# An Overview of DVD Technology

*by Garry Musgrave, CTS-D*

*Originally published: February 1997*
*Last updated: January 2001*

---

**Courtesy of: Conceptron *Associates***

---

## Introduction

DVD (**D**igital **V**ersatile **D**isc) technology is aptly named. It is this very versatility, however, that has led to a lot of confusion. DVD is intended to eventually replace a number of separate technologies. Because of this, there are several "*flavours*" of DVD – while each is DVD, they are not necessarily compatible!

There are three major types of DVD that are intended as high capacity replacements for existing technology: **DVD-ROM** compliments, and should eventually replace, **CD-ROM**; **DVD-Audio** should eventually replace **audio CD's**; and **DVD-V** (digital video disc) has already replaced **Laser discs**. This latter is most often simply called **DVD**, and this is what most people think of when they think "DVD."

In addition, there are several types of recordable **DVD-ROM** for computer applications: **DVD-R** is a high speed write-once disc; **DVD-RW**, **DVD+RW**, and **DVD-RAM** can all be re-written thousands of times.

**CAVEAT:** Any article written about DVD technology has a limited life – this technology can change significantly in a year. A two-year old article may be out of date – we will try to update this article periodically (check the mast head for the update date).

## DVD-ROM

While DVD is the same physical size as a CD-ROM, the similarity ends there – DVD can hold up to 25 times more information, and be up to nine times faster. A CD-ROM generally has a storage capacity of about 650 MB, DVD discs, however, are available in different densities.

The basic disc (**DVD-5**) is a single-sided/single-layer disc with a capacity of 4.37 GB. Next come: **DVD-9**, a single-sided/dual-layer disc holding about 7.9 GB; **DVD-10**, a dual-sided/single-layer disc holding about 8.7 GB; **DVD-14**, a dual-sided/mixed-layer disc (i.e.: single layer on one side, double layer on the other) holding about 12.3 GB; and, finally, **SD-18**, a dual-sided/dual-layer disc holding about 15.9 GB. If blue laser technology becomes viable, these figures could triple. The capacity of **DVD-R**, **DVD-RW**, and **DVD-RAM** ranges between about 1.4 GB and 8.8 GB.

This increase in capacity from CD-ROM technology is due to: a smaller pit length, tighter track spacing, a slightly larger data area, less sector overhead, and more efficient modulation and error correction.

Note that DVD discs can be either single or double sided, and each side can have one or two layers. The laser re-focusses to read through the outer layer to the inner layer (a distance of 20 to 70 microns). The capacity of a dual-layer disc is slightly less than double that of a single-layer disc.

## DVD-Audio

While the DVD-Video standard includes both surround sound audio and better-than-CD audio, DVD-Audio is a completely separate format designed to replace music CD's. When the DVD standard was released, there was initially no DVD-Audio format. The final DVD-Audio 1.0 specification (minus copy protection) was only released in March, 1999. Pioneer introduced the first DVD-Audio players in Japan in late 1999, but they wouldn't play copy-protected discs. Several manufacturers plan to imminently release DVD-Audio/DVD-Video combination players (called "universal players"), and a few plan to release DVD-Audio-only players – unfortunately, there are currently no DVD-Audio titles to play.

While DVD-Audio supports the same high-definition multichannel audio as DVD-Video, it also includes higher-quality PCM audio with up to 6 channels at sample rates of 48, 96, and 192 kHz (also 44.1, 88.2, and 176.4 kHz) and sample sizes of 16, 20, and 24 bits. This allows a theoretical frequency response of up to 96 kHz, and dynamic range of up to 144 dB. Sampling rates and sizes can vary for different channels. The maximum data rate is 9.6 Mbps.

The MLP lossless compression used in DVD-Audio allows playing times that range from about 74 to 135 minutes of 6-channel 96kHz 24-bit audio on a single layer (compared to 45 minutes without compression). Two-channel 192kHz 24-bit playing times range from about 120 to 140 minutes (compared to 67 minutes without compression).

