Optimizing the HDTV Experience

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Introduction

I wrote in a previous BAS article, "For sure, digital transmission offers benefits, but it is not a panacea. Thus, buying a product labeled digital does not imply the highest audio fidelity, a perfect picture, a high-definition picture (HDTV), or a product that costs less than analog." In this article I examine the impact of digital technology on television broadcasting and TV sets.

The analog-to-digital transition has had a profound impact on broadcast television picture quality in terms of resolution and shape. The results can be stunning compared to a mediocre analog show, or can be annoying with artifacts and a distorted image. The optimal viewing experience with a high-definition television (HDTV) depends on the source material, the broadcaster, the broadcast channel, the TV connection, and the television setup. David Weinberg, the BAS editor, wrote a comprehensive piece on HDTV (BASSv35n2, summer 2013). I have extended his article by examining some of the practical impacts of HDTV on picture quality such as compression artifacts and image shape.

Digital TV (DTV) is a signal carrying a digital encoding of either standard definition TV (SDTV) or high definition TV (HDTV) programs. SDTV displays images with a resolution comparable to an analog broadcast (480 lines per picture). HDTV resolution is 720 or 1080 lines per picture, with the potential to produce a sharper image.

HD reception is complicated because TV stations are intermixing SD and HD programming even during the same show. Furthermore, HD material is sometimes being converted to SD before being broadcast. This mixture of SD and HD is likely to persist for years because of huge SD archives, the cost of HD production, and revenues from multiple SD streams. As David noted, broadcasters can transmit four or more SD signals in one channel in addition to one compressed HD signal, thereby generating more ad revenue.

DTV reception

The first decision for consumers is how to receive the digital television (DTV) signal. There are four choices:

- An antenna for local broadcasts
- Cable TV (including fiber-optics such as Verizon FiOS)
- Satellite TV
- Internet Protocol TV (IPTV)

The same program may look sharper and clearer depending on this choice because of signal compression. All HD signals are compressed before transmission by the station for economic reasons. This involves removing image data that are supposedly imperceptible, called *lossy compression* as contrasted with ZIP that is *lossless compression* for data files where every bit is reproducible. Some cable, satellite, and IPTV companies compress the images even more.

Too much compression results in less sharpness and colors that look smeared or flat. The least compression and hence the best quality HDTV signal is usually obtained from an antenna.

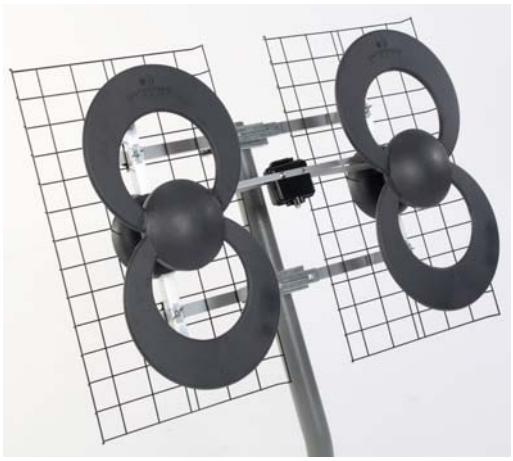
Reception problems and antenna choices

With over-the-air digital broadcasting, the signal received must be strong enough so the data can be decoded perfectly by the TV tuner. With analog TV a weak signal or a signal distorted by reflections from buildings and hills looks snowy and may have ghosts. But the contents are still visible. A weak signal carrying digital data will display either nothing or a picture that breaks into blocks or freezes.

The FCC (Federal Communications Commission) estimates that antenna reception of DTV is possible up to 75 miles from the TV tower, as with an analog signal. However, Centris reports[1] little continuous DTV coverage beyond 35 miles. U.S. residents can check expected reception at www.antennaweb.org. If you are near a building or a hill, the higher you can mount the antenna, the better chance of receiving a stable picture.

Figure 1 shows two antennas I have tested. I am located just 13 miles from the Boston TV towers, but lose some reception especially during wind and rain. Behind my building is a 25-foot hill with trees that are probably affecting the DTV signal. I had never noticed a problem with analog reception.

[1] http://www.broadcastingcable.com/news/washington/centris-9m-households-could-have-dtv-reception-issues/44261



(Courtesy of Antennas Direct)

(Courtesy of Audiovox, Inc.)

