolution picture of DTV signals and re-formats it to a lower resolution picture that analog TV sets is capable of displaying.

Well, it's already 2003 and the DTV transition has been rather slow to date. Only a few percent of all U.S. households have DTVs or DTV-ready displays. The problem is similar to that of the chicken and the egg. The chicken being DTVs and the egg being DTV programming. (Or is it the other way around?) Without DTV programming, why would consumers want to upgrade to the more expensive DTVs or DTV-ready displays? From the content producers and broadcasters’ perspective, why would they upgrade their production equipment to DTV when there are not enough consumers with DTV capability to justify the investment?

Given the more realistic (read “slower than expected”) rate of DTV rollout by content producers, broadcasters, and distributors, and the adoption rate by everyday consumers, this 2006 “deadline” would have to be extended. The U.S. Congress provision calls for the transition to occur when 85% of the United States population has Digital Television. So don’t worry. Your analog TVs are safe from obsolescence for quite a few years.

**Recording Digital TV & HDTV**

Naturally, with DTV content available, everyday consumers will want to record such programs whether it be for time shifting, sharing programs, or archival purposes. But recording DTV is one of the sticking points of this new technology. Since DTV, particularly HDTV, contains very high picture quality and its digital form theoretically allows bit-for-bit perfect copies to be made, content owners are leery of allowing their precious, revenue-generating content to
be recorded. Most of this is understandable, considering they are the rightful owners. But for sometimes, their resistance may be viewed as just paranoia. As a result, there is ongoing debate as to whether consumers should be able to record certain DTV programs in light of the Fair Use Act.

Whatever the case, recording DTV does have some technical challenges. First, the data rate for HDTV peaks at some 28 Mbps, about four to seven times that of the DVD-Video format. So whatever recording medium is used, it must accommodate a fast data rate. And since many movies and sporting events are a couple of hours long in duration, the recording medium must also have a large data capacity, on the order of 25 - 50 GB.

Right now, there are three hypothetical ways in which consumers may be able to record HDTV programs. **Digital-VHS** is the only format available today, while **high definition personal video recorders** and **recordable high definition DVD** are expected to be available soon.

**Digital-VHS (D-VHS).** JVC took its aging VHS and Super-VHS formats and gave it new life as a video tape-based DTV recording medium. The **Digital-VHS** format is capable of recording HDTV in either 1080i or 720p, for up to four hours on a single D-VHS video tape. This recording capability is available now. There are four D-VHS VCRs available, including the JVC HM-DH30000 ($600, as low as $549.88 at [JandR.com](http://www.JandR.com)), Marantz MV8300 ($1,600), Mitsubishi HS-HD1100U, and Mitsubishi HS-HD2000U. For playback of high definition movies, JVC also added a proprietary copy protection feature called **D-Theater**, allowing movie studios to release movies in full HDTV quality without fear of it being pirated. So far DreamWorks, Fox, Universal, and Artisan have embraced the D-Theater format and have begun releasing a handful of movies to this format. For more information about Digital-VHS and D-Theater, read our [Digital-VHS and D-Theater Overview](http://www.example.com).

**High Definition Personal Video Recorders (HD-PVRs).** Hard disk-based personal video recorders such as TiVo and ReplayTV have revolutionized the way consumers time shift TV. And soon, by the end of 2003 or early 2004, HD-PVRs capable of recording HDTV programming may become available. These devices are likely to be integrated with the set-top broadcast satellite receivers or cable boxes and come with large hard disk capacities, in order to capture the high bandwidth of HDTV programming. Current and previous generations of PVRs are designed for analog TV, and cannot record DTV and HDTV broadcasts.

**Recordable High Definition DVD.** On the near horizon is the introduction of the recordable High Definition DVD (HD DVD) format. This new optical disc format would use the new blue-violet laser technology to allow more data to be recorded on the familiar 12.0-cm optical disc form factor. Two formats are being considered, **Blu-Ray Disc** and **Advance Optical Disc** (AOD). The Blu-Ray Disc format seems to have a leg up on the AOD format, as Sony just
released a production Sony BDZ-S77 Blu-Ray Disc Recorder (equivalent $3800 US, available since April 2003) to the Japanese consumer market. For more information about these HD DVD formats, read our High Definition DVD Tutorial.

The Future of Digital TV & HDTV

DTVs and DTV-ready displays will undoubtedly get cheaper and better with time. More and more sets will incorporate a built-in DTV receiver. And hopefully with more DTV programming comes more DTV adopters. As we discussed above, HD DVD recorders are only a few years years away, providing the convenience of an optical disc format. HD-PVRs based on today's TiVo and ReplayTV devices will probably converge with the new HD DVD recordable format and allow us to archive HDTV quality programming onto removable and shareable HD DVDs. Years from now, our children will ask us how we ever got along without Digital Television. Until then, we’ll help you navigate the road ahead and avoid the pitfalls of an evolving technology.

For more info, visit (the following links open in a new browser window):

- National Association of Broadcasters (NAB) offers a list of complete & current listing of DTV stations and some recent info on DTV.
- PBS offers a digital technology web site, with a DTV primer, consumer-oriented guides, and some white papers on DTV.

What do you want to do next?

- Digital TV & HDTV Buying Guide - Coming soon!
- Digital-VHS and D-Theater Tutorial - See how you can record HDTV and view HDTV-quality movies today
- HD DVD Tutorial - The high definition version of DVD
- Recordable DVD Tutorial - Learn about the different recordable DVD formats
- DVD Recorders Buying Guide - Find out what you should look for
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