Since DVD-Audio players will output PCM and Dolby Digital, they will work with existing receivers – some may also support the optional DTS and DSD formats. However, most current receivers can't decode the high-definition, multichannel PCM audio of DVD-Audio. Even if they could, it can't be carried on standard digital audio connections – receivers with improved digital connections such as IEEE 1394 (FireWire) will be needed to use the full digital resolution of DVD-Audio. As a stop-gap, some players are expected to include high-end digital-to-analog converters (DACs). Unfortunately, these can only be hooked up to receivers with two-channel or six-channel analog inputs, and some quality will be lost if the receiver then converts this analog input back into digital for processing.

DVD-Audio discs can be designed to work in DVD-Video players. Since the DVD-Audio specification includes new formats and features (with content stored in a separate DVD-Audio zone on the disc that DVD-Video players never look at), it is possible to make a DVD-Audio disc that won't play at all in a DVD-Video player.

## DVD-Video

DVD-V is the technology that will have the biggest impact on audio-visual and presentation projects. The video content will be compressed from 124Mbps 4:2:0 digital video using an **MPEG-2** algorithm – the amount of compression varying with the disc density. A typical DVD-5 disc is expected to be produced with up to 133 minutes of audio and video at an *average* data rate of 4.7Mbps (3.5Mbps for the video portion, or 36:1 compression). This should yield good quality video, but there may be some visible compression artefacts. The DVD-9 disc, however, will allow up to two hours of material at an average data rate of 9.5Mbps, which should be free of visible artefacts. *The density of the disc vs. its running time should always be checked as an indicator of the quality of the video on the disc* – a DVD-5 DVD ***can*** hold up to six hours of video and audio, if highly compressed (i.e.: over 70:1 compression). **Certainly nothing greater than 133 minutes on a standard DVD-5 disc should be accepted for presentation use**.

Another caveat is that, just like current CD-ROM and VideoCD technology, DVD can also accommodate **MPEG-1** encoding – this is particularly true of DVD-ROM. This yields a video quality that is, at best, only as good as VHS tape. Again, ***read the disc label*** – **this video quality is definitely not adequate for presentation use**.

While DVD-V supports both NTSC and PAL, the same problems exists as with current technology. The player needs to be able to reproduce both standards. While there certainly will be multi-standard players, most are expected to be one or the other.

DVD-V supports up to eight surround-sound audio tracks (the idea is to allow for multiple languages). Interactivity is built-in to accommodate different endings, different versions (e.g.: two cuts of the same movie, with different ratings), or different camera angles for the same scene. Basic interactive menuing is built-in, with the ability to jump to a title, chapter, or track. In addition, a disc can also have up to 32 sub-picture streams which can be used to overlay the video with simple animation, menus, captioning, subtitles, karaoke lyrics, etc. These are full-screen bitmaps in four colours, each with four contrast levels. The sub-picture streams can contain built-in scrolling and fading effects.

DVD-V can also accommodate different aspect ratios. The program can be encoded either as 4:3 or "*squeezed*" 16:9. If the material is stored as 16:9, it may be displayed as: letterbox on a 4:3 monitor; pan & scan (following "*centre of interest*" data encoded during transfer) on a 4:3 monitor; and "*unsqueezed*" for wide displays.

For compatability with existing television sets, DVD's MPEG-2 video resolutions and frame rates are closely tied to NTSC and PAL/SECAM video formats. Note that while DVD does use the same 16:9 aspect ratio as HDTV, this 16:9 encoding is simply wide screen, **it is not HDTV**. The current DVD standard simply does not support HDTV – a new HD-DVD standard will be required to support it

The two most common flavours of HDTV in the US are 720p (1280x720 at 24p, 20p, and 60p) and 1080i (1920x1080 at 24p, 30p and 60i) – 24p means 24 progressive frames/sec, and 60i means 60 interlaced fields/sec (i.e.: 30 frames/sec). These HD formats are 2.7 and 6 times the resolution of current DVD respectively, and the 60p version is twice the frame rate. The ITU-R is working on BT.709 HDTV standards which may be used in Europe, and are up to 5.3 times the resolution of DVD. The 19.4 Mbps data rate required for HDTV is almost twice the maximum DVD-Video data rate.