Figure 1 – High Quality DTV Antennas

IPTV

In July 2013, *IP&TV News*, reported that 7% of U.S. households use antenna for TV reception exclusively. This probably understates antenna usage since many cable and satellite subscribers have one or more TVs receiving broadcast signals via antennas, especially portable TVs.

More importantly, millennial-age viewer (born 1980-2000) are increasingly opting for Internet TV with free and subscription services (such as Hulu and Netflix) and using antennas for local broadcasts. Therefore, they may have cable TV or FiOS, but subscribe only to high-speed Internet access. According to CNET, "In North America, with AT&T U-verse and Verizon FiOS actively promoting IPTV services, the North American IPTV subscriber base has arrived at 11.7 million, or 12.7 percent of the global market."[2]

Confusing connections

The TV industry has been in a five-year transition from analog to digital connections using multiple analog and digital formats. This is confusing customers and often results in sub-optimum connections. Figure 2 shows the variety of interfaces found on some TV sets. These connectors offer multiple options for delivering audio and video, but with different quality levels. It is likely that purchasers of expensive DTVs are experiencing sub-optimum performance because they connected to the wrong jack.

[2] http://cable.tmcnet.com/topics/cable/articles/2014/03/31/374816-global-iptv-market-set-sail-past-100m-sub.htm

Display/TV ↔ DVR/DVD/Blu-ray Connections		
Connector	**Description**	**Sample Cable**
Coaxial cable	An analog A/V signal viewed on TV channel 3 or 4	
Composite video	An analog video signal on one wire using an RCA connector	
S-video (Super-video)	Separate brightness and color analog signals	
Component video	Separate brightness and two color analog signals on three wires using RCA connectors	
DVI (Digital Visual Interface)	Encoded digital video signal	
HDMI (High-Definition Multimedia Interface)	Encoded digital video plus audio and control signals	
Stereo audio	Two-channel analog audio signals using RCA connectors (not used with coax and HDMI cables)	
S/PDIF (Sony/Philips Digital Interface Format)	Digital audio interconnection cable using a coaxial cable with an RCA connector or a fiber optics connector called TOSLINK (Toshiba Link)	Coax  TOSLINK 

Figure 2 – Connection Options for a Display

The present industry goal is to migrate to HDMI. However, HDMI cables are limited in length, bulky, and expensive. Other connection options are emerging that I may present in another BAS article.

Aspect ratio

NTSC adopted the 4:3 shape for TV from movies. As TV sales were booming in the 1950s, the movie industry developed wide-screen formats to improve theater attendance. The ATSC (American Television Systems Committee) decided that DTV should change the aspect ratio from 4:3 to 16:9 (from 1.33 width-to height ratio to 1.78). 16:9 is not as wide as any of the wide-screen movie formats, but was chosen as the widest practical picture tube (before flat screen TVs were invented).

Until 1952, a movie theater and TV presented an experience that shared similar features: an image with a 4:3 shape and monaural sound. With the introduction and overwhelming success of Cinerama in 1952, Hollywood discovered that multi-channel sound and a wide screen could draw customers away from the TV and back into movie theaters.

Many studios and production companies invented proprietary wide-screen formats that were less expensive to produce than Cinerama. Some of these formats have familiar names like Cinemascope, Panavision, and Vista Vision. The screen shapes vary from 1.85:1 to 2.76:1 with the most popular being 1.85:1 and 2.35:1. Movie theaters accommodated these aspect ratios by projecting all movies on a screen with the same height and varying the width of the screen. The various screen widths are compared in Figure 3.