While HD-DVD "technology demonstrations" have been made by a few manufacturers, this does not mean that HD-DVD is imminent –the manufacturers are simply jockeying for technology and patent positions. HD-DVD is expected to be available in 2003 at the very earliest – although 2006 is more likely. Players are expected to use blue or violet lasers to read smaller pits, increasing the data capacity to around 20 GB per layer. MPEG-2 Progressive Profile will probably be used to encode the video.

HD-DVD players are expected to play current DVD-Video discs, and make them look even better (with progressive-scan video and picture processing), but new HD-DVD discs won't be playable in older DVD players (unless one side is HD and the other standard DVD).

HDTV displays currently support component video connections (YCbCr) and will, in the future, support digital data connections (such as IEEE 1394/FireWire). These digital connections will provide the best possible reproduction of DVD-Video. Once DVD players have digital outputs, they may be usable as "transports" which can output any kind of A/V data (even formats developed after the player was built) to any sort of external display or converter.

For distribution of movies, cost is another attractive feature of DVD – a single-sided/single-layer DVD video disc can be produced for about the same cost as a current audio CD. Thus, DVD-V will eventually replace VHS tape for post-theatrical movie distribution (it has already replaced Laser disc). By the end of 2000 there were over 10,000 DVD movie titles available in the US, and over 15,000 worldwide (compared with over 9,000 laserdisc titles in the US and over 35,000 titles worldwide).

DVD production involves three stages of cost: production, pre-mastering (authoring, encoding, and formatting), and mastering/replication.

> DVD video production costs are no different than for other video formats unless extra features such as multiple sound tracks, camera angles, seamless branching, etc. are employed.
>
> Authoring and pre-mastering costs are the most expensive aspect of DVD production. Video and audio must be encoded, menus and control information must be authored and encoded, it all has to be multiplexed into a single data stream, and finally encoded in low level format. At the time of writing, typical charges ($US) for compression are $60/min for video, $20/min for audio, $6/min for subtitles, plus formatting and testing at about $30/min. Many facilities simply charge for time (at rates of around $400/hour). A simple two-hour DVD-Video title with menus and various video clips can cost as low as $3,000 to pre-master – a more elaborate effort can drive this cost up to to as much as $20,000 US. If you want to do it yourself, authoring and encoding systems can be purchased at prices from $400 to over $2 million (with varying degrees of quality and sophistication). Prices for software and hardware are expected to drop very rapidly in the next few years to where DVDs are expected to be able to be produced on a desktop computer system that costs less than $20,000.
>
> Videotapes don't have a mastering cost, and currently run about $2.40 US for replication. CDs cost about $1,000 US to master and $0.50 US to replicate. Laserdiscs cost about $3,000 US to master and about $8 US to replicate. DVDs currently cost about $1,000 US to master, and about $1.60 US to replicate. Since DVD production is based mostly on the same equipment used for CD production, mastering and replication costs should quickly drop to CD levels.

The hardware consists of two different types of devices: a *DVD-ROM drive* for computers, and a *DVD player* for audio and video applications.

## DVD-Video On Computers

DVD-ROM drives first appeared in mid-1997, and are now commonly available from most computer suppliers as an upgrade option to a CD-ROM drive. Separate units are also available from most of the same sources as CD-ROM drives.

In addition to a DVD-ROM drive, you must have either extra hardware (to decode MPEG-2 video and Dolby Digital or MPEG-2 audio) or your computer must be fast enough to handle software decoding. Good quality software-only playback requires a minimum of a 350-MHz Pentium II or a Mac G4. Thus, very few new computers with DVD-ROM drives include decoder hardware, since software decoding is now possible on even the least expensive machines.

To play back movie titles, your computer operating system and playback software must support regional codes and be licensed to descramble copy-protected movies – if your computer has a TV video output, it must support Macrovision in order to play copy-protected movies. You may also need software that can read the MicroUDF file system format used by DVDs. You don't need special drivers for Windows, since the existing CD-ROM drivers work fine with DVD-ROM drives.