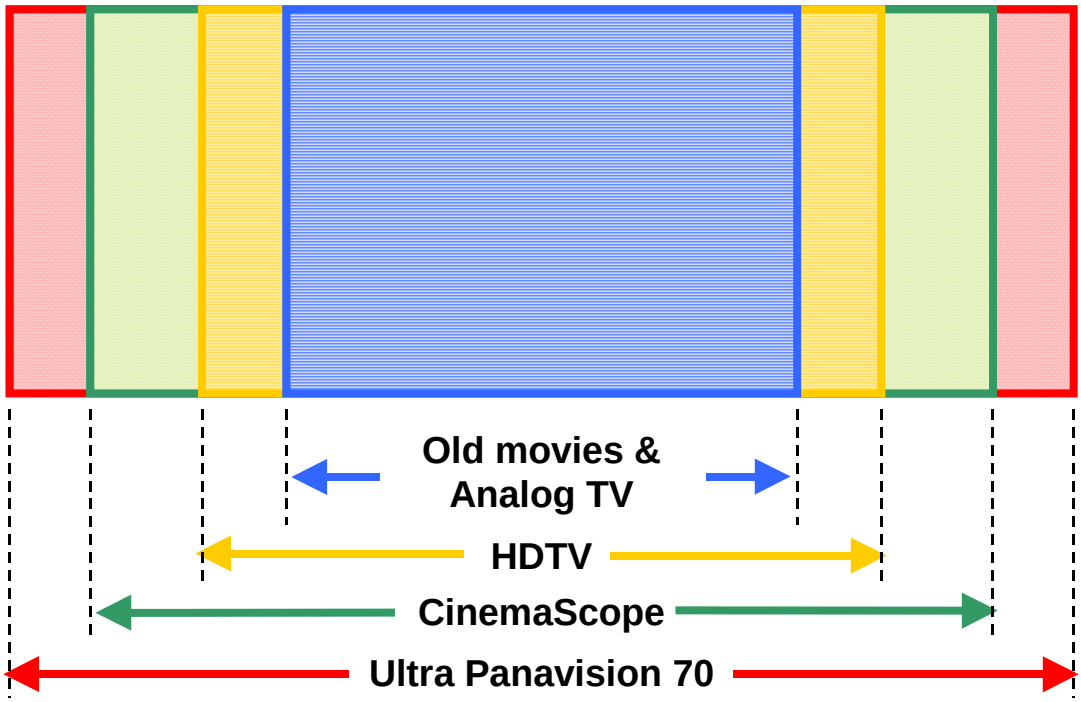


Figure 3 – Wide-screen, Fixed-height Display

In older theaters, curtains on the far left and right covered unused portions of the screen. For dramatic effect, theaters in the 1950s and 1960s would show a newsreel in 4:3 and then open the

curtains wider (almost doubling the width) as the feature film began, usually with a trumpet fanfare.

Wide-screen movies were often cropped to 4:3 for analog TV by removing the left and right edges. However, many broadcasters are now transmitting the original wide-screen format, called *letterbox*. SD programs and letterbox movies produce TV pictures that often contain black areas on HDTV sets.

Black areas on the left and right side of the picture are called *pillars*, while black areas on the top and bottom are called *bars*. Sometime a picture is framed with both pillars and bars, creating what the industry calls a *postage stamp* image, as illustrated in the center of Figure 4. This happens when the studio has 16:9 material, encodes it as standard definition, transmits it in digital format, and you view it on an HDTV.

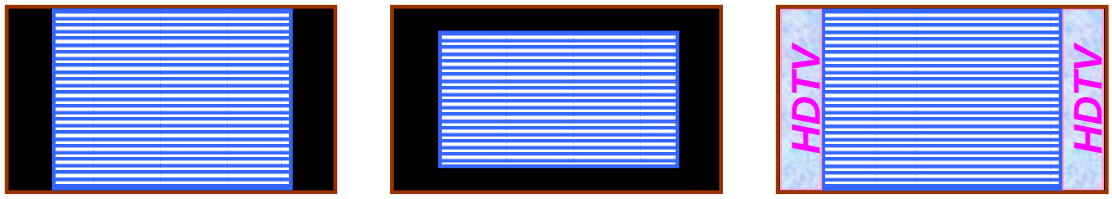


Figure 4 – Fitting an SD Picture onto an HDTV Screen

Most HDTV sets include an option called *width* (or *aspect* or *picture size*) on the remote control unit to stretch an SD picture so it fills the screen without needing pillars. I don't like this format because it distorts images, especially faces. Another feature zooms a postage stamp image to fill the screen. This preserves shapes. However, it cannot convert an SD into an HD signal, so the image may appear soft without sharp detail.

Some broadcasters encode SD signals in unusual ways:

- Pillars with graphics: SD broadcasts with pillars containing the station name or *HDTV* in large letters (see the right-hand image in Figure 4). Of course, the image is not HD.