Certain MPEG decoding tasks (such as motion compensation and subpicture decoding) can be performed by additional circuitry on a video graphics chip – greatly improving the performance of software decoders. This is usually called “hardware motion comp,” “hardware decode acceleration,” or “hardware assist” – some video card manufacturers also call it “hardware decode,” even though they don't do all the decoding in hardware.

Microsoft Windows 98 and Windows 2000 includes DirectShow, which provides standardized support for DVD-Video and MPEG-2 playback – DirectShow can also be installed in Windows 95. While DirectShow creates a framework for DVD applications, a third-party hardware or software decoder is still required.

Apple QuickTime is partially ready for DVD-Video and MPEG-2, but does not yet have full decoding or DVD-Video playback support in place. Mac OS 8.1 or better is required to directly read UDF discs.

DVD player computer applications (using either software or hardware decoding) are virtual DVD players, and support most DVD-Video features (menus, subpictures, etc.), as well as emulate the functionality of a DVD-Video player remote control. Many player applications include additional features such as chapter lists, bookmarks, and sub-title language lists.

## Stand-Alone DVD-Video Players

DVD players also first appeared in mid-1997 at costs of about $1,000 US. – there are now literally hundreds of models available from dozens of manufacturers. Current prices range from about $100 US to about $1,500 US (for progressive scan units) – with the average unit selling for about $350 US.

As with any new technology, there are compatibility problems. Some models (particularly less expensive units) cannot properly play all discs – before buying a player, you should test it with a few complex discs such as “Independence Day,” “The Matrix,” or “The Abyss.” This is because both the DVD specification and the process of authoring the discs are complex – with the former having been subject to some interpretation by the manufacturers. Discs have become more complex as authoring tools have improved, so recent discs often uncover design flaws in older players – some discs behave strangely (or wont play at all) in certain players. Problems can also occur, of course, because of damaged or defective discs or a defective player.

In general, video and audio performance in all modern DVD players is excellent. Unless you have a critical; viewing situation (such as an attraction or high-end home theatre), a player in the $400 US range should be adequate. Try out several players in your budget range – since there is not generally a large variation in picture and sound quality within a given price range, pay particular attention to ease-of-use features (e.g.: remote control design, front-panel controls, user interface, etc.).

There are two ways to display video: *interlaced scan* or *progressive scan.* Progressive scan (used in computer monitors and some digital television formats) displays all the horizontal lines of a picture in a single video frame at one time. Interlaced scan (used in standard television formats) displays only half the horizontal lines at a time – the first field, containing the odd-numbered lines, is displayed, followed by the second field, containing the even-numbered lines. The disadvantage is that the horizontal resolution is halved and the scanning lines are visible – particularly if the image is projected (i.e.: magnified).

Thus, for critical viewing, you will want to use a progressive scan player. These units convert the interlaced video from the DVD (at 480i) into a progressive scan format (at 480p) for connection to a graphics monitor or video projector. Progressive scan players work with all standard DVD titles, but look best with material that was originally shot on film – the end result is a significant increase in perceived vertical resolution, for a more detailed, film-like image. As an option, you can also use an external video scaler to create a progressive scan output from a standard DVD player – to make this worthwhile, you should invest in a high-quality player.

## DVD vs. Laser Disc

DVD has all but replaced Laser disc except for some highly specialised applications. Pioneer's introduction of its industrial DVD player with RS-232 control and seek-to-frame capabilities have now made DVD practical even for themed and exhibit projects.

Advantages of DVD-V over laser disc:

- greater capacity; DVD-V will hold from two to four hours per disc side vs. 1/2 hour for CAV laser disc and one hour for CLV;
- built-in captioning and subtitling; much more flexible than closed caption encoders;
- more audio tracks; ***can*** have higher quality audio (if encoded at a higher rate);
- ***potentially*** better video; horizontal resolution is about 30% greater than laser disc; actual video quality, however, is dependent upon video compression used to encode the disc;
- more compact (portable);
- laser disc is obsolete technology, and players will likely disappear soon;
- mechanically quieter.

Disadvantages of DVD-V over laser disc:

- current DVD players cannot play in reverse or at faster-than-normal speed;
- quality of video is dependant upon encoded data rate; its best will outperform laser disc, but its worst is very bad indeed.

---