- Stretched picture: I saw a station that regularly stretches SD to 16:9, thereby distorting all images. Others horizontally compress HD source material for an SD signal, resulting in skinny people and objects.

- For HD programs in 16:9 format containing clips from old TV programs, some producers do not add pillars, but instead crop off the top and bottom to create a 16:9 shape. The faces are not distorted, but some background is lost and a few heads are occasionally clipped.

DTV artifacts

As David explained, some broadcaster cram an HD and multiple SD channels into their allocated 6-Mhz broadcast band. The ATSC digital TV broadcast standard adopted in the U.S. and South

Korea specifies an encoding method (MPEG-2[3]) that compresses an HD stream of more than 1 billion bits per second to 19.39 million bits per second. Within this data stream are the compressed video, audio, and parameters for managing the stream, the program, and timing. The audio is encoded in the Dolby Digital AC-3 format supporting 5.1-channel sound.

Every DTV broadcast tuner includes a demodulator to recover the 19.39-Mbps stream of data from the broadcast signal. Cable and satellite systems use different parameters, but also deliver a data stream that is decoded in a set-top box. Satellite and cable customers with HDTVs must subscribe to special HD channels. Otherwise, they will be watching only SD signals.

The visible effects of excessive compression include small dots around objects (called *mosquito noise*), a series of blocks in place of a fast-moving object across the screen such as a basketball or blocks on a smooth surface (call *macroblocking*), and image blurring. Examples of these defects are shown in Figure 5 and Figure 6.

Original Image Compressed Image

Figure 5 – Mosquito Noise in a Compressed HD Image
(Courtesy of Algolith)

[3] MPEG-2 is version 2 of a communications protocol specified by the Moving Picture Experts Group (MPEG). MPEG-2 is now an international series of standards, ISO/IEC 13818, published by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), both located in Geneva, Switzerland. A TV Emmy was awarded for this ISO/IEC work.

Original Image Compressed Image

Figure 6 – Macroblocking in a Compressed HD Image
(Courtesy of Algolith)

Sorting out the confusion

Retailers should recommend products that satisfy consumer-viewing preferences with minimal compromises. This will enhance the viewing experience and produce satisfied customers who may buy additional home theater equipment. Some retailers are recognizing that a happy HDTV consumer needs more than the lowest price for the TV. The consumer needs services to accompany the product sale. Such services may involve:

- Determining that the large TV can be viewed comfortably, considering room size and lighting.
- Selecting an antenna or HD service from satellite, cable TV, fiber optics service, or IPTV.
- Delivery and setup, including wall mounting.
- Configuration and calibration. Most TVs are set in *showroom mode* with high contrast and saturated colors.
- Possible installation of a Blu-ray or DVD player.
- Possible installation of a DVR (digital video recorder) from the TV service provider or purchased from TiVO, Channel Master, etc.
- Possible installation of a surround-sound system. I have found that adding just a subwoofer improves the quality of TV sound.

- Programming of the TV and the remote control unit.

- Instructing the customer how to use the system.

Future service opportunities include control of lighting and automated window coverings in a media room to create a theater-like experience. Thus, the sale of high-end TVs may lead to consumer interest in home automation.

Even with these procedures, the HDTV experience will not be optimal unless:

- The producer uses HDTV cameras or coverts a movie to HD. (35-mm film is higher resolution than HDTV).

- The broadcaster actually sends an HD signal.

- The broadcaster or cable operator or satellite operator does not over-compress the HD signal.

According to the American Television Systems Committee (ATSC) a high-definition signal must display 720 or 1080 lines per image. As David noted, broadcasters have been free to alter the number of picture elements (pixels) per line and the color quality. The result is that HD is not always as good as it could be or as good as the program director created in the studio. Some cable TV operators have advertised that satellite HD is inferior to cable HD because of compression. However, a side-by-side comparison is needed for an objective evaluation since both use compression to conserve bandwidth for additional channels.

U.S. federal regulators have standards for describing the size and capability of TV sets. We need similar disclosures for TV signals so consumers know what they are getting. If a consumer is paying for HD programming, they should not be receiving *HD Lite*. According to Wikipedia, "HD Lite refers to the TV-program received by the viewer, which has been somehow compromised (reduced) in fidelity."